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Minerals Yearbook

1969

Volume I—II

METALS, MINERALS, AND FUELS

Prepared by staff of the

BUREAU OF MINES

UNITED STATES DEPARTMENT OF THE INTERIOR

BUREAU OF MINES

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Foreword

This edition of the Minerals Yearbook provides a record of performance of the world's minerals industry during 1969. It continues the Federal Government's historical record of mineral industry developments, begun on an annual basis in 1882. The intervening 88 years have seen this report grow from a one-volume publication devoted principally to domestic activities to three books encompassing global mineral industry developments. The general content of the individual volumes is as follows:

Volume I–II, Metals, Minerals, and Fuels, contains chapters on virtually all metal, nonmetal, and mineral fuel commodities important to the domestic economy. In addition, it includes a general review chapter on these industries, a statistical summary, and chapters on employment and injuries and on technologic trends.

Volume III, Area Reports: Domestic, contains chapters covering the mineral industry of each of the 50 States, the U.S. island possessions in the Pacific Ocean and the Caribbean Sea, the Commonwealth of Puerto Rico, and the Canal Zone. This volume also has a statistical summary chapter, identical with that in Volume I–II, and a chapter on employment and injuries.

Volume IV, Area Reports: International, presents the latest available mineral statistics for more than 130 foreign countries and areas and discusses the importance of minerals to the economies of these nations. A separate chapter reviews minerals and their relationship to the world economy.

The Bureau of Mines will continue its efforts in the years ahead to increase the Yearbook's value to its many users. Toward that end, the constructive comments and suggestions of readers will be most welcome.

ELBURT F. OSBORN, *Director*

Acknowledgments

Volume I–II, Metals, Minerals, and Fuels, results from the cooperative effort of both the headquarters and field staffs of the Bureau of Mines Mineral Supply Activities. All chapters in this volume were prepared by these staffs except for the chapters on Injury Experience and Worktime and on Helium. They were prepared in the Office of Accident Analysis and the Division of Helium, respectively.

The collection and compilation of statictics on the domestic minerals and mineral fuels industries were performed by the statistical staffs of the Division of Ferrous Metals, Fossil Fuels, Nonferrous Metals, and Nonmetallic Minerals. These data were based largely upon information supplied by mineral producers, processors, and users, and acknowledgment is made of their indispensable cooperation. Information obtained from individuals by means of confidential surveys has been grouped to provide statistical aggregates. Data on individual firms are presented only if available from published or other nonconfidential sources or when permission of the companies concerned has been granted.

The tabular material on world production and foreign country trade was compiled in the Office of Technical Data Services from many sources, including reports from the Foreign Service, U.S. Department of State.

The cooperation of the business press, scientific and technical journals, trade associations, international organizations, and other Federal agencies that supplied information is also gratefully acknowledged.

General direction on the preparation and coordination of the chapters in this volume was provided by the Minerals Yearbook Staff, Office of Technical Data Services, which also reviewed the manuscripts to insure consistency among the tables, figures, and text between this volume and other volumes, and between this edition and those of former years.

The Bureau of Mines has been assisted in collecting mine-production data and the supporting information appearing in the Minerals Yearbook by more than 45 cooperating State agencies. These organizations are listed in the acknowledgment section of Volume III.

ALBERT E. SCHRECK
Editor-In-Chief

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Review of the Mineral Industries

By Bernadette S. Schumaker [1] and Jeannette I. Baker [2]

The U.S. economy continued to expand in 1969. However, modest gains in real growth, a decline in labor productivity, and increases in prices and costs reflected the inflationary pressures which dominated the economy. After 4 years of persistent inflation and nearly a decade of uninterrupted growth, restrictive monetary and fiscal policies were applied in 1969 to control inflation, with mixed results. A slowdown in the growth of money supply to a seasonally adjusted annual rate of 4.4 percent in the first 6 months of 1969 and to 0.7 percent for the last half was transmitted to the economy via tight credit and high interest rates. Fiscal policy was also geared to inflation fighting with a budget surplus of almost $10 billion in 1969 compared to a 1968 deficit of $5 billion. Federal expenditures were trimmed to an increase of $9 billion compared with a $20 billion average annual increase for the prior 3 years.

Despite these restrictive measures, all major price indicators—the implicit gross national product (GNP) deflator, the consumer price index, and the wholesale price index—advanced more rapidly in 1969 than in any year since 1951. The price of consumer services rose sharply, reflecting the increased costs of housing and continued advances in medical costs. Among minerals, price increases were consistently above average in metal and metal products, largely reflecting increases in steel and nonferrous metal prices.

Although prices continued to climb, the impact of economic restraint eventually triggered a slowdown in the growth of demand. In the closing quarter of 1969, constant dollar GNP was unchanged from the third quarter. Factory production and corporate profits fell. Tight credit resulted in a decline in home building, and personal income grew just enough to offset rising prices. Overall, the national output of goods and services for the year was valued at $932 billion, up 7.7 percent compared with a 9.1-percent gain in the previous year. Because physical volume grew by less than 3 percent, a very large part of the GNP advance originated from a rise in price.

In 1969, the Federal Reserve Board Index of Industrial Production for both mining and total U.S. production climbed moderately. The mining sector again lagged behind the total index average, despite a sharp rise in production from metal mines. The Bureau of Mines Index of Physical Volume registered slight gains for nonmetals and fuels. Metals, however, were up substantially.

Perhaps the brightest spot in the economy in 1969 was the average annual unemployment rate of 3.5 percent, slightly less than the annual rate for 1968, which was the lowest since 1953. Total employment reached 77.9 million, a 2-million annual increase that exceeded the average annual increase for 1961–68, a period of sustained economic expansion. Wages and salaries in all industries continued to rise in 1969. For the first time in the 1960's, wages and salaries advanced faster in mining than in the manufacturing industries.

Consumption of major minerals and mineral fuels continued upward in 1969. Total mining output also increased. Gains in metal mining included sharp increases in copper and lead production and more moderate gains in iron ore and zinc production. Among the nonmetals, production advanced slightly to moderately for most construction and fertilizer materials. Fuel production included a moderate increase in natural gas production and slight gains for crude petroleum and bituminous coal.

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Exports of crude and scrap metals and manufactured metals were up significantly in 1969, while mineral energy resources and related products had only moderate gains. Imports of both ferrous ore and nonferrous base metal ores were down for the year; the pattern for manufactured metals was mixed. Petroleum and petroleum products imported in 1969 rose slightly.

Developments in the foreign exchange market included adjustment of two important currencies in 1969. A reduction in the exchange rate of the French franc and a new higher parity for the German mark resulted in exchange rates better geared to the internationally competitive situation.

Significant among congressional activities in 1969 was the Tax Reform Act. Important features of the act included repeal of the 7-percent tax credit for business equipment expenditures, continuation of the income tax surcharge for the first half of 1970 at the reduced rate of 5 percent, increases to $750 by 1973 in the personal income tax exemption, and a cut in the 27.5-percent petroleum depletion allowance to 22 percent. The depletion allowances for other minerals were similarly cut. The Federal Coal Mine Health and Safety Act for underground mines also became law in 1969 and was promptly labeled the most stringent regulation on health and safety ever enacted in the United States.

Disposal of material from mineral stockpile inventories increased sharply, and the acquisition cost of total inventories dipped slightly for the year. The Office of Minerals Exploration through its financial assistance program continued to encourage exploration for new domestic sources of essential materials. Government assistance on 12 contracts was largely directed toward exploration for gold, silver, copper, mercury, and uranium.

Total world trade increased in 1969, but establishing freer trade had mixed results. The General Agreement on Tariffs and Trade (GATT) has been seriously concerned that the lowering of tariffs has not been accompanied by similar success in lowering nontariff barriers, which range from informal administrative procedures to defined quotas.

A record deficit in U.S. international transactions was reached in 1969. The balance of payments, as measured on a liquidity basis, was much larger in 1969 than in any prior year, despite a fourth-quarter surplus. Measured on an official settlement basis, however, a record surplus in balance of payments characterized the year. Accounting for the above difference were the unusually large short-term capital flows into the United States, which are treated differently in arriving at a liquidity balance compared to an official settlement balance.

Official U.S. gold reserves, which had begun to rise in the last half of 1968, increased by nearly $1 billion in 1969, the first net gain in gold reserves since 1967. A continued deficit in silver production induced further withdrawals from silver stocks with relatively high sales occurring from U.S. Treasury bullion stock.

To insure that adequate mineral resources are developed and made available, Bureau of Mines research funding for fiscal 1970 was increased 12 percent. Bureau of Mines research programs were directed toward developing more effective, efficient, and less costly extraction, processing, and utilization techniques. Programs in health and safety of miners also received prominent attention, and programs were continued to alleviate the problems in minerals recycling and to improve methods of solid waste disposal.

SOURCES AND USES OF MINERALS

Production.—In 1969, domestic production of primary minerals and mineral fuels was valued at $27 billion, a 7.8-percent gain from the 1968 level. In 1967 constant dollars, the value of mineral production was $25.5 billion. Metals recorded a 15-percent constant dollars increase for the year, while nonmetals and fuels gained approximately 2 percent each.

The Bureau of Mines index of physical volume of mineral production (1967 = 100) increased moderately in 1969. While metals, especially the base metals, were up significantly, nonmetals and mineral fuels registered only slight gains. Figure 1 shows historical trends for important mineral commodities. During the past 10 years, copper output has increased rapidly except during the 1967 copper strike which cut production sharply. Iron ore output, although irregular, had risen moderately, and coal production, after an initial decline in 1961, had a moderate growth. For 1969, the production index for copper was 158.8, up 32 points for the year, the largest increase for copper in the decade. The index for iron ore was up 9.5 points, while the index for coal was quite stable in 1969. (See table 2 in the statistical summary, which shows both production and value for minerals and minerals fuels in 1969.)

Based on preliminary data, the Federal Reserve Board Index of Industrial Production rose 7.3 points for the year compared to a 7.4-point increase in 1968. The mining sector lagged behind the total index average, but gained 3.7 points, the largest mining increase since 1966. Coal mining was down slightly for the second consecutive year, while crude oil and natural gas extraction gained moderately. Although stone and earth minerals were up 6.9 points, it was metals that scored the largest gain in mining—an increase of 15.6 points. In primary metals manufacturing, a gain of 12.1 points was recorded along with a 10-point rise in iron and steel, the largest gain for both since 1964. The clay, glass, and stone products category was also up about 10 points. Largely reflecting a sharp increase in copper output, nonferrous metals and products gained 21.1 points for the year.

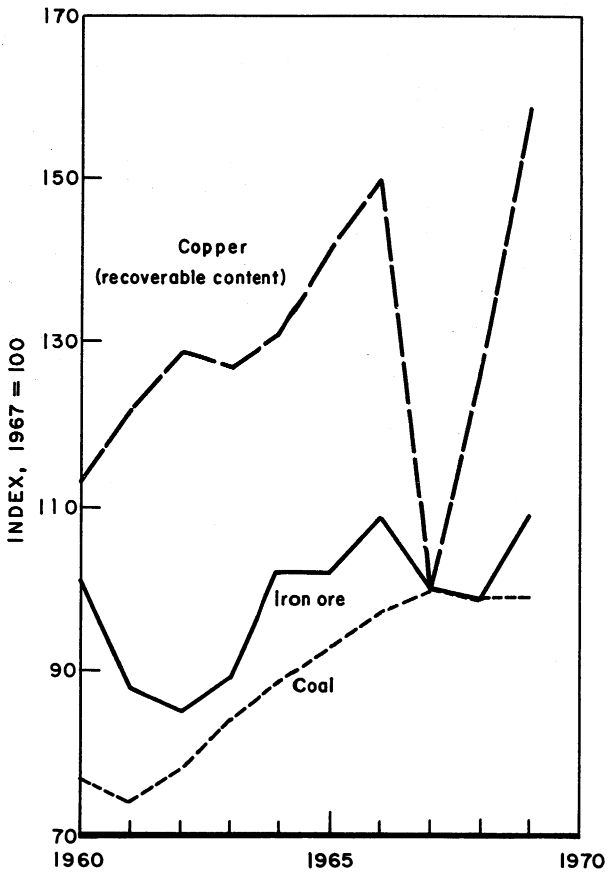

Figure 1.—Index of physical volume of mineral production for selected items in the United States.

Production of minerals and mineral fuels in the 1960's has generally trended upward. However, rates of growth for individual mineral groups have varied. Coal mining, for example, had a mixed pattern of growth in the last decade. Metal mining, which had small to moderate production gains in the early 1960's, declined substantially in 1967 as a result of copper strikes. In the last 2 years, however, production increases have been substantial. Crude oil and natural gas production has consistently increased, with moderate to sharp gains in the index. Both primary metals and iron and steel had a mixed pattern of growth. For nonferrous metals and products, a signficant gain of 78 index points in the last decade was recorded. In total, average industrial production consistently trended upward in the 1960's, averaging a 6-point gain per year.

A total of 56,634 trillion British thermal units (Btu) were produced by the fossil fuels group, an increase of 3.5 percent from the 1968 production level. Heat value of primary electricity produced at hydropower and nuclear-powered plants, when added to that of mineral fossil fuels, brought the total to 59,462 trillion Btu, a 4.0-percent increase.

Primary fossil fuels supplied the bulk of national energy supplies. Natural gas and component liquids remained the top energy source, with a preliminary marketed production of over 20,000 billion cubic feet, a 7.1-percent increase. Crude petroleum had a preliminary marketed production of 3,372 million barrels, a gain of 1 percent from 1968. Higher demand for petroleum in 1969 was met by increased domestic production and increased imports. Preliminary bituminous coal and lignite production increased slightly in 1969 to 556 million short tons, while preliminary anthracite production declined to 10.8 million short tons. The smallest source of energy came from primary electricity generated at hydropower and nuclear-powered plants, with 2,687 trillion Btu and 141 trillion Btu produced in 1969, compared with 2,352 trillion and 132 trillion Btu in 1968.

The net supply of principal minerals had a mixed pattern in 1969. Among the ferrous metals, the net supply of iron ore was up. Copper increased moderately, while lead recorded a substantial gain in net supply. The net supply of uranium concentrate (U_3O_8) increased by 8 percent during the year. Most nonmetals had slight to moderate gains. Among the agricultural minerals, the net supply of sulfur and phosphate rock declined while potash increased moderately. Increases in both sand and gravel and crushed stone were also recorded. Shipments of primary metals increased to 57.1 billion, a 13.2-percent gain. Both net orders and unfilled orders were up in 1969.

Changes in the relative shares of domestic and foreign sources of supply occurred in a few selected minerals. In 1969 more reliance was placed on foreign sources for petroleum, pig iron, nickel and nickel alloys, zinc and zinc alloys, tin and tin alloys, and organic chemicals. Fewer supplies from foreign sources were registered for iron ores and concentrates, ores and concentrates of nonferrous base metals, iron and steel products, refined copper, manufactured aluminum, and lead and lead alloys.

Stocks and Government Stockpile.—The Bureau of Mines index of stock of crude minerals (1967 = 100) for metals and nonmetals declined slightly in 1969. While nonmetals recorded a gain of 14 index points, the index of metal stocks declined 16 points. Iron ore and other ferrous metals, especally molybdenum, accounted for this decline. The index for nonferrous metal stocks gained 10 points in 1969.

Producers' stock of mineral energy resources and related products was generally down in 1969. Preliminary data indicated a 48-percent decline in producers' stock of coke; most other declines in mineral energy resources and related products, however, were less than 10 percent. For the second consecutive year, the physical stock of carbon black declined. Increased stocks were reported for natural gas, gasoline, and other petroleum products.

The seasonally adjusted book value of inventories for selected mineral processing industries showed gains in all categories in 1969. Petroleum and coal products inventories increased 7.4 percent, no significant change from the 1968 increase. Stone, clay, and glass products again registered a sharp increase in inventory position. For the third consecutive year, this category showed a gain of at least 10 percent in book value of inventories. The inventory position of primary metals rose 6.6 percent at the end of 1969. Both blast furnace and steel mills and other primary metals advanced moderately. Blast furnace and steel mills continued to account for over half of the total book value for primary metals. The overall book value of inventories for selected mineral processing industries gained 7.7 percent for the year.

Among the components of the Nation's minerals supply was the national stockpile of strategic materials. In terms of market value, important ferrous metals in the stockpile during 1969 were tungsten, metallurgical chromite, and metallurgical manganese. Leading the nonferrous metals in market value were tin, aluminum, lead, and zinc. All of these commodities were down slightly from their 1968 quantity level except aluminum and tungsten, which declined moderately.

Exports.—Compared to a 6-percent increase in 1968, the value of exports showed a 24-percent rise in 1969, resulting from signficant gains in metals exported. By far the most noteworthy gain in crude and scrap metals exported was the 51-percent increase in iron and steel scrap. In manufactured metals, gains of 50 percent or greater were registered for steel ingots, bars, and universals as well as for copper and copper alloys and silver and platinum. All other categories showed moderate gains, except for a slight decline in crude nonmetallics.

Imports.—The value of imports for selected minerals and mineral products declined by 5 percent in 1969 compared with a 22-percent increase in 1968. Copper and copper alloys and iron or steel universals, plates, and sheets registered the largest declines in value of metals imported. Both crude and scrap and manufactured metals declined. The value of crude nonmetallic mineral imports showed little change in 1969, while mineral energy resources rose moderately. Gains of approximately 20 percent in value of imports were scored for chemicals and manufactured nonmetallic minerals.

Consumption.—Consumption of selected metals in the United States generally increased in 1969. In the ferrous metals, iron ore and raw steel consumption rose, but a further decline in manganese ore consumption was registered. Nonferrous metals consumption was highlighted by a 14-percent increase in copper, a 4.5-percent increase in lead, and a 4.0-percent increase in zinc. Uranium consumption (U_3O_8), which totaled 12,338 short tons in 1968, dipped to 10,934 short tons in 1969.

Among the major nonmetals, consumption of construction materials generally trended upward. Cement consumption rose to 408 million barrels, a 1.2-percent increase; sand and gravel consumption advanced to 937 million short tons, a 2.2-percent increase; crushed stone consumption reached 863 million short tons, a 5.2-percent increase. Consumption of agricultural minerals was also generally up in 1969. Potash consumption increased 8 percent to 3.9 million short tons, sulfur consumption advanced to 9.2 million long tons, and phosphate rock consumption registered a slight gain for the year. Although consumption of agricultural minerals generally increased, this increase failed to keep pace with the rapid expansion of U.S. and world supply.

Petroleum consumption, including natural gas liquids, climbed to 5,160 million barrels, a 5.3-percent increase, but failed to match the 7-percent increase recorded in 1968. During the 1960's, U.S. consumption of petroleum steadily advanced in all the major consumer sectors. Throughout the decade the transportation sector was the largest consumer, utilizing about 50 percent of gross petroleum consumption.

An increase of 7.5 percent raised natural gas consumption to 20,388 billion cubic feet in 1969. The industrial sector continued to be the single largest consumer of natural gas.

Bituminous coal consumption in the United States reached 507 million short tons in 1969, a 1.7-percent gain. The electric utility industry was again the largest consumer, utilizing 308 million tons of coal, a 4.7-percent gain from 1968 consumption. One hundred eighty million tons of coal was used for industrial purposes, including 93 million tons used to make coke. Coal consumption in the household and commerical sector, the industrial sector, and the transportation sector declined for the year. During the past 10 years, use of bituminous coal in the household and commercial sector as well as the transportation sector has steadily declined. However, industrial consumption of bituminous coal has risen moderately, and consumption by electric utilities has grown substantially. Development by electric utilities of mine-mouth generating stations, which use high-voltage transmission lines to transport power, has contributed to the increased use of coal.

Hydropower generation output was 250 billion kilowatt-hours, a 12-percent increase from the 1968 level. Nuclear power generation output climbed to 13.9 billion kilowatt-hours, an 11-percent gain for the year.

Future fuel consumption patterns will no doubt be influenced by the growing interest in cleaner air which intensified in 1969. At the local, State, and national level, a switch to low-sulfur fuels as an aid in air pollution control was strongly encouraged. In the petroleum industry, environmental attention centered on reducing the amount of lead in gasoline.

Accounting for 31 percent of total energy consumption, the industrial sector continued to be the major energy market in 1969. Within this sector, both petroleum and natural gas increased as sources of energy, while coal registered a slight decline.

The transportation sector, the second largest energy consumer, accounted for 24 percent of total energy resources consumed in 1969. Petroleum supplied the greater part of energy resources required for transportation, with natural gas and coal supplying much smaller amounts.

Utilizing 23 percent of the total energy resource inputs, the electric utility sector increased slightly its share of the total energy resource inputs in 1969. Bituminous coal and lignite and natural gas remained the principal energy sources for this sector.

In the household and commercial market, both natural gas and petroleum increased as energy inputs, while coal continued to trend downward. Natural gas was the largest source of energy in this sector. The household and commercial sector used 21 percent of total gross energy inputs.

For all sectors total gross energy inputs advanced 5.3 percent. Fossil fuels comprised 96 percent of total energy inputs, and hydropower and nuclear power accounted for the remainder.

EMPLOYMENT AND PRODUCTIVITY

Employment.—Employment in the mineral industries increased in 1969, with slight gains in total mining and total minerals manufacturing. The increase in mining employment was concentrated in copper mining and oil and gas field services. Declines were registered for iron ore, coal and nonmetals mining, and crude petroleum and natural gas extraction.

By groupings, percentage changes in employment in 1969 compared to 1968 were as follows:

	Percent
All industries	+3.4
Mining (including fuels)	+.5
Metal mining	+9.5
Nonmetal mining and quarrying	−3.0
Coal mining	−2.2
Crude petroleum and natural gas	−2.6
Oil and gasfield services	+4.3
Minerals manufacturing	+1.6
Nonfuel minerals	+2.4
Fuels	−1.6

Employment in selected minerals and fuels manufacturing showed a gain of 14,000 employees in 1969. For the third consecutive year, fertilizers and hydraulic cement registered declines in employment; blast furnaces, steelworks, rolling mills, and nonferrous smelting and refining gained employees. Petroleum refining employment dipped in 1969 for the second consecutive year, while employment in other petroleum and coal products was up slightly. A comparison of mineral industry employment in 1960 and 1969 revealed that employment gains during the decade were concentrated in nonferrous smelting and refining and copper mining with somewhat smaller gains in oil and gas field services, fertilizers, and other petroleum and coal products. The largest loss in employment in the minerals group was sustained by the coal industry, which declined by over 25 percent in 10 years.

Hours and Earnings.—Average hours worked in metal mining declined for both iron and copper ores in 1969. Following a record high for the decade of 47.2 average weekly hours in copper mining, the 1969 figure dipped to 46.3 hours. The decrease in average weekly hours for iron ore was slight, from 41.7 hours in 1968 to 41.4 hours in 1969. Average hourly earnings were up 6.6 percent for iron ore and 6.1 percent for copper ore; average hourly earnings for metal mining increased 6.4 percent for the year. In nonmetals mining and quarrying, the average number of hours worked increased. Average weekly earnings climbed by 9.6 percent and hourly earnings advanced 7.9 percent for this group. For mineral fuels the average number of hours worked increased, except for crude petroleum and natural gas which declined for the first time since 1964. Weekly and hourly earnings for fuels were up 9 percent and 7.6 percent, respectively. In the total mining sector, weekly and hourly earnings gained 8 percent for the year, reflecting rather healthy gains in metal and nonmetal mining and fuels earnings.

In the mineral manufacturing sector, average weekly hours increased for fertilizers, cement, blast furnaces, steel and rolling mills, and petroleum and coal products. Slight declines in the average work week for petroleum refining and nonferrous smelting and refining were recorded. Overall total manufacturing increased slightly in average weekly hours. Increases in weekly earnings in the nonfuel minerals and fuels manufacturing industries ranged from 5 to 8 percent, no significant change from the 1968 increases. Hourly earnings for this group increased from 5.6 to 7.4 percent. For total manufacturing all industries, the average increase in weekly earnings was 7.6 percent for the second consecutive year.

Labor Turnover Rates.—A mixed pattern was recorded in the accession rates (hires and rehires) for selected mineral industries in 1969. The average labor turnover rates for iron ore, copper ore, and metal mining were up moderately; the rates for petroleum refining and nonferrous smelting and refining were down slightly. The overall accession rate for manufacturing was up slightly. Separation rates for metals were generally down, but the rate was up for petroleum refining and related industries. For selected mineral industries, layoff rates declined except for the manufacturing rate and the nonferrous smelting and refining rate, which were stable.

Wages and Salaries.—Wages and salaries in all industries continued to rise in 1969. For the first time in the 1960's, wages and salaries advanced faster in mining than in the manufacturing industries. Following a 4.9-percent gain in 1968, wages and salaries in mining registered a sharp increase of 10.5 percent for the year. In the manufacturing sector, wages and salaries advanced 8 percent, a slight decline from the previous year; for all industries, wages and salaries gained 9.5 percent. Average earnings per full-time employee in mining rose to $8,587, exceeding the $7,768 received by manufacturing employees and the $7,087 all-industry average. An increase of 7.8 percent in earnings per employee in mining compared favorably with a 5.7-percent increase in manufacturing and a 6.5-percent increase for all industries.

Productivity.—The productivity indexes for 1968 (most recent data available) for the production worker man-hour category showed gains in all the important mining sectors but one. An increase in output per production worker man-hour of 3.4 index points (1957–59 = 100) was registered for crude copper ore in 1968, but for recoverable copper, the index was down 3.6 points. Iron ore, both crude and usable, showed increases in output per production worker man-hour. For crude iron ore the index was up almost 17 points. Bituminous coal and lignite gained over 8 points in output per production worker man-hour.

PRICES AND COSTS

Index of Average Unit Mine Value.—For all minerals the index of average unit mine value increased by 3.9 points in 1969 compared with a 1.1-point increase in 1968. Average unit values for metals and fuels gained almost 5 points each, while nonmetals were up less than 1 point. Among the significant changes in the index was a 13.5-point increase in the base metals, the result of a very successful year for the copper, lead, and zinc industries. In the nonmetals category, the average value for chemicals declined for the first time since 1963. Highlighting the fuels were a continuation of the upward trend in crude oil and natural gas and an impressive rise in the value of bituminous coal.

Index of Implicit Unit Value.—The implicit unit value index was designed to show real price changes and is obtained by dividing the value of mineral production index, using 1967 constant dollars, by the index of physical volume. The resulting index of implicit unit value is a price deflator which may be used to show the relative value of mineral commodities over time. In 1969, the total index registered a moderate increase of 4.3 points. Metals gained sharply for the year, fuels were up moderately, and nonmetals registered a slight rise. Within the metals group, ferrous metals gained 2 points and nonferrous metals increased by over 10 points. The base metals value in the index increased by over 13 points as a result, primarily, of a very sharp rise in value of production of copper and a less sharp rise in production. Monetary and other nonferrous metals declined. Nonmetals had a mixed pattern for the year. In the fuels group crude oil and natural gas and coal recorded gains.

Prices.—Price increases in the mineral industries in 1969 included a slight increase in the price of fuels and moderate gains in the price of selected metals and minerals. Most metal prices were up, especially scrap metal. Nonferrous scrap increased by 25 percent, while the price of ferrous scrap rose by about 19 percent. Other substantial price increases were recorded for both lead and nonferrous metals. Nonmetals showed a mixed pattern. Once again, increases in fertilizer supplies exceeded demand and adversely affected prices. The price of potash fell by over 20 percent, and the price of fertilizer materials overall was off over 16 percent. On the other hand, prices for most building materials showed moderate gains. Prices for fuels and related products and power rose in all categories.

The average cost of coal, residual fuel, and natural gas was unchanged in 1968 (the latest year for which data are available). Natural gas, for the second consecutive year, was the cheapest fossil fuel for power generation in the United States at 24.7 cents per million Btu compared with 25.2 cents for coal and 32.2 cents for oil.

The average cost of electrical energy declined to 1.5 cents per kilowatt-hour in 1968. The New England region, the South Atlantic region, the West North-Central region, and Alaska and Hawaii had slight declines in electrical costs, while the Middle Atlantic region rose slightly. All other regions showed no change. The East South-Central region continued to have the lowest average cost for power in 1968. Cost of electrical energy remained lowest in the commercial and industrial markets at 1.3 cents per kilowatt-hour, and highest in the residential market at 2.1 cents per kilowatt-hour.

Index of Principal Metal Mining Expenses.—Once again higher index values for principal metal mining expenses were reported for the year. Prices of supplies, labor, and fuel increased moderately and accounted for almost all of the gain in the index; electrical energy costs advanced very slightly. Overall, the index was up 4 points in 1969, compared with a 1-point gain in 1968.

Costs.—The indexes of relative labor costs and productivity for selected minerals generally increased in 1969. In the index of labor costs per unit of output, both iron ore and copper costs were up 3 index points. A very sharp rise in copper value of product per man-hour was recorded, while iron ore's value advanced moderately. The index of labor costs per dollar of product increased for iron ore and dropped sharply for copper. Except for portable air compressors, prices of principal mining, construction, and material handling equipment were up in every category in 1969. Prices of construction machinery and mining machinery increased 4.1 and 2.8 percent, respectively. In the specialized categories, oilfield machinery and tools recorded the largest price increase, while power cranes, draglines, shovels, etc., showed the smallest gain.

INCOME AND INVESTMENT

National Income Generated.—National income generated by mining was at a record level of $7.2 billion in 1969, a 5.5-percent increase. Income from both metal mining and coal mining was up substantially, with increases of 9.2 percent and 10.5 percent, respectively. In nonmetallic mining and quarrying, however, income was down 2.7 percent. Income in manufacturing reached a record high of $226 billion in 1969. For stone, clay, and glass products, income was up 9 percent. An 8-percent rise in income was recorded for all industries in 1969.

Profits and Dividends.—The 1969 average annual profit rate on shareholders' equity for manufacturing was 11.5 percent, the lowest since 1964 and a decline from the 1968 figure of 12.1 percent. The profit rate for primary metals was up less than 1 percent, while iron and steel remained at the 1968 level. Primary nonferrous metals were up 1.5 percent, reflecting a generally good year for copper, lead, and zinc. Stone, clay, and glass products remained the same, while chemicals were down to 12.8, the lowest point since 1963, but still the highest profit rate of the selected industries in table 42. Average profits for petroleum refining and related industries declined to 11.7 percent. In general, the profit rate for most industries in table 42 declined or remained the same in 1969 except for the primary nonferrous metals, and consequently the primary metals. Dividends for all manufacturing in 1969 were up 6.1 percent to $15 billion, compared with a 7-percent rise in 1968. Petroleum, chemicals, and primary nonferrous metals showed gains in dividends, while primary iron and steel, and stone, clay, and glass products were down.

In the whole economy, business failures in 1969 were the smallest number in any year since 1953 and 5 percent less than in 1968. Total liabilities, however, were up 21 percent from the 1968 level. In the mining sector there were 23 fewer failures for the year with liabilities of $15,104,000, a decline of almost 50 percent from 1968. Manufacturing liabilities, meanwhile, were up 49 percent for the year, while the number of business failures in manufacturing showed little change.

New Plant and Equipment.—Expenditures for new plant and equipment by mining firms totaled $1.86 billion, up $23 million from 1968. In the manufacturing category, expenditures for primary iron and steel declined. However, primary nonferrous metals, stone, clay and glass products, chemicals and allied products, and petroleum and coal products all recorded gains in new plant and equipment expenditures. Expenditures in the all-manufacturing category increased 12 percent to $31.68 billion.

Plant and equipment expenditures of foreign affiliates of U.S. companies in mining and smelting rose by $190 million to $1.2 billion in 1969, an 18-percent increase. Petroleum expenditures were up to $4.2 billion; manufacturing expenditures increased by 28 percent to $5.3 billion. Each reporting area showed gains in mining and smelting, petroleum, and manufacturing investment for 1969.

Issues of Mining Securities.—Estimated gross proceeds of new corporate securities offered for the extractive industries in 1969 were $1,721 million, considerably more than the $594 million offered in 1968. Over 75 percent of the proceeds in the extractive industry offerings during the year came from common stock, about 22 percent came from bonds, and less than 1 percent came from preferred stock.

Sources and Uses of Funds.—The latest available data at the time of printing on the "Sources of funds of direct foreign investment by U.S. mining and smelting industries" and "Uses of funds for direct foreign investment by U.S. mining and smelting industries" are 1965 figures which have previously been published in the 1967 and 1968 *Minerals Yearbook*. (See tables 44 and 45 in the *1967 Minerals Yearbook* or tables 49 and 50 in the *1968 Minerals Yearbook*). Publication of "Sources and Uses" will be resumed in the *1970 Minerals Yearbook,* using more current data.

Foreign Investment.—At the end of 1968, the book value of direct private investment in foreign petroleum industries was almost $19 billion, a $1.4 billion increase from the beginning of the year. Capital outlays accounted for most of this investment gain. Investment in Canadian enterprises, which has increased every year in the 1960's, grew by about $0.3 billion in 1968. Investments in Latin American and other Western Hemisphere countries, which had registered declines from 1961 to 1967, increased by about $0.2 billion in 1968. In the Middle East, U.S. petroleum investment was up less than $0.1 billion as petroleum exploration activities moved to other areas, notably Africa, which showed the largest area increase of over $0.3 billion. Book value for all industries rose from $59.5 billion to $64.8 billion.

In 1968, the value of U.S. direct investment in foreign mining and smelting industries rose $0.6 billion to $5.4 billion. The value of such investment in Canada increased about $0.3 billion, while investment in Latin America was up almost $0.2 billion. The Latin American increase was concentrated in Mexico, Brazil, Chile, and Peru. During the 1960's the combined Canadian and Latin American share of total U.S. direct investment has consistently been over 70 percent, with Canada's share of the total investment figure exceeding the Latin American share. Both income and earnings rose in 1968, as they have every year in the 1960's except 1961.

TRANSPORTATION

The transportation of selected minerals and mineral energy products by rail and water advanced slightly during 1968 (latest data available). Overall, total mineral products transported by rail and water advanced about 2 percent each in 1968. Except for bauxite and other aluminum ores and concentrates, all selected metals registered slight to moderate increases in quantities transported by rail. Nonmetals had a mixed pattern. Overall, the quantity of selected metals and nonmetals transported by rail was up 2.4 percent for a total of 426 million short tons. Transportaton by water of selected metals and nonmetals increased 4.7 percent to 224 million short tons.

Commodities showing a higher quantity transported by water than rail included gypsum and plaster rock, liquid sulfur, limestone flux and calcareous stone, and crushed and broken stone. Significant changes in table 50 included a 68-percent decline in the amount of other nonferrous ores and concentrates shipped by water. Also, the quantity of dry sulfur transported by water fell over 35 percent.

The greater part of mineral fuels and related products continued to be moved by water in 1968. The quantity of fuels transported by water was up less than 1 percent while rail transport of fuels declined 1 percent. Bituminous coal, crude petroleum, and gasoline continued to account for the majority of mineral energy resources transported by water.

A comparison of rail and water transportation of selected minerals and mineral energy products in 1960 and 1968 indicates no significant change. Most metals continued to be transported by rail throughout the decade. Among the nonmetals, most construction materials relied on rail transportation also. In the minerals fuels, anthracite continued to be transported by rail although the quantity transported in 1968 was only about 50 percent of the 1960 level, owing to declining production. Bituminous coal and lignite utilized rail transportation throughout the 1960's with a moderate increase in quantity transported. The quantity of crude petroleum transported by water gained, while rail transportation of crude petroleum further declined.

Gas pipeline mileage totaled 862,000 miles in 1968 (latest year for which data are available) or 4 percent more than in 1967. Natural gas lines continued to comprise about 99 percent of the total, with the remaining 1 percent divided among manufactured, mixed, and liquefied petroleum gas.

Total petroleum pipeline mileage, recorded at the beginning of 1968 (latest data available) at 210,000 miles, was down slightly less than 1 percent, the first reduction in the last four decades. Total pipeline fill at the beginning of 1968, at 104.6 million barrels, was 3.9 percent greater than that reported for 1965. This was a markedly lower increase than that shown for 1962–65. Of the total petroleum pipeline mileage reported in 1968, 35 percent was in crude gathering systems in field operations, 34 percent in larger size crude trunklines, and 31 percent in petroleum product pipelines that extend from refineries to distribution terminals.

RESEARCH ACTIVITIES

Data on national expenditures for research and development activities in selected industries in 1967 (latest year for which data are available) showed that chemicals and allied products accounted for 9.5 percent of total funds expended. Petroleum refining and extraction accounted for 2.9 percent of the total, slightly more than in 1966. Federal funds in 1967 made up slightly under 15 percent of the total spent for chemicals and allied products research, and slightly under 10 percent of that expended on petroleum refining and extraction research. Only about 3.0 percent of Federal funds available for industrial research was spent on research related to the chemical industry and the petroleum industry. Of this amount, 2.5 percent was expended for chemicals and allied products research, and 0.5 percent on petroleum refining and extraction.

Bureau of Mines.—During 1969 the Bureau of Mines continued its work on research problems under established programs for minerals and mineral fuels research and resource development. Emphasis again was placed on insuring adequate mineral supplies at reasonable cost to the consumer with no sacrifice in environmental quality. Research projects concentrating on waste recycle were stressed by the Bureau in recognition of the increasing urgency of many problems of an environmental nature. Health and safety research received renewed incentive with the passage into law of the Federal Coal Mine Health and Safety Act. Bureau efforts continued to stress an inherently safer, economic, and environment-preserving technology for the mining of coal. Mining and metallurgical research continued to explore new technologies for recovery and utilization of our national mineral resources. Research continued in petroleum and coal research to meet expanding energy requirements with dependable low-cost fuel supplies. In economic studies, environmental projects as well as supply and demand studies received special attention.

Bureau of Mines funding obligations for mining and mineral research and development totaled $46.0 million for fiscal year 1970. Fifty-nine percent of this amount was allocated to applied research, 14 percent to basic research, and 27 percent to development. Total research funds of $33.5 million obligated by the Bureau for fiscal year 1970 were divided as follows: engineering science, $23.7 million; physical sciences, $7.5 million; mathematical sciences, $0.6 million; and environmental sciences, $1.8 million.

Highlights of the accomplishments of Bureau research programs, including work in progress, follow.

Mining Research.—In 1969 research efforts to minimize the hazard of explosive methane in coal mines produced techniques for laboratory simulation of underground conditions that govern methane desorption from coal. In an experiment in which boreholes were drilled vertically from the surface to remove large volumes of methane from gob areas formed by an advancing longwall face, concentrations of the explosive gas in the mine atmosphere were reduced sufficiently to permit an additional daily operating shift. Sealing abandoned coal workings to exclude air was shown to be a promising method, in certain conditions, of reducing water pollution from acid mine drainage. In an experiment in which a small abandoned mine was air-sealed, the sulfuric acid in the discharge was reduced by the equivalent of 15 tons per year.

Field tests were completed and engineering criteria and instrumentation developed to relate structural damages to ground vibrations caused by nearby blasting operations. This information will enable local governments to formulate blasting codes to protect residential and commercial properties and permit mining and construction organizations to devise means of utilizing explosives to minimize damage. Microseismic equipment and techniques were developed to detect and locate high-stress areas in rockburst-prone mines. The procedure makes it possible for mining companies to locate stress concentrations and implement destressing operations to prevent dangerous rockbursts. Studies to relate rock properties and behavior to the application of various forms of energy yielded basic information needed to advance the technology of rock breaking.

As a result of a 3-year research effort, a system of television camera and calibration probe was developed to locate, measure, and monitor subsurface movements in vertical drill holes. The technique will permit early detection of ground movements and enable mine operators to devise improved safety measures.

In marine mining, the order of priorities for research was reexamined. As a result, emphasis was shifted to the problems of predicting and preventing environmental disturbances that may be caused by mining as it develops off U.S. shores. Since considerable information and data needed to be developed to provide a basis for research in this area, the major research activities during the year continued to deal with the problem of accurately sampling and characterizing seafloor mineral deposits. Inhouse research into drill sampling and geophysical characterization of seafloor deposits was augmented by cooperative efforts with industry and universities.

Metallurgy Research.—The Bureau's electrooxidation process for recovering gold from the carbonaceous gold ores of Nevada was extended to mercury recovery from ores containing as little as 0.6 pound of mercury per ton of ore. The new mercury process eliminated the roasting step in conventional mercury ore processing by electrolytically oxidizing the insoluble mercury sulfides to the soluble oxide form from which elemental mercury is precipitated with zinc. The electrooxidation step permitted mercury recoveries of greater than 90 percent from ores previously too lean for economic processing. Not only did the new process appear to be more economical and efficient than the older roasting technique, but it also greatly reduced the dangers of salivation of workers in the mercury industry and eliminated the production of SO_2, an atmospheric contaminant. Preliminary work on low-grade silver ores indicated that electrooxidation may also permit much higher silver recoveries from these ores than conventional processing.

An important new antipollution process for removing and recovering sulfur from dilute copper smelter stack gases was developed and is currently undergoing pilot plant testing at a large Arizona smelter. In the initial part of the process, particulate matter and sulfur trioxide were cleaned from the stack gas. The sulfur dioxide in the gas was then absorbed in sodium acid citrate solution. The clean gas discharged from the absorption tower met even the most demanding of air quality standards.

As part of the Bureau's continuing research on developing new electrolytic reduction techniques for preparing high-purity rare-earth metals and alloys, a samarium-cobalt intermetallic compound was prepared. The compound was suitable for use in permanent magnets and had a magnetic strength at least five times that of conventional Alnico magnets of similar size and geometry. Replacement of Alnico magnets with much smaller rare-earth magnets of equal magnetic strength could, in the near future, lead to the production of electric motors that are one-quarter their present size.

Research was undertaken to develop a continuous process for making steel in electric furnaces to replace the present batch process. Both power and heat losses were minimized by the development of a heat exchanger using only the heat from furnace off-gases to preheat the scrap charge. Preheating also decreased the tap-to-tap time of the furnace, thus permitting increased steel output and lower costs per ton of metal produced. For direct steelmaking prereduced iron ore pellets must have less than 3 percent silica, which is much lower than the silica levels resulting from the prereduction of normal oxide pellets. Using conventional beneficiation techniques, the Bureau developed a method for producing iron concentrates with 2 percent silica from the magnetic iron concentrates generated during conventional taconite processing. Use of these low-silica concentrates in direct steelmaking, such as in the BOF or electric furnace, represents a potential savings of 5 to 10 percent in operating costs, and an estimated one-third reduction in capital costs for most steelmakers.

Waste Recycling Research.—Undesirable air and land pollution problems associated with the more than 200 million tons of waste tailings generated by the base metals industry each year have been partially solved by the development of new stabilization techniques. The Bureau demonstrated that the tailings ponds can be restored to productive land with chemicals, vegetation, or combinations of both. Stabilization procedures that encourage the growth of grass, coniferous trees, and other vegetation have been developed and found effective for preventing wind and water erosion. In an effort to combat the pollution from stack gas discharges from the basic oxygen and electric steel furnace and to recover the valuable constitutents contained in the dusts, the Bureau has developed techniques for recovering the nonferrous elements in the dusts and for preparing a purified iron oxide for recycle to the ironmaking process. The value of the recovered base metals alone should pay for much of the cost of this operation. The urban waste utilization research for recovering and recycling the metal, mineral, and energy values contained in municipal incinerator residues has progressed to the point where the Bureau's separation pilot plant is being proposed as a national prototype installation. The pilot plant was designed to process up to 1,000 pounds of refuse per hour, separating the material into metallic iron concentrates, clean nonferrous metal composites, clean fine glass fractions and fine carbonaceous ash. All of these components can be reprocessed and reused in various forms.

The Bureau's smokeless automobile incinerator has undergone testing to determine optimum operating conditions and material and cost balances. The incinerator was built to process two cars at a time, and preliminary tests indicate a 52-car capacity per 8-hour work shift. The smoke normally associated with automobile incineration is absent in the Bureau incinerator because all unoxidized material is completely burned with natural gas in an afterburner operating at 1,350° F. Moreover, the incinerator allows smokeless burning of hard-to-burn materials, including insulated copper wire. The installation costs less than $25,000, maintenance is minimal, and the cost to incinerate one car is estimated at only $2.25. In cooperation with a major U.S. rubber company, the Bureau developed a process by which scrapped automobile tires may one day become a source of valuable products, heat, and power. In this work surprisingly large quantities of chemicals, oil, gas, and tar were produced by the pyrolysis of shredded tires.

Based on a Bureau technique developed to convert lignite to oil, carbon monoxide and steam were applied under pressure to transform garbage into a petroleum-like liquid. In early tests at 5,000-pounds per square inch gage (p.s.i.g.) pressure and 380° C, the organic content of garbage was converted, to the extent of 90 percent, to a benzene-soluble product and water. In related work, destructive distillation (also known as carbonization) was used effectively to produce oil, gas, and a residual char from municipal wastes. In one test, charged wastes were converted to products, which in addition to the residual char amounted to 55 percent liquor, 3 percent tar and light oils, and 27 percent gas. The available heating value of the gaseous component was equivalent to 4 million Btu per ton of treated waste—more than enough heat to make the process thermally self-sustaining.

A new technique was developed to recover gold from scrap electronic solders. Small amounts of aluminum were added to the molten solder to form a separable solid phase. Over 99 percent of the gold contained in the scrap solders was recoverable by conventional base-bullion treatment of the separated phase.

Coal Research.—In 1969 progress was achieved in several areas of coal gasification. For example, the first successful test was completed with the Bureau's fixed-bed pressurized gas producer, operating with a strongly caking coal feed. This test involved conversion of Pittsburgh seam coal into a gas rich in hydrogen and carbon monoxide. In other coal gasification work, successful operation of the new 40-atmosphere pilot plant produced a methane-containing gas, capable of catalytic enrichment to the methane content level of natural gas. Future plans encompass the design, construction, and operation of a prototype semicommercial coal-to-gas plant, having a production capacity of 2.5 million cubic feet per day of high-Btu gas. In a third Bureau gasification research effort, experiments revealed that coal could be acceptably converted to pipeline gas by hydrogasification under a pressure of 1,000 p.s.i.g.—a pressure one-third as low as that found to be essential in previous tests.

In work directed toward improving the quality of air, continuing exploratory tests showed that complete removal of sulfur oxides as well as 75 percent of the equally objectionable nitrogen oxides could be accomplished by injection of ammonia into a stream of synthetic flue gas, which was then water scrubbed. Sufficient interest was generated to warrant consideration of expanding this investigation to a pilot-scale operation. In related work two catalysts, nickel oxide and zirconium oxide, successfully removed 100 percent of the nitric oxide from a simulated flue gas comprised of nitrogen, oxygen, carbon dioxide, water vapor, and nitric oxide. With the nickel oxide catalyst, however, the presence of sulfur dioxide in the simulated flue gas reduced catalyst effectiveness and interfered with its regeneration. In the study of fouling characteristics of U.S. coals, samples of a variety of Illinois bituminous coals were burned in the Bureau's 75-pound-per-hour furnace to compare their ash deposition behavior with that of North Dakota lignites. It was found that the deposition rate of "fouling" bituminous coal was half that of "fouling" lignite, indicating the more serious nature of the problem with respect to lignite combustion.

In work applicable to monitoring dusty atmospheres, Bureau research successfully utilized a laser beam to count the number of dust particles having a size range of 1 to 10 microns and less. A monitoring unit with such capability will have increasing importance in analyzing coal mine atmospheres and other dust-laden environments. Research progress was also made during the year in the area of combustion of pulverized coal and char. Base tests with bituminous coal were completed in the Bureau's 500-pound-per-hour experimental furnace, and combustion efficiencies as high as 98 percent were obtained. In firing with char having a 3-percent volatile content, it was found necessary to supplement this volatile with natural gas—to the extent of 25 percent of the total heat input—to maintain stable combustion.

Investigative research was conducted on the operation of the Bureau's magnetohydrodynamics (MHD) combustor with K_2CO_3 seed added to the combustion products. Spent seed regeneration was under study on the premise that if regeneration could be accomplished before the seed is recycled to the magnetohydrodynamics generator, the effluent gas from the magnetohydrodynamics-topped power plant would be sulfur free. During the year regeneration of spent seed with a reducing gas of $4H_2/CO_2$ composition in a differential reactor produced sulfur conversion as high as 91 percent, considerably higher than earlier test yields.

Petroleum Research.—In nuclear projects a 6-month flow test was completed on Project Gasbuggy, bringing the total number of cubic feet of gas produced during flow tests from this project to 200 million. Project Gasbuggy was the first experimental use of a nuclear device to stimulate gas production in tight formations. The nuclear device for Project Rulison was successfully detonated in September 1969. Rulison was the first test of the commercial feasibility of nuclear devices to develop large natural gas resources that cannot be recovered economically by present production methods. Two nonnuclear explosive fracturing tests in a shallow gas-producing formation in Oklahoma were successfully completed in cooperation with an oil company. This research is aimed at making economically available those gas resources in tight formations too shallow for nuclear stimulation.

A rapid, inexpensive technique for applying information on surface-joint and fracture orientations to petroleum exploration was developed during 1969. Examination of the surface-fracture patterns and the location of completed oil and gas wells led to the conclusion that the better wells are located at the intersection of several surface-fracture zones. It was further shown that well-bore fracture orientations correlated with surface-fracture orientations.

Results of that research on asphalt led to an expanded program that includes cooperative projects supported by the Bureau of Public Roads, U.S. Department of Transportation. The expanded program is to include a study of the interaction between paving asphalts and the types of rock aggregate commonly used in paving mixes. A new technique, developed during the past year, led to substantial progress in understanding the chemistry of asphalt interactions observed earlier while using Inverse Gas Liquid Chromatography (IGLC). The IGLC method was previously developed by the Bureau to obtain empirical correlation between certain asphalts and their durability in use. Seventy-five out of a total of 160 oilfield brine samples from various oil-productive basins of the United States were analyzed as part of a cooperative water pollution study for the Oklahoma Corporation Commission. The remainder of the samples were studied to determine if they contained minerals which might be economically recovered.

Work was completed and a publication prepared on computerized methods of obtaining data for making an economic analysis of potential waterflooding operations in an oilfield. Also completed was a supplement to the decks of crude oil analysis automatic data processing cards to make available in coded form analytical data accumulated through 1967.

Oil Shale Research.—Research by the Bureau on the feasibility of retorting oil shale in situ entered a new phase with a successful demonstration at a site near Rock Springs, Wyo. The oil shale zone at this site had been prepared by a combination of fracturing techniques. At the termination of the experiment, the volume of oil recovered was increasing and percent oxygen utilization was improving daily. Approximately 190 barrels of shale oil were collected for analysis. Other in situ research was highlighted by successful completion of the first two runs of a new 150-ton batch retort in which ungraded oil shale ranging up to 4-ton blocks was retorted with oil recovery reaching 62.2 percent of Fischer assay. This retort simulated conditions expected in a nuclear fractured oil shale bed. Research also continued on characterization of shale oil fractions and on the minerals associated with oil shale. Completion of a study of a Coloredo core produced results indicating that the conditions causing diagenesis were sufficiently great to remove functional groups from the kerogen and soluble extract, but not great enough to remove hydrogen from hydroaromatic structures or to cleave carbon-carbon bonds in significant amounts. New research aimed at environmental problems associated with conventional mining and aboveground retorting of oil shale was initiated. This research included composition studies of retort waters and conditioning and vegetation studies on spent shale piles.

The Bureau also provided technical and other assistance in connection with a proposed new Departmental program to permit leasing of a number of tracts of public oil shale lands in Colorado, Utah, and Wyoming. This program, still in its planning stages, was expected to provide material encouragement toward development of an oil shale industry under conditions that ensure full protection of the environment.

Economic Studies.—The Bureau continued to emphasize analysis of the economic forces within the mineral industry and of the economic relationship between the industry and the national economy.

Results of studies completed in 1969 included the final publication in the series of studies on energy balance, a study of the natural gas liquids industry, and a study of the demand for steel by each of its major end uses.

Several environmental impact projects were completed in 1969, including a study undertaken by contract to provide a computer model that estimates costs of not conserving sand, gravel, and crushed stone resources. In addition, several studies were made on the probable impact of the recently passed mine safety act on industrial and social costs. Work continued on input-output tables in the Bureau with special emphasis on "multipliers" that permit estimation of the impact of additional mineral consumption on the national economy.

Among the research projects recently completed by contract were an analysis of the mineral industry's impact on the United States balance of payments, an empirical and theoretical study of the modern exploration process, and a study of mineral price behavior.

Health and Safety.—As a result of the explosion at the Consol No. 9 mine in West Virginia, major efforts were directed towards eliminating hazards in coal mining, especially fires and explosions, falls of roofs, and injurious respirable dust produced in mining. Because of increased mechanization to meet ever-increasing demands and a minimal level of research effort in the past to develop the technology to cope with the resulting problems, health and safety hazards in coal mining are numerous and severe. The Federal Coal Mine Health and Safety Act of 1969 stipulated concerted research to provide more effective means to improve the working conditions in the Nation's coal mines. A significant increase in effort was planned for immediate implementation.

During the year, a systems engineering firm was granted a contract to conduct a study on the status of coal mining technology and needs for research, with primary emphasis on health and safety. A 1-year study on post-disaster survival and rescue techniques was undertaken for the Bureau of Mines by the National Academy of Engineering to develop a research program to improve rescue techniques and to increase the prospects for survival of trapped mine workers.

Inhouse research was conducted on the formation, nature, behavior, detection, and control of respirable dust; the prevention and quenching of gas/dust explosions; roof control measures; development of improved instrumentation for detection and measurement of hazardous atmospheric conditions in mines; development of improved analytical methods and techniques for toxic and other hazardous constitutents that may be encountered in mines; and development of portable instruments for determining the incombustible content of coal dust.

Explosives and Explosions Research.—The development of new low-cost explosives from ammonium nitrate continued to be a major area of research. Slurries were formulated which met schedule standards for gassy mines, and which could be stored for several months. Two of the slurries were pumpable, and two were rigid enough for packaging. Experiments to compare the action of various commerical extinguishants with that of rock dust in inhibiting coal mine fires were initiated. Progress continued in elucidating combustion mechanisms of individual coal particles and of coal dust-methane-air dispersions. In continuing research on mechanisms controlling deflagration, a good experimental correlation was obtained for theoretical concepts of low-velocity detonation developed earlier.

In the first of two investigations completed for the National Aeronautics and Space Administration, the thin films deposited by hydrazine/hydrazine nitrate solutions on the walls of Apollo attitude control engines were found to contribute significantly to "hard start" problems in these engines. In the second, the detonability of gaseous nitric oxide was investigated at pressures up to 1,000 pounds per square inch gage. Hazards associated with the marine transport of liquefied natural gas and of liquid chlorine were investigated for the U.S. Coast Guard.

Helium Conservation.—The helium conservation program in 1969 stressed the maximum beneficial use of helium resources in the United States for production and sale of helium for current use, the acquisition and storage of helium that would otherwise be wasted when helium-bearing natural gas is used for fuel, and helium-oriented research and development. Acquisition and storage of helium is aimed at assuring a reserve supply after presently known helium resources are depleted. Research is presently focused on improving processes and reducing costs of helium analysis, extraction, and purification, and on improving liquid-helium handling technology.

LEGISLATION AND GOVERNMENT PROGRAMS

Legislation of interest to the minerals industry in 1969 centered principally around the Tax Reform Act and the Federal Coal Mine Health and Safety Act. Following an 11-month discussion, Congress, in overhauling the Nation's tax structure, reduced the mineral industry's long-standing depletion allowance. In the case of oil and gas, the depletion allowance was cut from 27.5 to 22 percent. The rate for sulfur, uranium, and strategic minerals was reduced from 23 to 22 percent. Minerals previously allowed 15 percent were cut to 14 percent with certain exceptions. The depletion allowance for minerals which previously had an allowance under 15 percent remained unchanged. Another part of the Tax Reform Act was the repeal of the 7-percent investment tax credit for business equipment purchases, retroactive to April 1969.

The Farmington, W. Va., mine disaster in late 1968 claimed 78 lives and set the stage for intense interest in a mine safety bill. Enacted in December 1969, the law has not been in force long enough to judge its effectiveness; however, its provisions are generally regarded as setting strict standards for mine safety. Highlighting the law are provisions which place limits on the amount of coal dust in the atmosphere of underground mines, provide strict safety standards for underground mine equipment, require compensation for miners disabled by pneumoconiosis, and authorize Federal funds for mine health and safety research. The new law also requires Federal health and safety inspections to be made by the Bureau of Mines and imposes fines for violations of the act.

Congress passed the National Environmental Policy Act late in 1969, and the bill was signed into law on January 1, 1970. A prominent feature of the law was the establishment of a Council on Environmental Quality with responsibilities to develop new environmental programs and see that all Federal Government agencies examine the environmental impact of their programs. The President submitted to Congress a trade bill that would restore Presidential power to make limited tariff reductions. The bill envisioned elimination of the American selling price (ASP) system in which certain duties are based on the domestic selling price of competing U.S. products. Also during 1969 a bill was introduced and passed in the Senate to establish a national mining and minerals policy. Besides encouraging the development of an economically sound domestic minerals industry and providing direction in the management of mineral resources, the bill would require an annual report on the status of the domestic minerals industry by the Secretary of the Interior.

Regarding the national stockpile program during 1969, the acquisition cost of strategic materials totaled $6.6 billion, down slightly from the 1968 figure, and the market value amounted to $7.2 billion. Inventories considered in excess of conventional stockpile needs were valued at $2.84 billion at cost and $2.76 billion at estimated market value. Twelve materials accounted for 80 percent of the market value of the stockpile excesses, and this group included aluminum, metallurgical-grade bauxite (Jamaica and Surinam), metallurgical-grade chromite (upgraded forms and subspecification ores), cobalt, industrial diamond stones, lead, metallurgical-grade manganese, quartz crystals, tin, tungsten, and zinc. Congress authorized the disposal of 100,000 short tons of excess lead with a market value of $30 million. Major mineral stockpile items sold in 1969 were tungsten, aluminum, silver, cobalt, molybdenum, magnesium, and nickel. In all, $327 million of mineral commodities were disposed of in calendar year 1969, a 77-percent increase from the 1968 figure.

Continued exploration for new domestic sources of strategic and critical mineral commodities was encouraged under a program of Federal financial assistance administered by the Office of Mineral Exploration (OME). During 1969, 12 contracts representing Government funding of $0.3 million were executed. Gold, silver, mercury, copper, and uranium were the principal commodities toward which the program was directed. Initiated on the behalf of small mine operators, the OME program has been an important factor in maintaining adequate supplies of vital minerals.

WORLD REVIEW

World Economy.—Although the gross national product (GNP) in the major industrial countries continued to rise in 1969, rates of growth varied considerably. In the United States, GNP was up 7.7 percent, but a very large part of this gain resulted from a rise in price (real GNP grew by 3 percent). Among the Western European countries, Germany and France registered striking increases in real GNP of over 8 percent (France's increase partly reflected strikes in 1968). On the other hand, the United Kingdom's increase in real GNP was approximately 2 percent. Increases in industrial production also ranged from moderate increases for the United States and Canada to more substantial increases for West Germany and Japan.

World Production.—World output of minerals and mineral fuels generally increased in 1969. In the mineral fuels sector, total output of crude petroleum climbed to 15.2 billion barrels, an 8.1-percent increase from 1968. Total natural gas output advanced to 34 trillion cubic feet, a 9.6-percent gain. World production of principal nonmetals also generally increased in 1969. Among metallic ores, total copper output reached 6.7 million short tons, a 13-percent increase, and iron ore production totaled 713 million long tons, a 6.3-percent increase. On a smelter basis, world production of copper was up 7.3 percent, and pig iron gained 8.2 percent. A sharp increase in world lead production (14 percent) brought total lead output (on a smelter basis) to 3.7 million short tons.

The U.S. share of metallic ore production in 1969 generally declined. The percent of total copper ore and total lead ore produced by the United States increased, however. Nonmetals and fuels supplied by the United States, as compared to world output, continued to decline.

World Trade.—In 1968 (latest data available) the value of world trade for all commodities reached $238.7 billion, an 11.4-percent increase for the year. Mineral commodities accounted for 21.6 percent of this total figure or $51.5 billion. Trade in the mineral fuels group rose 11 percent to $23 billion; trade in the metals category increased 13 percent to $26.5 billion. The crude nonmetals group increased 5.5 percent to $2.1 billion. Among mineral commodities, the greatest percentage increase in trade was the 18-percent advance in the nonferrous metals group. The value of major mineral commodities exported from the United States in 1968 totaled $3.2 billion while imports reached $7.7 billion.

World Prices.—Following a 2-year decline, overall export prices for crude minerals increased by two index points in 1969. No change was recorded in the fuels component of the index. However, the index registered a gain of six index points in the price of metal ores. Export prices for total minerals increased slightly in less developed areas in 1969, while the more developed nations recorded a moderate increase. For both the more developed and less developed areas, nonferrous base metal prices increased substantially for the year.

Table 1.—Value of mineral production, imports, and exports by groups

(Millions)

Mineral group [1]	1965			1966			1967		
	Production	Imports	Exports	Production	Imports	Exports	Production	Imports	Exports
Metals and nonmetals except fuels:									
Nonmetals	$4,933	$354	$185	$5,176	$412	$228	$5,206	$414	$241
Metals	2,544	973	154	2,703	1,192	158	2,333	1,117	171
Total	7,477	1,327	339	7,879	1,604	386	7,539	1,531	412
Mineral fuels	14,047	1,295	487	15,088	1,311	490	16,195	1,289	601
Grand total [2]	21,524	2,622	826	22,968	2,915	876	23,734	2,820	1,013

Mineral group [1]	1968			1969		
	Production	Imports	Exports	Production	Imports	Exports
Metals and nonmetals except fuels:						
Nonmetals	r $5,448	$490	$246	$5,625	$489	$220
Metals	2,703	r 1,161	241	3,338	1,089	246
Total	r 8,151	r 1,651	487	8,963	1,578	466
Mineral fuels	16,820	r 1,309	r 539	17,965	1,428	632
Grand total [2]	r 24,971	r 2,960	r 1,026	26,928	3,006	1,098

r Revised.
[1] For details, see the "Statistical Summary" chapter of this volume.
[2] Data may not add to total shown because of rounding.

Table 2.—Value of mineral production by group, 1967 constant dollars [1]

(Millions)

Mineral group	1965	1966	1967	1968	1969 p
Metals and nonmetals except fuels:					
Nonmetals	$5,096	$5,320	$5,200	$5,373	$5,504
Metals	2,644	2,801	2,333	2,574	2,970
Total	7,740	8,121	7,533	7,947	8,474
Mineral fuels	14,467	15,318	16,195	16,753	17,061
Grand total	22,207	23,439	23,728	24,700	25,535

p Preliminary.
[1] Value deflated by the index of implicit unit value.

Table 3.—Indexes of the physical volume of mineral production by group and subgroup [1]

(1967 = 100)

	1962	1963	1964	1965	1966	1967	1968	1969 p
METALS								
Ferrous	82.8	87.5	98.9	100.9	109.2	100.0	102.4	111.1
Nonferrous:								
Base	118.0	118.0	123.0	132.7	138.4	100.0	120.4	149.6
Monetary	103.7	98.9	101.0	115.0	123.9	100.0	97.1	115.5
Other	113.0	100.3	101.4	89.8	90.4	100.0	113.9	109.9
Average	115.6	113.0	117.6	125.6	131.0	100.0	117.6	141.6
Average, all metals	99.4	100.9	109.0	114.5	121.2	100.0	110.8	127.9
NONMETALS								
Construction	86.1	90.1	96.1	100.6	103.2	100.0	104.6	106.2
Chemical	66.1	69.5	76.3	87.8	97.0	100.0	98.9	101.1
Other	81.4	85.9	91.3	97.2	105.2	100.0	106.5	106.5
Average	81.5	86.0	91.5	97.6	101.9	100.0	103.4	105.1
FUELS								
Coal	78.9	85.6	90.1	93.7	96.9	100.0	98.5	98.5
Crude oil and natural gas [2]	81.8	84.7	86.4	88.5	94.3	100.0	104.2	106.6
Average	80.7	84.4	86.7	89.2	94.5	100.0	103.4	105.7
Average, all minerals	82.4	86.2	89.8	93.5	98.7	100.0	104.1	107.6

p Preliminary.
[1] Rebased and reweighted using 1967 data. Splicing period was 1962–64.
[2] Does not cover isopentane, LP gases, and other natural gas liquids.

Table 4.—Federal Reserve Board indexes of industrial production, mining and selected mineral and mineral fuels related industries

(1957–59 = 100)

	1965	1966	1967	1968	1969 p
Mining:					
Coal	113.3	117.0	120.4	118.2	117.7
Crude oil and natural gas:					
Crude oil	111.9	119.3	126.3	130.5	132.0
Gas and gas liquids	143.0	152.0	163.5	174.5	184.0
Average [1]	112.3	118.0	123.1	126.8	129.3
Average coal, oil, and gas	112.5	117.8	122.7	125.3	127.4
Metal	124.2	133.4	120.3	126.4	142.0
Stone and earth minerals	126.5	133.5	135.4	137.8	144.7
Average	125.5	133.5	128.9	132.9	143.5
Average mining	114.8	120.5	123.8	126.6	130.2
Industrial production:					
Primary metals	137.6	142.7	132.5	137.0	149.1
Iron and steel	133.6	136.2	126.8	130.7	140.3
Nonferrous metals and products	152.2	166.2	153.2	160.0	181.1
Clay, glass, and stone products	133.5	140.7	138.7	146.2	156.0
Average industrial production	143.4	156.3	158.1	165.5	172.8

p Preliminary.
[1] Includes oil and gas drilling.

Source: Board of Governors of the Federal Reserve System. Federal Reserve Bulletin. February–June 1970. A description and historical data are available in Business Indexes, Industrial Production, 1957–59 Base, published monthly by Federal Reserve Board.

Table 5.—Federal Reserve Board monthly indexes of mining production, seasonally adjusted

(1957–59 = 100)

Month	Total mining [1]		Coal, oil, and gas		Coal		Crude oil and natural gas: Total [2]		Crude oil and natural gas: Crude oil		Crude oil and natural gas: Gas and gas liquids [3]		Metal, stone and earth materials		Metal mining		Stone and earth materials	
	1968	1969	1968	1969	1968	1969	1968	1969	1968	1969	1968	1969	1968	1969	1968	1969	1968	1969
January	121.6	125.8	121.9	122.4	113.4	115.3	123.6	123.9	127.4	124.0	NA	NA	120.3	142.1	100.0	140.2	135.3	143.5
February	123.9	124.8	123.2	120.2	116.8	112.4	124.5	121.8	129.7	124.0	NA	NA	127.0	146.4	102.8	142.7	145.0	149.2
March	126.2	126.7	126.0	121.9	126.0	114.3	126.0	123.5	130.9	127.0	NA	NA	127.4	149.9	108.7	149.1	141.2	150.5
April	127.1	128.8	124.7	125.7	124.4	120.2	124.8	126.9	128.7	130.2	NA	NA	138.3	143.6	139.9	146.6	137.1	141.4
May	126.9	130.3	125.6	128.7	120.4	123.9	126.6	129.6	131.2	133.1	NA	NA	133.5	138.3	131.4	134.5	135.0	141.2
June	129.2	134.4	128.1	133.1	126.7	124.8	128.4	134.8	132.4	139.2	NA	NA	134.3	140.4	130.8	137.4	136.9	142.6
July	130.0	133.2	128.7	131.7	126.6	130.0	192.2	132.1	134.0	135.5	NA	NA	135.8	140.5	134.1	138.1	137.1	142.2
August	129.4	131.2	127.9	128.8	121.8	122.1	129.3	130.2	134.8	132.4	NA	NA	136.2	142.6	134.5	142.3	137.5	142.8
September	127.0	131.6	125.8	129.9	120.8	114.7	126.8	133.1	131.2	135.6	NA	NA	132.8	139.5	127.7	133.1	136.5	144.3
October	120.7	130.2	118.9	128.1	86.6	115.7	125.5	130.7	129.1	132.8	NA	NA	129.2	140.2	125.1	141.1	132.2	139.6
November	126.4	132.0	124.6	129.1	115.9	118.9	126.3	131.2	128.6	133.5	NA	NA	135.3	149.6	135.1	153.3	135.5	146.8
December	127.4	134.4	124.2	130.3	118.3	119.3	125.4	132.6	126.4	135.0	NA	NA	143.0	153.7	137.6	152.3	147.0	154.8
Average	126.6	p 130.3	125.3	p 127.5	118.2	p 119.3	126.8	p 129.2	130.5	131.9	174.5	p 184.0	132.9	p 143.9	126.4	p 142.6	137.8	p 144.9

p Preliminary. NA Not available.
[1] Including fuels.
[2] Total includes oil and gas drilling.
[3] Source no longer publishes monthly figures.

Source: Board of Governors of Federal Reserve System. Federal Reserve Bulletin, March 1969–April 1970.

Table 6.—Production of mineral energy resources and electricity from hydropower and nuclear power

(Trillion Btu)

Year	Anthracite	Bituminous coal and lignite	Natural gas, wet (unprocessed)	Crude [1] petroleum	Electricity [2]		Total
					Hydropower	Nuclear power	
1965	378	13,417	17,652	15,930	2,051	39	49,467
1966	329	13,988	18,894	16,925	2,062	58	52,256
1967	311	14,479	20,087	18,098	2,344	81	55,400
1968	291	14,279	21,548	18,593	2,352	132	57,195
1969 p	277	14,569	23,008	18,780	2,687	141	59,462

p Preliminary.

[1] Heat values employed for crude petroleum are 1965, 5,531,000 Btu; 1966, 5,257,440 Btu; 1967, 5,628,540 Btu; 1968, r 5,585,016 Btu; and 1969, 5,582,640 Btu.

[2] Hydropower and nuclear power include installations owned by manufacturing plants and mines as well as Government and privately-owned public utilities. The fuel equivalent of hydropower and nuclear power is calculated from the kilowatt-hours produced, converted to theoretical energy resources inputs calculated from prevailing average heat rates at central electric stations using 10,530 Btu per kilowatt-hour in 1965, 10,586 Btu in 1966, 10,582 Btu in 1967, 10,582 Btu in 1968, and 10,712 Btu in 1969.

Table 7.—Consumption of major mineral products, mineral fuels, and electricity, 1968, 1969, and projections

Commodity	1968	1969 p	Projections [1]	Average annual growth rate 1947–65 (percent)
MINERAL PRODUCTS				
Ferrous metals:				
Iron ore ... thousand long tons	131,753	140,235	240,000–330,000	+0.8
Raw steel (production) ... thousand short tons	131,462	141,262	NA	+1.5
Chromite ores (gross weight):			3,150–4,700	
Metallurgical grade ... do	804	898	NA	+4.0
Refractory grade ... do	311	302	NA	+ .8
Chemical grade ... do	202	211	NA	+2.0
Manganese ore (35 percent or more Mn) ... do	2,228	2,181	3,400–4,300	+1.9
Molybdenum (Mo content) ... thousand pounds	49,271	51,622	150,500–206,500	[2] +5.2
Tungsten (W content) ... do	11,038	13,053	60,000–93,000	+3.6
Nonferrous metals:				
Aluminum (apparent consumption) ... thousand short tons	4,662	4,660	22,400–44,400	+7.4
Antimony, primary ... short tons	18,520	17,843	28,000–52,000	−1.5
Copper, refined [3] ... thousand short tons	1,880	2,142	8,950–14,350	+1.0
Lead, primary and secondary ... do	1,329	1,389	2,520–4,140	.0
Zinc, all classes ... do	1,728	1,797	2,460–4,700	+1.3
Mercury, primary ... 76-pound flasks	75,422	79,104	120,000–180,000	+3.4
Platinum-group metals ... thousand troy ounces	1,368	1,357	2,315–4,195	+6.9
Silver (industrial consumption) ... do	145,293	141,546	280,000–560,000	NA
Ilmenite and titanium slag (estimated TiO_2 content) ... short tons	610,944	639,822	1,800,000–4,300,000	+4.8
Uranium (U_3O_8 content, production) ... do	12,338	10,934	72,000–81,000	+4.9
Nonmetals:				
Asbestos (apparent consumption) ... thousand short tons	817	784	1,285–1,865	+ .8
Cement (production) ... million barrels	403	408	NA	+3.7
Clays (apparent consumption) ... thousand short tons	57,348	58,694	136,500–203,500	+2.1
Lime (sold or used) ... do	18,637	20,209	NA	+5.3
Phosphate rock (P content, apparent consumption) ... do	3,475	3,502	8,800–15,500	+4.9
Potash (K content, apparent consumption) ... do	3,600	3,901	8,500–15,500	+6.4
Salt (apparent consumption) ... do	44,002	46,831	NA	+4.6
Sand and gravel ... million short tons	917	937	3,153–3,990	[4] +4.2
Stone, crushed (sold or used) ... do	820	863	2,460–4,025	+8.1
Sulfur, all forms (apparent consumption) ... thousand long tons	9,007	9,175	23,000–37,000	+3.0
MINERAL ENERGY RESOURCES AND ELECTRICITY				
Bituminous coal ... million short tons	499	507	1,275–2,639	−1.1
Coal carbonized for coke [5] ... do	(91)	(93)	(62)	(−.6)
Anthracite ... do	10	9	1–4	−7.1
Petroleum, including natural gas liquids ... million barrels	4,902	5,160	7,343–16,412	+4.3
Natural gas, dry [6] ... billion cubic feet	18,973	20,388	34,800–55,700	+7.3
Electricity generation, net ... million kilowatt-hours	1,436,029	1,552,299	NA	+7.6
Utilities ... do	1,329,443	1,441,939	[7] 9,036,400	+8.2
Hydropower [8] ... do	222,491	250,078	[7] 632,000	+1.9
Nuclear power ... do	12,528	13,898	[7] 5,491,000	[9] +54.0
Conventional fuel-burning plants ... do	1,094,424	1,177,963	[7] 2,961,000	+9.2

Industrial ... do	106,586	110,360	NA	+3.9
Total energy resources inputs ... trillion Btu	62,448	65,773	168,600	+2.7

[p] Preliminary. NA Not available.
[1] All projections are for the year 2000.
[2] Growth rate 1956–65.
[3] Changed from withdrawals from total supply to refined copper consumption.
[4] Growth rate 1954–65.
[5] Figures in parenthesis are not added into totals.
[6] Residue gas excludes extraction loss but includes transmission loss.
[7] Morrison, Warren E., and Charles L. Readling. An Energy Model for the United States, Featuring Energy Balances for the Years 1947 to 1965 and Projections and Forecasts to the Years 1980 and 2000. Bureau of Mines Inf. Cir. 8384, 1968, 127 pp.
[8] Net generation, adjusted for net imports or exports. The bulk of net trade is hydropower with an undetermined amount of steam plant power.
[9] Growth rate 1957–65.

Table 8.—Calculated gross consumption of mineral energy resources, and electricity from hydropower and nuclear power in British thermal units (Btu), and percent contributed by each [1]

Year	Anthracite	Bituminous coal and lignite	Natural gas, dry	Petroleum (excluding natural gas liquids)	Natural gas liquids	Electricity		Total
						Hydropower	Nuclear power	
				TRILLION BTU				
1965	328	12,030	16,098	21,364	1,877	2,049	39	53,785
1966	290	12,740	17,393	22,405	1,989	2,073	58	56,948
1967	274	12,587	18,250	23,191	2,144	2,341	81	58,868
1968	260	13,069	19,580	24,607	2,445	2,355	132	62,448
1969 p	245	13,293	21,040	25,877	2,542	2,635	141	65,773
				PERCENT				
1965	0.6	22.4	29.9	39.7	3.5	3.8	0.1	100.0
1966	.5	22.4	30.5	39.4	3.5	3.6	.1	100.0
1967	.5	21.4	31.0	39.4	3.6	4.0	.1	100.0
1968	.4	20.9	31.4	39.4	3.9	3.8	.2	100.0
1969 p	.4	20.2	32.0	39.3	3.9	4.0	.2	100.0

p Preliminary.

[1] Heat values employed are anthracite, 12,700 Btu per pound, bituminous coal and lignite, 13,100 Btu per pound. Weighted average British thermal units for petroleum products were obtained by using 5,248,000 for gasoline and naphtha-type jet fuel, 5,670,000 for kerosine and kerosine-type jet fuel, 5,825,000 for distillate, 6,287,000 for residual, 6,064,800 for lubricants, 5,537,280 for wax, 6,636,000 for asphalt, and 5,796,000 for miscellaneous; natural gas, dry, 1,032 Btu; natural gas liquids, weighted average British thermal units in 1965 based on production of natural gasoline and cycle products at 110,000 Btu per gallon; LP-gas, including ethane, 95,000 Btu per gallon in 1966, ethane production converted at 73,390 Btu per gallon thereafter. Hydropower (adjusted for net imports or net exports) and nuclear power are derived from net electricity generated, converted to theoretical energy resources inputs calculated from prevailing average heat rates at central electric stations using 10,530 Btu per kilowatt-hour in 1965, 10,586 Btu in 1966, 10,582 Btu in 1967, 10,582 Btu in 1968, and 10,712 Btu in 1969.

Table 9.—Gross consumption of energy resources by major sources and consuming sectors [1]

(Trillion Btu)

Year	Anthracite	Bituminous coal and lignite	Natural gas, dry [1]	Petroleum [2]	Hydropower [3]	Nuclear power [3]	Total gross energy inputs [4]	Utility electricity purchased [5]	Total sector energy inputs [6]
HOUSEHOLD AND COMMERCIAL									
1965	[7] 168	546	5,518	5,635	------	------	11,867	1,948	13,815
1966	143	575	5,945	5,766	------	------	12,429	2,101	14,530
1967	128	497	6,223	6,206	------	------	13,054	2,257	15,311
1968	122	447	6,451	6,129	------	------	13,148	2,467	15,615
1969 p	118	376	6,897	6,237	------	------	13,628	2,681	16,309
INDUSTRIAL									
1965	[7] 101	5,640	7,671	4,138	------	------	17,550	1,634	19,184
1966	88	5,806	8,203	4,352	------	------	18,449	1,788	20,237
1967	90	5,553	8,599	4,298	------	------	18,540	1,868	20,408
1968	81	5,537	9,274	4,820	------	------	19,712	2,044	21,756
1969 p	72	5,505	9,894	5,099	------	------	20,570	2,219	22,789
TRANSPORTATION [8]									
1965	NA	19	517	12,179	------	------	12,715	18	12,733
1966	NA	18	553	12,777	------	------	13,348	16	13,364
1967	NA	14	594	13,542	------	------	14,150	17	14,167
1968	NA	11	610	14,681	------	------	15,302	18	15,320
1969 p	NA	9	651	15,290	------	------	15,950	20	15,970
ELECTRICITY GENERATION, UTILITIES [3]									
1965	55	5,825	2,392	744	2,049	39	11,104	3,600	------
1966	56	6,341	2,692	905	2,073	58	12,125	3,905	------
1967	55	6,523	2,834	1,013	2,341	81	12,847	4,142	------
1968	56	7,074	3,245	1,181	2,355	132	14,043	4,529	------
1969 p	53	7,403	3,598	1,603	2,635	141	15,433	4,920	------
MISCELLANEOUS AND UNACCOUNTED FOR									
1965	[7] 4	------	------	545	------	------	549	------	------
1966	3	------	------	594	------	------	597	------	------
1967	1	------	------	276	------	------	277	------	------
1968	1	------	------	242	------	------	243	------	------
1969 p	2	------	------	190	------	------	192	------	------
TOTAL GROSS ENERGY INPUTS									
1965	328	12,030	16,098	23,241	2,049	39	53,785	------	------
1966	290	12,740	17,393	24,394	2,073	58	56,948	------	------
1967	274	12,587	18,250	25,335	2,341	81	58,868	------	------
1968	260	13,069	19,580	27,052	2,355	132	62,448	------	------
1969 p	245	13,293	21,040	28,419	2,635	141	65,773	------	------

p Preliminary. NA Not available.
[1] Excludes natural gas liquids.
[2] Petroleum products including still gas, liquefied refinery gas, and natural gas liquids.
[3] Represents outputs of hydropower (adjusted for net imports or net exports) and nuclear power converted to theoretical energy inputs calculated from prevailing heat rates at central electric stations using 10,530 Btu per kilowatt-hour in 1965, 10,586 Btu in 1966, 10,582 Btu in 1967, 10,582 Btu in 1968, and 10,712 Btu in 1969. Excludes inputs for power generated by nonutility plants which are included within the other consuming sectors.
[4] Gross energy is that contained in all types of commercial energy at time it is incorporated in the economy, whether energy is produced domestically or imported. Gross energy comprises inputs of primary fuels (or the derivatives) and outputs of hydropower and nuclear power converted to theoretical energy inputs. Gross energy includes energy used for production, processing, and transportation of energy proper.
[5] Utility electricity, generated and imported, distributed to the other consuming sectors as energy resource inputs. Distribution to sectors is based on historical series in the Edison Electric Institute Yearbook. Conversion of electricity to energy equivalent by sectors was made at the value of contained energy corresponding to 100-percent efficiency using a theoretical rate of 3,412 Btu per kilowatt-hour.
[6] Energy resource inputs by sector, including direct fuels and electricity distributed.
[7] The household and commercial and industrial sectors include an estimated breakdown of undistributed energy formerly included under miscellaneous and unaccounted for.
[8] Includes bunkers and military transportation.

Table 10.—Estimated gross consumption of energy resources in the mineral and manufacturing industries, by major sources of energy within selected two-digit SIC industry groups, 1969 p

SIC code	Industry group	Anthracite		Bituminous coal and lignite		Natural gas, dry[1]	
		Million short tons	Trillion Btu	Million short tons	Trillion Btu	Billion cubic feet	Trillion Btu
20	Food and kindred products	0.1	2.7	8.3	258.6	621.8	641.3
26	Paper and allied products	.2	6.3	14.7	457.5	356.9	368.8
28	Chemicals and allied products	.2	6.3	21.2	655.3	1,277.1	1,318.2
29	Petroleum refining and related industries	--------	--------	(5)	(5)	1,060.8	1,094.4
32	Stone, clay, glass, and concrete products	(6)	1.8	12.8	401.8	470.4	485.5
33	Primary metal industries	2.0	47.8	98.1	2,769.6	904.0	933.2
	All mineral and other manufacturing industries	.3	7.2	30.9	962.6	5,010.0	5,170.0
	Total	2.8	72.1	186.0	5,505.4	9,701.0	10,011.4

SIC code	Industry group	Petroleum[2]		Total gross energy inputs, trillion Btu	Utility electricity purchased[3]		Total sector energy inputs, trillion Btu[4]
		Million barrels	Trillion Btu		Billion kwhr	Trillion Btu	
20	Food and kindred products	25.3	152.7	1,055.3	39.0	133.6	1,188.9
26	Paper and allied products	40.3	240.5	1,073.1	32.5	110.8	1,183.9
28	Chemicals and allied products	347.8	1,625.3	3,605.1	188.6	643.0	4,248.1
29	Petroleum refining and related industries	304.0	1,811.0	2,905.4	26.0	89.0	2,994.4
32	Stone, clay, glass, and concrete products	16.1	99.1	988.2	32.5	110.8	1,099.0
33	Primary metal industries	68.0	348.8	4,099.4	149.6	510.8	4,609.9
	All mineral and other manufacturing industries	133.6	821.8	6,961.6	182.1	621.3	7,582.9
	Total	935.1	5,099.2	20,688.1	650.3	2,219.0	22,907.1

p Preliminary.
[1] Excludes natural gas liquids.
[2] Petroleum products including still gas, liquefied refinery gas, and natural gas liquids.
[3] Utility electricity, generated and imported, distributed to the industrial sector as resources inputs. Distribution is based on historical series in the Edison Electrical Institute Yearbook. Conversion of electricity to energy equivalent was made at the value of contained energy corresponding to 100-percent efficiency using a theoretical rate of 3,412 Btu per kilowatt-hour.
[4] Energy resource inputs, including direct fuels and electricity distributed.
[5] Included in "All mineral and other manufacturing industries."
[6] Less than ½ unit.

Table 11.—Domestic supply and demand for coal

	1968		1969 p	
	Thousand short tons	Trillion Btu	Thousand short tons	Trillion Btu
ANTHRACITE				
Supply:				
Production [1]	11,460.8	293.4	10,800.0	276.5
Exports [2]	−1,300.8	−33.3	−1,414.0	−36.2
Imports	NA	NA	NA	NA
Stock change: withdrawals (+), additions (−)	----------	----------	+166.0	+4.2
Losses, gains, and unaccounted for	----------	----------	+22.0	+.6
Total	10,160.0	260.1	9,574.0	245.1
Demand by major consuming sectors: [3]				
Household and commercial [4]	4,759.0	121.8	4,599.0	117.7
Industrial [5]	3,152.0	80.7	2,816.0	72.1
Transportation [6]	(7)	(7)	(7)	(7)
Electric generation, utilities	2,203.0	56.4	2,065.0	52.9
Miscellaneous and unaccounted for	46.0	1.2	94.0	2.4
Total	10,160.0	260.1	9,574.0	245.1
BITUMINOUS COAL AND LIGNITE				
Supply:				
Production [1]	545,245.0	14,285.4	556,051.0	14,568.5
Exports	−50,637.0	−1,326.7	−56,234.0	−1,473.3
Imports	+224.0	+5.9	+109.0	+2.9
Stock change: withdrawals (+), additions (−)	+7,946.0	+208.2	+5,500.0	+144.1
Losses, gains, and unaccounted for	−3,948.0	−103.5	+2,011.0	+52.6
Total	498,830.0	13,069.3	507,437.0	13,294.8
Demand by major consuming sectors:				
Fuel and power:				
Household and commercial [4]	15,224.0	447.3	12,671.0	376.3
Industrial [5]	182,909.2	5,374.6	180,480.2	5,343.7
Coal carbonized for coke [8]	(90,765.0)	(2,667.0)	(92,837.0)	(2,757.3)
Transportation [6]	417.0	10.9	322.0	8.5
Electricity generation, utilities	294,739.0	7,073.7	308,461.0	7,403.0
Total	493,289.2	12,906.5	501,934.2	13,131.5
Raw material: Industrial [9]				
Crude light oil	1,185.3	34.8	1,259.2	37.0
Crude coal tar	4,355.5	128.0	4,243.6	124.7
Total	5,540.8	162.8	5,502.8	161.7
Grand total	498,830.0	13,069.3	507,437.0	13,293.2

p Preliminary. NA Not available.
[1] Includes use by producers for power and heat.
[2] Includes shipments to U.S. Armed Forces in West Germany.
[3] Except for small quantities used as raw material for coal chemicals, all anthracite represents fuel and power.
[4] Data represent "retail deliveries to other consumers." These are mainly household and commercial users with some unknown portion of use by small industries.
[5] Includes consumption by coke plants, steel and rolling mills, and other industrial uses.
[6] Includes bunkers and military transportation.
[7] Data not available. Believed to be small and of minor significance.
[8] Figures in parenthesis are not added into totals.
[9] Coal equivalent based on British thermal unit value of raw materials for coal chemicals.

Table 12.—Domestic supply and demand for natural gas

	1968		1969 p	
	Million cubic feet	Trillion Btu	Million cubic feet	Trillion Btu
Supply:				
Production [1]	19,322,400	21,547.5	20,698,240	23,008.2
Exports	−93,745	−96.7	−51,304	−52.9
Imports	651,885	672.7	726,951	750.2
Stock change: withdrawals (+), additions (−)	−95,539	−98.6	−119,500	−123.3
Transfers out, extraction loss [2]	−812,086	−2,444.9	−866,560	−2,542.0
Loss, gains, and unaccounted for	----------	--------	----------	--------
Total	18,972,915	19,580.0	20,387,827	21,040.2
Demand by major consuming sectors:				
Fuel and power:				
Household and commercial	6,250,997	6,451.0	6,682,804	6,896.6
Industrial [3]	8,546,122	8,819.5	9,069,419	9,359.6
Transportation	590,965	609.9	630,962	651.2
Electricity generation, utilities	3,143,858	3,244.5	3,486,391	3,598.0
Total	18,531,942	19,124.9	19,869,576	20,505.4
Raw material: Industrial: [4]				
Carbon black	104,973	108.3	98,251	101.4
Other chemicals [5]	336,000	346.8	420,000	433.4
Total	440,973	455.1	518,251	534.8
Grand total	18,972,915	19,580.0	20,387,827	21,040.2

p Preliminary.
[1] Marketed production includes wet gas sold or consumed by producers, losses in transmission, producers' additions to storage, and increases in gas pipeline fill; excludes repressuring and vented and wasted. British thermal unit value of production is for wet gas prior to extraction of natural gas liquids. Higher values assigned to extraction loss are reflected in value of production for each year.
[2] Extraction loss from cycling plants represents offtake of natural gas for natural gas liquids as reported to Bureau of Mines. Energy equivalent of extraction loss is based on annual outputs of natural gasoline and associated products at 110,000 Btu per gallon, annual outputs of LPG at 95,500 Btu per gallon, and annual outputs of ethane at 73,390 Btu per gallon. (Prior to 1967, ethane production was included with LPG in converting to Btu values.)
[3] Includes transmission losses of 325,062 million cubic feet in 1968 and 331,587 million cubic feet in 1969.
[4] Includes some fuel and power used by raw materials industries.
[5] Estimated from partial data.

Table 13.—Domestic supply and demand for petroleum [1]

	1968		1969 [p]	
	Million barrels	Trillion Btu	Million barrels	Trillion Btu
Supply:				
Crude oil: [2]				
Production	3,329.0	18,592.5	3,371.8	18,824.7
Exports	−1.8	−10.1	−1.4	−7.8
Imports	[3] 472.3	2,637.7	[3] 513.8	2,868.5
Stock change: withdrawals (+), additions (−)	−23.2	−129.6	+7.0	+39.0
Losses and transfers for use as crude	−1.9	−10.6	−11.1	−61.8
Total	3,774.4	21,079.9	3,880.1	21,662.6
Petroleum input runs to stills:				
Crude oil [2]	3,774.4	21,079.9	3,880.1	21,662.6
Transfers in, natural gas liquids [4]	259.4	1,167.3	264.6	1,190.7
Other hydrocarbons	3.4	17.8	4.2	22.0
Total	4,037.2	22,265.0	4,148.9	22,875.3
Output:				
Refined products	4,037.2	22,265.0	4,148.9	22,875.3
Unfinished oils, net	26.2	164.7	33.6	211.2
Overage or loss	116.7	643.5	123.0	678.3
Total	4,180.1	23,073.2	4,305.5	23,764.8
Exports	−82.7	−473.0	−83.9	−479.8
Imports	567.0	3,468.2	640.7	3,879.4
Stock change, including natural gas liquids	−32.2	−177.7	+4.7	+25.9
Transfers in, natural gas liquids [4 5]	290.7	1,277.6	315.5	1,351.3
Losses, gains, and unaccounted for	−21.1	−116.5	−22.7	−122.6
Total	4,901.8	27,051.8	5,159.8	28,419.0
Demand by major consuming sectors:				
Fuel and power:				
Household and commercial	921.3	5,145.0	940.7	5,228.5
Industrial	535.2	3,186.1	551.2	3,273.0
Transportation [6]	2,703.8	14,535.3	2,818.5	15,144.6
Electricity generation, utilities	188.0	1,180.6	255.2	1,602.9
Other, not specified	25.2	142.2	17.6	98.9
Total	4,373.5	24,189.2	4,583.2	25,347.9
Raw material: [7]				
Petrochemical feedstock offtake	260.1	1,181.4	301.3	1,351.9
Other nonfuel use	250.1	1,581.6	258.7	1,627.9
Total	510.2	2,763.0	560.0	2,979.8
Miscellaneous and unaccounted for	18.1	99.6	16.6	91.3
Total	4,901.8	27,051.8	5,159.8	28,419.0

[p] Preliminary.
[1] Supply and demand for crude oil and petroleum products. Petroleum products include products refined and processed from crude oil, including still gas and LRG; also natural gas liquids transferred from natural gas.
[2] Btu value for crude oil for each year shown is based on average British thermal unit value of total output of petroleum products (including refinery fuel and losses) adjusted to exclude natural gas liquids inputs and their implicitly derived values. Value for net imports of crude is based on the average value of crude runs to stills.
[3] Includes some Athabasca hydrocarbons.
[4] Btu values for natural gas liquids for each year shown are implicitly derived from weighted averages of production of major natural gas liquids, derived by converting natural gasoline and cycle products at 110,000 Btu per gallon, LPG at 95,000 Btu per gallon, and ethane at 73,390 Btu per gallon.
[5] Includes natural gas liquids other than those channeled into refinery input as follows: Petrochemical feedstocks, direct uses for fuel and power, and other uses.
[6] Includes bunkers and military transportation.
[7] Includes some fuel and power used by raw materials industries.

Table 14.—Petroleum consumption, by major products and by major consuming sectors [1]

	Household and commercial		Industrial		Transportation [2]		Electricity generation, utilities		Miscellaneous and unaccounted for		Total domestic product demand	
	Million barrels	Trillion Btu	Million barrels	Trillion Btu	Million barrels	Trillion Btu	Million barrels	Trillion Btu	Million barrels	Trillion Btu	Million barrels	Trillion Btu
1968												
Fuel and power:												
Liquefied gases	160.0	641.8	24.9	99.9	29.3	117.5	--------	--------	4.3	17.2	218.5	876.4
Jet fuels:												
Naphtha type	--------	--------	--------	--------	126.6	680.3	--------	--------	--------	--------	126.6	680.3
Kerosine type	--------	--------	--------	--------	222.8	1,263.8	--------	--------	--------	--------	222.8	1,263.8
Total	--------	--------	--------	--------	349.4	1,944.1	--------	--------	--------	--------	349.4	1,944.1
Gasoline	--------	--------	--------	--------	1,956.0	10,265.1	--------	--------	--------	--------	1,956.0	10,265.1
Kerosine	76.3	432.6	26.6	150.8	--------	--------	--------	--------	--------	--------	102.9	583.4
Distillate fuel	510.7	2,974.8	104.7	609.9	242.2	1,410.8	3.0	17.5	13.9	81.0	874.5	5,094.0
Residual fuel	174.3	1,095.8	175.0	1,100.2	126.9	797.8	185.0	1,163.1	7.0	44.0	668.2	4,200.9
Still gas	--------	--------	149.8	898.8	--------	--------	--------	--------	--------	--------	149.8	898.8
Petroleum coke	--------	--------	54.2	326.5	--------	--------	--------	--------	--------	--------	54.2	326.5
Total	921.3	5,145.0	535.2	3,186.1	2,703.8	14,535.3	188.0	1,180.6	25.2	142.2	4,373.5	24,189.2
Raw material: [3]												
Special naphthas	--------	--------	27.0	141.7	--------	--------	--------	--------	--------	--------	27.0	141.7
Lubes [4] and waxes	--------	--------	28.6	177.4	24.2	145.8	--------	--------	--------	--------	52.8	323.2
Petroleum coke [5]	--------	--------	22.1	133.2	--------	--------	--------	--------	--------	--------	22.1	133.2
Asphalt and road oil	148.2	983.5	--------	--------	--------	--------	--------	--------	--------	--------	148.2	983.5
Petrochemical feedstock off-take:												
Liquefied refinery gas	--------	--------	46.5	186.5	--------	--------	--------	--------	--------	--------	46.5	186.5
Liquefied petroleum gas [6]	--------	--------	120.7	484.1	--------	--------	--------	--------	--------	--------	120.7	484.1
Naphtha (−400 degrees)	--------	--------	55.6	291.8	--------	--------	--------	--------	--------	--------	55.6	291.8
Still gas	--------	--------	9.8	58.8	--------	--------	--------	--------	--------	--------	9.8	58.8
Miscellaneous (+400 degrees)	--------	--------	27.5	160.2	--------	--------	--------	--------	--------	--------	27.5	160.2
Total	148.2	983.5	337.8	1,633.7	24.2	145.8	--------	--------	--------	--------	510.2	2,763.0
Miscellaneous and unaccounted for	--------	--------	--------	--------	--------	--------	--------	--------	18.1	99.6	18.1	99.6
Total domestic product demand	1,069.5	6,128.5	873.0	4,819.8	2,728.0	14,681.1	188.0	1,180.6	43.3	241.8	4,901.8	27,051.8
1969 p												
Fuel and power:												
Liquefied gases	174.0	697.9	28.5	114.3	32.5	130.4	--------	--------	4.0	16.0	239.0	958.6
Jet fuels:												
Naphtha type	--------	--------	--------	--------	108.3	575.8	--------	--------	--------	--------	108.3	575.8
Kerosine type	--------	--------	--------	--------	253.2	1,435.6	--------	--------	--------	--------	253.2	1,435.6
Total	--------	--------	--------	--------	361.5	2,011.4	--------	--------	--------	--------	361.5	2,011.4

Gasoline	-------	-------	-------	-------	2,042.5	10,719.0	-------	-------	-------	-------	2,042.5	10,719.0
Kerosine	73.9	419.0	26.5	150.2	-------	-------	-------	-------	-------	-------	100.4	569.2
Distillate fuel	528.2	3,076.8	108.0	629.1	255.0	1,485.4	3.3	19.2	5.6	32.6	900.1	5,243.1
Residual fuel	164.6	1,034.8	170.4	1,071.3	127.0	798.4	251.9	1,583.7	8.0	50.3	721.9	4,538.5
Still gas	-------	-------	160.4	962.4	-------	-------	-------	-------	-------	-------	160.4	962.4
Petroleum coke	-------	-------	57.4	345.7	-------	-------	-------	-------	-------	-------	57.4	345.7
Total	940.7	5,228.5	551.2	3,273.0	2,818.5	15,144.6	255.2	1,602.9	17.6	98.9	4,583.2	25,347.9
Raw materials:[3]												
Special naphthas	-------	-------	29.6	155.3	-------	-------	-------	-------	-------	-------	29.6	155.3
Lubes[4] and waxes	-------	-------	29.6	178.0	24.1	145.0	-------	-------	-------	-------	53.7	323.0
Petroleum coke[5]	-------	-------	23.4	141.0	-------	-------	-------	-------	-------	-------	23.4	141.0
Asphalt and road oil	152.0	1,008.6	-------	-------	-------	-------	-------	-------	-------	-------	152.0	1,008.6
Petrochemical feedstock offtake:												
Liquefied refinery gas	-------	-------	44.5	178.5	-------	-------	-------	-------	-------	-------	44.5	178.5
Liquefied petroleum gas[6]	-------	-------	162.1	650.2	-------	-------	-------	-------	-------	-------	162.1	650.2
Naphtha (−400 degrees)	-------	-------	57.6	302.3	-------	-------	-------	-------	-------	-------	57.6	302.3
Still gas	-------	-------	10.0	60.0	-------	-------	-------	-------	-------	-------	10.0	60.0
Miscellaneous (+400 degrees)	-------	-------	27.1	160.9	-------	-------	-------	-------	-------	-------	27.1	160.9
Total	152.0	1,008.6	383.9	1,826.2	24.1	145.0	-------	-------	-------	-------	560.0	2,979.8
Miscellaneous and unaccounted for	-------	-------	-------	-------	-------	-------	-------	-------	16.6	91.3	16.6	91.3
Total domestic product demand	1,092.7	6,237.1	935.1	5,099.2	2,842.6	15,289.6	255.2	1,602.9	34.2	190.2	5,159.8	28,419.0

p Preliminary.
1 Includes liquefied refinery gas and natural gas liquids.
2 Includes bunkers and military transportation.
3 Includes some fuel and power used by raw materials industries.
4 Lubricants are distributed equally between the Industrial and Transportation sectors.
5 Includes portions of petroleum coke estimated to be consumed in nonfuel uses.
6 Includes LPG for synthetic rubber.

Table 15.—Electrical energy sales to ultimate consumers

(Million kilowatt-hours)

Region	Total consumption	Residential	Industrial and commercial	Total consumption	Residential	Industrial and commercial
	1965			1966		
New England	36,984	12,813	22,806	40,184	13,883	24,877
Middle Atlantic	145,248	38,850	96,783	156,302	42,088	104,153
East North-Central	193,539	52,544	133,919	207,521	57,005	142,858
West North-Central	61,335	23,864	35,458	66,030	25,303	38,579
South Atlantic	132,883	45,178	82,932	148,757	50,920	92,723
East South-Central	106,314	26,811	78,118	112,594	29,589	81,463
West South-Central	92,586	27,396	60,602	102,760	29,753	68,071
Mountain	43,086	11,445	29,913	47,198	12,313	33,100
Pacific	138,376	40,939	93,085	154,302	44,502	103,093
Alaska and Hawaii	3,063	1,130	1,861	3,334	1,216	2,038
Total United States	953,414	280,970	635,477	1,038,982	306,572	690,955
	1967			1968		
New England	43,361	15,437	26,496	47,386	16,970	28,946
Middle Atlantic	164,125	45,410	108,184	176,158	49,854	115,301
East North-Central	219,554	61,238	149,630	238,138	67,080	161,679
West North-Central	71,481	27,138	41,950	77,624	29,644	45,375
South Atlantic	161,567	55,692	99,916	180,463	63,790	109,589
East South-Central	115,851	31,166	83,027	122,608	36,033	84,770
West South-Central	113,125	32,739	74,872	126,160	37,070	83,202
Mountain	49,342	13,157	33,774	53,157	14,164	36,513
Pacific	164,998	48,210	108,502	176,682	51,640	116,230
Alaska and Hawaii	3,619	1,338	2,184	3,945	1,447	2,380
Total United States	1,107,023	331,525	728,535	1,202,321	367,692	783,985

Source: Edison Electric Institute. Statistical Yearbook of the Electrical Utility Industry. 1965 through 1968.

Table 16.—Net supply of principal minerals, by components [1]

(Thousand short tons of mineral content, unless otherwise stated)

Commodity, and mineral content measured	Total net supply			Components as percent of total, before subtracting exports						Exports as percent of gross supply	
	1968	1969	Percent change	Primary shipments		Old scrap		Imports		1968	1969
				1968	1969	1968	1969	1968	1969		
FERROUS METALS											
Iron ore	119,991	125,452	+5	65	69	--------	--------	35	31	5	4
Pig iron	89,862	95,835	+7	99	100	--------	--------	1	(2)	(2)	(2)
Steel ingot	148,895	149,769	+2	88	91	--------	--------	12	9	2	4
Chromite (Cr_2O_3)	436	416	−5	--------	--------	--------	--------	100	100	13	18
Cobalt	r 10	12	+20	60	57	--------	--------	40	43	11	12
Manganese	r 863	967	+12	1	1	--------	--------	99	99	2	2
Molybdenum	33	23	−30	98	100	--------	--------	2	(2)	31	56
Nickel	171	162	−5	8	10	8	12	84	79	3	1
Tungsten	r 7	18	+157	88	97	--------	--------	12	3	8	28
OTHER METALS											
Aluminum	r 4,004	3,948	−1	78	85	4	3	18	12	8	13
Antimony	35	37	+6	3	2	67	65	30	33	(2)	1
Beryl ore (BeO) short tons	r 433	W	--------	4	W	--------	--------	96	W	11	W
Cadmium	r 6	6	--------	85	92	--------	--------	15	8	4	8
Copper	r 2,408	2,498	+4	48	62	21	23	31	15	3	(2)
Lead	1,340	1,853	+38	27	27	41	33	32	40	1	(2)
Magnesium	r 104	107	+3	84	87	13	10	3	3	15	20
Mercury 76-pound flasks	79,004	74,427	−6	33	39	40	18	27	43	9	1
Platinum group thousand troy ounces	r 1,721	1,114	−35	1	1	15	23	84	76	19	31
Tin thousand long tons	r 74	71	−4	--------	--------	27	29	73	71	11	10
Titanium concentrate (TiO_2):											
Ilmenite and slag	r 671	699	+4	75	68	--------	--------	25	32	1	1
Rutile	W	W	--------	W	W	--------	--------	W	W	--------	--------
Uranium concentrate (U_3O_8)	12	13	+8	100	85	--------	--------	(2)	15	--------	--------
Zinc	r 1,403	1,545	+10	37	36	7	6	56	58	2	1
NONMETALS											
Asbestos	818	786	−4	14	15	--------	--------	86	85	5	4
Barite, crude	1,590	1,694	+7	58	64	--------	--------	42	36	--------	--------
Bromine	152	168	+11	100	100	--------	--------	--------	--------	--------	--------
Clays	r 55,926	57,202	+2	100	100	--------	--------	(2)	(2)	3	3
Fluorspar, finished	1,289	1,329	+3	19	14	--------	--------	81	86	1	(2)
Gypsum	r 24,297	25,047	+3	78	77	--------	--------	22	23	(2)	(2)
Mica (except scrap)	98	120	+22	99	99	--------	--------	1	1	13	5
Phosphate rock (P_2O_5)	9,288	8,139	−12	99	99	--------	--------	1	1	30	31
Potash (K_2O equivalent)	r 4,337	4,700	+8	57	57	--------	--------	43	43	15	13
Salt, common	44,002	46,831	+6	92	93	--------	--------	8	7	2	2
Sand and gravel million tons	918	938	+2	100	100	--------	--------	(2)	(2)	--------	--------
Stone, crushed do	r 818	861	+5	100	100	--------	--------	NA	NA	(2)	(2)
Sulfur, all forms thousand long tons	r 9,849	9,788	−1	85	84	--------	--------	15	16	14	14
Talc and allied minerals	916	980	+7	98	98	--------	--------	2	2	7	7

r Revised. NA Not available. W Withheld to avoid disclosing individual company confidential data. Figure is not included in net and gross supply.

[1] Net supply is the sum of primary shipments, secondary production, and imports minus exports. Stockpile disposals are included in primary shipment. Gross supply is the total before subtraction of exports.

[2] Less than ½ unit.

Table 17.—Shipments, net new orders, and yearend unfilled orders for selected mineral processing industries

(Millions)

Year and month	Shipments[1]			Net new orders			Unfilled orders at end of period		
	Primary metals	Blast furnaces	All other primary metals[2]	Primary metals	Blast furnaces	All other primary metals[2]	Primary metals	Blast furnaces	All other primary metals[2]
1965	$41,910	$22,916	$18,994	$41,017	$21,378	$19,639	$5,646	$2,730	$2,916
1966	45,651	23,707	21,944	46,879	24,285	22,594	6,909	3,305	3,604
1967	45,867	22,846	23,021	45,393	23,037	22,356	7,019	3,644	3,375
1968	50,457	24,901	25,556	49,790	24,380	25,410	6,327	3,100	3,227
1969	57,135	26,493	30,642	58,491	27,280	31,211	7,726	3,921	3,805
1969:									
January	4,508	2,089	2,419	4,675	2,124	2,551	6,494	3,134	3,360
February	4,585	2,096	2,489	4,666	2,071	2,595	6,575	3,109	3,466
March	4,578	2,115	2,463	4,614	2,110	2,504	6,611	3,104	3,507
April	4,571	2,096	2,475	4,806	2,307	2,499	6,848	3,316	3,532
May	4,643	2,119	2,524	4,772	2,246	2,526	6,975	3,442	3,533
June	4,728	2,212	2,516	4,825	2,308	2,517	7,073	3,538	3,535
July	4,777	2,238	2,539	5,161	2,510	2,651	7,456	3,810	3,646
August	4,739	2,176	2,563	5,001	2,370	2,631	7,718	4,004	3,714
September	5,016	2,329	2,687	5,313	2,592	2,721	8,015	4,267	3,748
October	5,144	2,422	2,722	5,300	2,571	2,729	8,172	4,415	3,757
November	5,013	2,338	2,675	4,751	2,190	2,561	7,909	4,267	3,642
December	4,945	2,354	2,591	4,760	2,007	2,753	7,726	3,921	3,805

[1] Monthly figures are seasonally adjusted and do not add to totals.
[2] "All other primary metals" obtained by subtracting blast furnace from primary metals figures.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 46–50, No. 3, March 1966–70, pp. S-5, S-6, S-7.

Table 18.—Value of selected minerals and mineral products imported and exported by the United States in 1969, by commodity groups and commodities [1]

(Thousands)

SITC code [2]	Commodity	Exports	Imports
	Minerals, nonmetallic (crude):		
271	Fertilizers, crude	$90,025	$9,255
273	Stone, sand and gravel	17,364	21,155
274	Sulfur and unroasted iron pyrites	57,401	57,544
275	Natural abrasives (including industrial diamonds)	40,134	55,006
276	Other crude minerals	108,496	157,501
	Total	313,420	300,461
	Metals (crude and scrap):		
281	Iron ores and concentrates	62,310	402,528
282	Iron and steel scrap	302,707	16,784
283	Ores and concentrates of nonferrous base metals	130,927	435,137
284	Nonferrous metal scrap	156,372	54,363
285	Platinum and platinum-group metal ores and concentrates	59,156	14,890
286	Uranium and thorium ores and concentrates	12	494
	Total	711,484	924,196
	Mineral energy resources and related products:		
321	Coal, coke, and briquets (including peat)	636,335	18,206
331	Petroleum, crude and partly refined	5,975	1,421,240
332	Petroleum products, except chemicals	427,918	1,110,921
341	Gas, natural and manufactured	60,500	215,935
	Total	1,130,728	2,766,302
	Chemicals:		
	Inorganic chemicals:		
513	Elements, oxides, and halogen salts	245,533	245,360
514	Other inorganic chemicals	127,555	58,041
515	Radioactive and associated materials except uranium and thorium	102,741	28,039
521	Mineral tar, crude chemicals from coal, petroleum, and natural gas	62,733	8,211
	Total	538,562	339,651
	Minerals, nonmetallic (manufactured):		
661	Lime, cement, and fabricated building materials, except glass and clay	12,573	54,382
662	Clay and refractory construction materials	58,727	47,949
663	Mineral manufactures, not elsewhere specified	75,830	26,669
	Total	147,130	129,000
	Metals (manufactured):		
671	Pig iron, spiegeleisen, sponge iron, iron and steel powder and shot, and ferroalloys	32,044	87,788
672	Iron or steel ingots and other primary forms	207,092	37,667
673	Iron or steel bars, rods, angles, shapes, and sections	108,652	507,712
674	Iron or steel universals, plates, or sheets	287,308	737,283
675	Iron or steel hoops and strips	38,160	40,518
676	Iron or steel rails and railway track construction materials	12,994	4,042
677	Iron or steel wire (excluding wire rod)	13,952	112,358
678	Iron or steel tubes, pipes, and fittings	204,489	274,880
679	Iron or steel castings or forgings, unworked	67,822	11,657
681	Silver, platinum, and platinum-group metals	149,159	160,287
682	Copper and copper alloys	282,092	489,672
683	Nickel and nickel alloys	45,084	218,929
684	Aluminum and aluminum alloys	293,938	263,787
685	Lead and lead alloys	3,913	72,678
686	Zinc and zinc alloys	10,680	88,261
687	Tin and tin alloys	9,419	188,990
688	Uranium and thorium metals and alloys	26	---------
689	Miscellaneous nonferrous base metals	66,896	56,848
	Total	1,833,720	3,353,357
	Grand total	4,675,044	7,812,967

[1] Data in this table are for the indicated SITC numbers only and therefore may not correspond to the figures classified by commodity in the "Statistical Summary" chapter of this volume.
[2] Standard Industrial Trade Classification.

Source: U.S. Department of Commerce, Bureau of the Census. U.S. Imports General and Consumption. FT 135, December 1969, table 1. U.S. Exports, Commodity and Country. FT 410, December 1969, table 1.

Table 19.—Percentage distribution of exports of selected minerals and mineral fuels and related products by area of destination, 1969

SITC code [1]	Commodity	North America [2]	South America	Europe	Asia	Africa	Oceania	Soviet bloc [3]	Undesignated area [4]
271	Fertilizers, crude	30	3	36	30	------	1	------	(5)
273	Sand and gravel	85	3	7	2	1	(5)	------	2
274	Sulfur and unroasted iron pyrites	5	10	69	3	5	8	------	(5)
275	Natural abrasives, including industrial diamonds	12	4	52	27	1	3	(5)	1
276	Crude minerals, n.e.c.	31	6	43	14	1	3	(5)	2
281	Iron ore and concentrates	42	------	1	57	------	------	------	(5)
282	Iron and steel scrap	12	1	33	54	(5)	------	(5)	(5)
283	Ores and concentrates of nonferrous base metal	7	1	68	19	(5)	1	4	(5)
284	Nonferrous metal scrap	10	1	70	18	(5)	------	1	(5)
286	Uranium and thorium ores and concentrates	------	------	------	------	------	------	------	100
321	Coke, coal, and briquets, including peat	28	6	26	39	------	(5)	1	(5)
331	Petroleum, crude and partly refined	23	------	47	30	------	------	------	(5)
332	Petroleum products, except chemicals	24	9	28	30	5	3	(5)	1
341	Gas, natural and manufactured	81	6	9	4	(5)	(5)	------	(5)
513	Inorganic chemical elements, oxides, and halogen salts	36	9	29	9	6	2	8	1
514	Other inorganic chemicals	34	12	26	18	1	6	1	2
515	Radioactive and associated materials	9	1	51	39	(5)	(5)	------	(5)
521	Mineral tar and crude chemicals from coal, petroleum, and natural gas	8	4	70	17	1	(5)	------	(5)
661	Lime, cement, and fabricated building materials, except glass and clay	42	4	30	11	3	3	------	7
662	Clay and refractory construction materials	50	16	20	8	1	2	(5)	3
663	Mineral manufactures, n.e.s	39	8	33	10	2	4	(5)	4
671	Pig iron, sponge iron, iron or steel powders and shot and ferroalloys	28	6	54	9	(5)	1	1	1
672	Iron and steel ingots and other primary forms	23	23	49	5	(5)	(5)	------	(5)
673	Iron and steel bars, rods, angles, shapes, and sections	53	6	11	23	5	1	(5)	1
674	Iron and steel plates and sheets	22	13	35	20	2	1	6	1
675	Iron and steel hoop and strip	52	3	32	7	2	2	(5)	2
676	Iron and steel nails and railway track construction material	32	37	11	15	2	1	(5)	2
677	Iron and steel wire (except insulated electric)	53	6	11	21	3	2	------	4
678	Iron and steel tubes, pipes, and fittings	41	19	10	13	12	2	1	2
679	Iron and steel castings and forgings (rough)	84	4	7	3	1	(5)	(5)	1
681	Silver, platinum, and platinum-group metals	3	1	87	9	(5)	(5)	(5)	(5)
682	Copper and copper alloys	15	10	58	15	(5)	(5)	1	1
683	Nickel and nickel alloys	36	9	42	11	(5)	1	------	1
684	Aluminum and aluminum alloys	27	8	32	29	2	1	1	(5)
685	Lead and lead alloys	15	8	50	20	------	(5)	------	7
686	Zinc and zinc alloys	36	2	27	32	------	------	------	3
687	Tin and tin alloys	23	3	16	57	------	------	------	1
688	Uranium and thorium and their alloys	------	------	------	------	------	------	------	100
689	Base metals and alloys, n.e.c.	27	4	56	11	(5)	1	(5)	1

[1] Standard Industrial Trade Classification.
[2] Includes Trinidad and Netherlands Antilles.
[3] U.S.S.R., Bulgaria, East Germany, Albania, Czechoslovakia, Hungary, Poland, Rumania, mainland China, North Korea, North Vietnam, and Yugoslavia.
[4] Special category exports.
[5] Less than ½ unit.

Source: U.S. Department of Commerce, Bureau of the Census. U.S. Exports Schedule B Commodity and Country. FT410, December 1969, table 2.

Table 20.—Percentage distribution of imports of principal minerals and mineral fuels and related products by area of destination, 1969

SITC code [1]	Commodity	North America	South America	Europe	Asia	Africa	Oceania	Soviet bloc [2]
2713000	Phosphates, crude and apatite	100	---	---	---	---	---	---
2732100	Gypsum	99	[3]	1	[3]	---	[3]	---
2743000	Sulfur	100	[3]	[3]	[3]	---	---	---
2752400	Natural abrasives	3	1	96	---	[3]	[3]	[3]
2762200	Graphite, natural	36	---	25	18	21	---	---
2762500	Magnesia, refractory and caustic calcined, and crude magnesite	[3]	3	74	14	---	3	6
2763000	Salt	70	22	3	[3]	5	---	---
2764000	Asbestos	93	---	[3]	---	7	---	[3]
2765200	Mica, including scrap	1	38	1	51	9	---	[3]
2765420	Fluorspar	69	1	29	---	1	---	---
2769300	Barite, crude	36	17	38	---	9	---	---
2769500	Talc	15	---	56	29	---	---	[3]
2810000	Iron ore and concentrates	54	37	1	[3]	7	1	---
2820000	Iron and steel scrap	88	---	10	2	---	---	---
2831100	Copper ores and concentrates	82	17	---	[3]	1	[3]	---
2833000	Bauxite	77	23	[3]	---	[3]	---	---
2834000	Lead ores and concentrates	53	23	2	[3]	[3]	22	---
2835000	Zinc ores and concentrates	84	13	1	[3]	1	1	---
2836000	Tin ores and concentrates	---	---	---	---	---	---	---
2837000	Manganese ores and concentrates	2	33	1	3	53	8	---
2839100	Chrome ores	---	---	18	18	23	---	41
2839200	Tungsten ores and concentrates	65	19	8	---	---	8	---
2839310	Tantalum, molybdenum, and vanadium ores and concentrates	38	24	4	2	27	5	---
2839320, 2839330	Titanium ores and concentrates	18	---	[3]	[3]	9	73	---
2839340	Zirconium ore	2	---	---	[3]	5	93	---
2839910	Antimony ores and needles	8	33	1	---	58	---	---
2839920	Beryllium ores and concentrates	---	73	2	[3]	25	[3]	---
2839930	Columbium ores and concentrates	17	54	6	2	21	---	---
2840200	Copper waste and scrap	96	2	2	[3]	---	[3]	---
2840300	Nickel waste and scrap	76	[3]	19	1	---	2	2
2840400	Aluminum waste and scrap	94	1	3	---	---	---	2
2840500	Magnesium waste and scrap	52	---	29	8	6	5	---
2840600	Lead waste and scrap	98	---	[3]	1	---	1	---
2840700	Zinc waste and scrap	100	---	[3]	---	---	---	---
2840900	Tin waste and scrap	97	---	---	3	---	---	---
2850140, 2850240	Platinum-group metals, ores, concentrates, and waste	25	14	32	8	7	14	---
2860000	Thorium ores and concentrates	---	---	---	39	---	61	---
3214000, 3218000, 3219000	Coal, coke, and briquets	92	---	8	[3]	[3]	---	---
3310000	Petroleum, crude and partly refined	43	30	1	13	13	---	---
3320000	Petroleum products, except chemicals	49	38	11	2	[3]	[3]	[3]
3410000	Gases, natural and manufactured	99	1	[3]	[3]	[3]	---	---
5132500	Mercury, including waste and scrap	71	[3]	26	---	[3]	---	3
5136500	Alumina	30	---	1	4	[3]	65	---
5210000	Mineral tar and crude chemicals from coal, petroleum, and natural gas	17	---	73	1	---	5	4
5613000	Potassic fertilizers and fertilizer materials	93	[3]	6	1	---	---	---

[1] Standard International Trade Classification.
[2] U.S.S.R., Bulgaria, East Germany, Albania, Czechoslovakia, Hungary, Poland, Rumania, mainland China, North Korea, North Vietnam, and Yugoslavia.
[3] Less than ½ unit.

Source: U.S. Department of Commerce, Bureau of the Census. U.S. Imports, FT135, December, 1969, table 2.

Table 21.—Index of stocks of crude minerals at mines or in hands of primary producers at yearend [1]

(1967 = 100)

Yearend	Metals and nonmetals [2]	Metals: Total	Metals: Iron ore	Metals: Other ferrous	Metals: Nonferrous	Nonmetals [2]
1962	114	88	91	70	85	146
1963	113	83	87	59	90	149
1964	107	79	84	45	87	140
1965	104	89	98	42	76	123
1966	100	88	94	35	99	115
1967	100	100	100	100	100	100
1968	121	120	123	119	100	123
1969 p	119	104	106	83	110	137

p Preliminary.
[1] Rebased and reweighted using 1967 data. Splicing period was 1962–64.
[2] Excludes fuels.

Table 22.—Index of stocks of mineral manufacturers, consumers, and dealers at yearend [1]

(1967 = 100)

Yearend	Metals and nonmetals [2]	Metals: Total	Metals: Iron	Metals: Other ferrous	Metals: Base nonferrous	Metals: Other nonferrous	Nonmetals [2]
1962	100	101	111	87	106	73	93
1963	95	97	103	108	101	79	93
1964	91	91	97	71	93	82	93
1965	92	93	95	71	97	86	79
1966	102	102	101	81	112	93	98
1967	100	100	100	100	100	100	100
1968	96	96	95	109	105	78	102
1969 p	92	92	85	102	110	72	91

p Preliminary.
[1] Rebased and reweighted using 1967 data. Splicing period was 1962–64.
[2] Excludes fuels.

Table 23.—Physical stocks of mineral energy resources and related products at yearend

(Producers' stocks, unless otherwise indicated)

Fuels	1965	1966	1967	1968	1969 p
Coal and related products: [1]					
Bituminous and lignite [2] short tons	79,739,516	76,808,024	95,408,000	85,525,000	NA
Coke do	2,702,946	3,078,768	5,467,532	5,985,025	3,120,000
Petroleum and related products:					
Carbon black thousand pounds	237,704	233,145	264,247	224,170	208,020
Crude petroleum and petroleum products thousand barrels	836,344	881,105	944,111	999,572	982,123
Crude petroleum do	220,289	238,391	248,970	272,193	265,227
Natural gas liquids do	35,867	40,423	(3)	(3)	(3)
Natural gasoline, plant condensate, and isopentane thousand barrels	(4)	(4)	5,782	5,466	5,704
Gasoline do	183,058	194,177	207,980	211,526	217,392
Special naphthas do	6,209	5,583	5,748	5,829	6,292
Liquefied gases do	(4)	(4)	[5] 64,165	[5] 76,160	[5] 59,602
Distillate fuel oil do	155,407	158,076	159,703	173,158	171,714
Residual fuel oil do	56,214	63,856	65,597	67,359	60,395
Petroleum asphalt do	16,178	17,309	19,939	20,055	16,753
Other products do	163,122	163,290	166,227	167,826	173,340
Natural gas [6] billion cubic feet	2,458	2,506	2,648	2,746	2,852

p Preliminary. NA Not available.
[1] Series on anthracite stocks in ground storage has been discontinued.
[2] Stocks at industrial, consumer, and retail yards and on upper lake docks.
[3] Now distributed among petroleum products shown below.
[4] Prior to 1967, included in natural gas liquids.
[5] Includes ethane.
[6] American Gas Association.

Table 24.—Seasonally adjusted book value of product inventories for selected mineral processing industries

(Millions)

End of year or month		Petroleum and coal products	Stone, clay, and glass products	Primary metals: Blast furnace and steel mills	Primary metals: Other primary metals [1]	Primary metals: Total
1965:	December	$1,756	$1,626	$3,678	$2,671	$6,349
1966:	December	1,869	1,746	4,043	3,066	7,109
1967:	December	1,971	1,952	4,319	3,325	7,644
1968:	December	2,118	2,219	4,039	3,513	7,552
1969:						
	December	2,274	2,483	4,312	3,740	8,052
	January	2,068	2,289	4,019	3,509	7,528
	February	2,076	2,372	4,042	3,512	7,554
	March	2,069	2,361	4,074	3,553	7,627
	April	2,061	2,391	4,121	3,561	7,682
	May	2,077	2,390	4,200	3,564	7,764
	June	2,079	2,431	4,194	3,604	7,798
	July	2,078	2,463	4,185	3,615	7,800
	August	2,075	2,453	4,234	3,673	7,907
	September	2,108	2,458	4,255	3,682	7,937
	October	2,156	2,449	4,234	3,691	7,925
	November	2,197	2,471	4,272	3,737	8,009

[1] "Other primary metals" obtained by subtracting blast furnace from primary metals figures.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 46–50, No. 3, March 1966–70, pp. S–5, S–6.

Table 25.—Total employment in selected mineral industries

(Thousands)

	1965	1966	1967	1968	1969
MINING					
Metal:					
Iron	25.9	26.3	27.5	25.7	25.4
Copper	30.0	31.7	23.8	30.3	37.2
Total [1]	83.8	86.5	79.1	84.2	92.2
Nonmetal mining and quarrying	119.6	120.8	120.9	121.8	118.2
Fuels:					
Bituminous	131.8	129.9	135.0	132.9	129.8
Other coal	9.6	7.8	7.0	6.2	6.3
Crude petroleum and natural gas fields	156.6	152.4	149.8	148.1	144.3
Oil and gas field services	130.5	127.4	120.7	131.7	137.3
Total	428.5	417.5	412.5	418.9	417.7
Total mining	631.9	624.8	612.5	624.9	628.1
MANUFACTURING					
Minerals:					
Fertilizers, complete and mixing only	39.7	40.7	40.6	39.1	38.4
Cement, hydraulic	38.0	38.0	36.5	35.6	35.1
Blast furnaces, steelworks, and rolling mills	580.2	571.3	553.1	553.4	563.5
Nonferrous smelting and refining	73.9	78.1	75.5	79.7	87.8
Total	731.8	728.1	705.7	707.8	724.8
Fuels:					
Petroleum refining	148.1	149.6	152.8	150.5	146.3
Other petroleum and coal products	34.8	36.4	36.6	36.2	37.5
Total [2]	182.9	186.0	189.4	186.7	183.8
Total manufacturing	914.7	914.1	895.1	894.5	908.6

[1] Includes other metal mining not shown separately.
[2] Standard Industrial Classification 295, paving and roofing materials, included in total.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Employment and Earnings Statistics for the United States 1909–67. Bull. 1312–5, October 1967, 851 pp. Employment and Earnings. V. 16, No. 9, March 1970, table B–2.

Table 26.—Average hours and gross earnings of production and related workers in the mineral and mineral fuels industries

	1965	1966	1967	1968	1969
MINING					
Metal:					
Iron ores:					
Weekly earnings	$129.24	$138.09	$138.60	$144.70	$153.18
Weekly hours	40.9	42.1	42.0	41.7	41.4
Hourly earnings	$3.16	$3.28	$3.30	$3.47	$3.70
Copper ores:					
Weekly earnings	$136.71	$140.07	$140.51	$162.37	$169.00
Weekly hours	43.4	43.5	43.1	47.2	46.3
Hourly earnings	$3.15	$3.22	$3.26	$3.44	$3.65
Total: [1]					
Weekly earnings	$127.30	$133.77	$136.83	$148.77	$157.61
Weekly hours	41.6	42.2	42.1	43.5	43.3
Hourly earnings	$3.06	$3.17	$3.25	$3.42	$3.64
Nonmetallic mining and quarrying:					
Weekly earnings	$117.45	$123.39	$128.65	$136.35	$149.44
Weekly hours	45.7	45.7	45.3	45.0	45.7
Hourly earnings	$2.57	$2.70	$2.84	$3.03	$3.27
Fuels:					
Total coal mining:					
Weekly earnings	$137.51	$145.95	$150.93	$151.59	$165.95
Weekly hours [2]	39.9	40.3	40.5	39.7	40.0
Hourly earnings [2]	$3.46	$3.62	$3.72	$3.80	$4.17
Bituminous coal:					
Weekly earnings	$140.26	$148.44	$153.09	$153.16	$168.46
Weekly hours [2]	40.2	40.6	40.7	39.8	40.2
Hourly earnings [2]	$3.49	$3.65	$3.75	$3.83	$4.21
Crude petroleum and natural gas:					
Weekly earnings	$116.18	$122.69	$130.66	$137.71	$147.19
Weekly hours	42.4	42.6	42.7	42.9	41.0
Hourly earnings	$2.74	$2.88	$3.06	$3.21	$3.59
Total fuels: [3]					
Weekly earnings	$124.29	$131.55	$138.83	$143.08	$155.97
Weekly hours	41.5	41.7	41.8	41.7	42.4
Hourly earnings	$3.01	$3.16	$3.33	$3.44	$3.70
Total mining: [3]					
Weekly earnings	$121.52	$127.73	$131.85	$141.35	$152.98
Weekly hours	44.0	44.2	44.0	44.4	44.7
Hourly earnings	$2.77	$2.90	$3.00	$3.18	$3.43
MANUFACTURING					
Fertilizers, complete and mixing only:					
Weekly earnings	$96.57	$101.38	$104.98	$108.97	$116.14
Weekly hours	43.5	43.7	43.2	42.4	42.7
Hourly earnings	$2.22	$2.32	$2.43	$2.57	$2.72
Cement, hydraulic:					
Weekly earnings	$124.42	$132.61	$133.40	$144.35	$155.87
Weekly hours	41.2	41.7	41.3	41.6	41.9
Hourly earnings	$3.02	$3.18	$3.23	$3.47	$3.72
Blast furnaces, steel, and rolling mills:					
Weekly earnings	$141.86	$145.71	$145.16	$155.86	$168.51
Weekly hours	41.0	40.7	40.1	40.8	41.2
Hourly earnings	$3.46	$3.58	$3.62	$3.82	$4.09
Nonferrous smelting and refining:					
Weekly earnings	$124.44	$129.98	$134.30	$144.08	$151.79
Weekly hours	41.9	42.2	42.1	42.5	42.4
Hourly earnings	$2.97	$3.08	$3.19	$3.39	$3.58
Petroleum refining and related industries:					
Weekly earnings	$138.42	$144.58	$152.87	$159.38	$170.83
Weekly hours	42.2	42.4	42.7	42.5	42.6
Hourly earnings	$3.28	$3.41	$3.58	$3.75	$4.01
Petroleum refining:					
Weekly earnings	$145.05	$151.56	$159.09	$166.27	$178.08
Weekly hours	41.8	42.1	42.2	42.2	42.1
Hourly earnings	$3.47	$3.60	$3.77	$3.94	$4.23
Other petroleum and coal products:					
Weekly earnings	$115.90	$120.22	$129.51	$135.91	$147.19
Weekly hours	43.9	43.4	44.2	43.7	44.2
Hourly earnings	$2.64	$2.77	$2.93	$3.11	$3.33
Total manufacturing: [3]					
Weekly earnings	$137.35	$141.83	$142.96	$153.76	$165.48
Weekly hours	41.3	41.2	40.9	41.3	41.6
Hourly earnings	$3.32	$3.44	$3.51	$3.74	$3.99

[1] Includes other metal mining not shown.
[2] 11-month average.
[3] Weighted average of data computed using figures for production workers as weights.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Employment and Earnings for the United States 1909–67. Bull. 1312–5, October 1967, 852 pp. Employment and Earnings, v. 15, No. 9, March 1969, and v. 16, No. 9, March 1970, table C-2.

Table 27.—Average labor-turnover rates in selected mineral industries [1]

(Per thousand employees)

Rates and year	Manu-facturing	Cement, hydraulic	Blast furnaces, steel and rolling mills	Nonferrous smelting and refining	Metal mining	Iron ore	Copper ore	Petroleum refining and related industries [2]	Petroleum refining	Coal mining
Total accession rate:										
1967	44	28	25	29	35	33	28	23	17	16
1968	46	28	30	35	34	28	29	24	18	18
1969	47	24	33	34	38	34	32	26	17	20
Total separation rate:										
1967	46	31	25	27	38	35	35	22	16	18
1968	46	25	35	30	35	36	27	24	17	17
1969	49	24	28	33	33	31	24	26	17	18
Layoff rate:										
1967	14	17	9	3	9	17	5	6	5	5
1968	12	10	14	3	8	18	5	6	4	5
1969	12	7	4	3	3	8	1	4	3	3

[1] Monthly rates are available in Employment and Earnings as indicated in source.
[2] Standard Industrial Classification Industry 295, paving and roofing materials, included in total.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Employment and Earnings Statistics for the United States, 1909–67. Bull. 1312–5, October 1967, 852 pp. Employment and Earnings, v. 15, No. 10, April 1969, and v. 16, No. 9, March 1970, table D–2.

Table 28.—Wages, salaries, and average annual earnings in the United States

	1967	1968	1969 [p]	Percent change 1967–68	Percent change 1968–69
Wages and salaries:					
All industries, total .... millions	[r] $423,075	$464,817	$509,034	+9.9	+9.5
Mining .... do	4,647	4,874	5,384	+4.9	+10.5
Manufacturing .... do	134,165	145,874	157,520	+8.7	+8.0
Average earnings per full-time employee:					
All industries, total	[r] 6,230	6,655	7,087	+6.8	+6.5
Mining	7,556	7,964	8,587	+5.4	+7.8
Manufacturing	6,880	7,347	7,768	+6.8	+5.7

[r] Revised. [p] Preliminary.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 50, No. 7, July 1970.

Table 29.—Labor-productivity indexes for selected minerals

(1957–59 = 100)

Year	Copper, crude ore mined per—			Iron, crude ore mined per—		
	Employee	Production worker	Production worker man-hour	Employee	Production worker	Production worker man-hour
1964	145.0	136.7	131.1	187.5	180.8	169.1
1965	146.0	136.1	129.1	183.0	176.9	162.6
1966 [1]	148.2	138.6	131.1	186.6	183.1	163.5
1967	126.5	129.3	123.7	190.8	188.2	168.4
1968 p	143.8	145.5	127.1	206.5	205.4	185.2
	Copper, recoverable metal mined per—			Iron, usable ore mined per—		
	Employee	Production worker	Production worker man-hour	Employee	Production worker	Production worker man-hour
1964	138.4	130.5	125.2	145.5	140.3	131.2
1965	135.3	126.2	119.6	143.2	138.5	127.3
1966	134.8	126.0	119.2	147.0	144.3	128.9
1967	112.5	115.0	110.0	139.5	137.5	123.1
1968 p	120.1	121.8	106.4	144.2	143.5	129.4
	Petroleum, refined per—			Bituminous coal and lignite mined per—		
	Employee	Production worker	Production worker man-hour	Employee	Production worker	Production worker man-hour
1964	153.9	156.9	154.7	162.6	161.5	144.4
1965	163.7	166.8	167.3	176.7	176.5	154.2
1966	177.2	180.9	180.4	187.3	188.8	162.5
1967	p 184.9	p 191.2	p 184.9	190.4	191.6	164.9
1968 p	NA	NA	NA	195.6	198.4	173.6

p Preliminary. NA Not available.
[1] Corrected figure.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Index of Output per Man-hour Selected Industries, 1939 and 1947–68. BLS Bull. 1652, December 1969, 110 pp.

Table 30.—Index of average unit mine value of minerals produced 1962–69 [1]

(1967 = 100)

	1962	1963	1964	1965	1966	1967	1968	1969 p
METALS								
Ferrous	89.3	91.5	94.3	95.3	95.7	100.0	102.0	103.9
Nonferrous:								
Base	79.8	81.3	88.8	97.8	98.9	100.0	106.3	119.8
Monetary	82.4	89.4	90.7	91.6	91.6	100.0	125.4	118.0
Other	108.1	112.2	115.5	115.0	106.7	100.0	100.8	95.9
Average	84.5	87.4	93.7	100.3	99.6	100.0	107.4	115.1
Average all metals	86.9	89.5	93.9	97.6	97.5	100.0	104.5	109.1
NONMETALS								
Construction	98.5	97.9	98.2	98.3	98.2	100.0	101.5	103.2
Chemical	89.6	88.7	91.5	93.2	95.6	100.0	102.9	98.3
Other	91.0	93.9	94.7	94.5	94.5	100.0	103.3	111.7
Average	96.4	95.8	96.6	97.0	97.4	100.0	101.9	102.6
FUELS								
Coal	97.4	95.8	96.9	96.4	98.1	100.0	101.3	109.0
Crude oil and natural gas [2]	99.0	99.2	98.2	98.0	98.8	100.0	101.4	105.2
Average	98.3	97.6	97.0	97.1	98.5	100.0	100.4	105.3
Overall average	97.3	96.8	96.8	97.1	98.2	100.0	101.1	105.0

p Preliminary.
[1] Rebased and reweighted using 1967 data. Splicing period was 1962–64.
[2] Does not cover isopentane, LP gases, and other natural gas liquids.

Table 31.—Index of implicit unit value of mineral produced [1]

	1962	1963	1964	1965	1966	1967	1968	1969 p
METALS								
Ferrous	87.7	91.2	94.1	95.4	95.7	100.0	101.9	103.9
Nonferrous:								
Base	80.1	80.8	87.1	95.5	96.8	100.0	106.7	120.4
Monetary	85.8	91.9	91.9	91.6	91.4	100.0	125.1	118.0
Other	109.5	113.1	115.9	112.3	105.1	100.0	100.4	96.3
Average	84.7	86.1	91.6	96.8	97.1	100.0	107.2	117.8
Average all metals	87.0	88.7	92.8	96.2	96.5	100.0	105.0	112.4
NONMETALS								
Construction	99.2	99.0	98.2	98.0	98.1	100.0	101.0	102.7
Chemical	89.7	89.2	91.7	92.8	95.4	100.0	102.4	98.1
Other	90.0	93.7	94.4	94.4	94.3	100.0	97.5	104.4
Average	96.8	96.2	96.7	96.8	97.3	100.0	101.4	102.2
FUELS								
Coal	96.8	95.4	96.9	96.5	98.1	100.0	101.2	108.9
Crude oil and natural gas	98.8	99.1	98.1	98.0	98.8	100.0	101.4	105.2
Average	98.0	97.5	97.0	97.1	98.5	100.0	100.4	105.3
Overall average	96.8	96.4	96.5	96.9	98.0	100.0	101.1	105.4

p Preliminary.
[1] Rebased and reweighted using 1967 data. Splicing period was 1962–64.

Table 32.—Price indexes for selected metals, minerals, and fuels

(1957–59 =100 unless otherwise stated)

Commodity	Annual average 1968	Annual average 1969	Percent change from 1968
Metals and metal products	112.4	118.9	+5.8
Iron and steel	r 105.6	111.0	+5.1
Iron ore	88.2	88.2	-----
Iron and steel scrap	67.4	80.1	+18.8
Semifinished steel products	107.3	112.4	+4.8
Finished steel products	108.6	113.8	+4.8
Foundry and forge shop products	115.0	119.3	+3.7
Pig iron and ferroalloys	80.7	81.7	+1.2
Nonferrous metals	r 125.1	137.4	+9.8
Primary metal refinery shapes	r 131.9	141.1	+7.0
Aluminum ingot	101.5	107.9	+6.3
Lead, pig, common	102.0	114.8	+12.5
Zinc, slab, prime western	121.3	131.3	+8.2
Nonferrous scrap	136.6	171.7	+25.7
Nonmetallic mineral products	r 108.2	112.8	+4.3
Concrete ingredients	r 109.3	115.6	+5.8
Sand, gravel, and crushed stone	113.1	117.4	+3.8
Concrete products	108.1	112.2	+3.8
Structural clay products	r 113.3	117.0	+3.3
Gypsum products	r 106.5	106.4	−.1
Other nonmetallic minerals	r 105.3	109.1	+3.6
Building lime	r 119.5	123.6	+3.4
Insulation materials	r 96.6	104.8	+8.5
Asbestos cement shingles	121.9	(1)	-----
Bituminous binders [2]	100.0	101.0	+1.0
Fertilizer materials	r 100.3	83.9	−16.4
Nitrogenates	88.5	70.7	−20.1
Phosphates	129.1	115.8	−10.3
Phosphate rock	147.4	147.4	-----
Potash	90.8	71.0	−21.8
Muriate, domestic	85.2	64.7	−24.1
Sulfate	115.0	101.8	−11.5
Fuels and related products and power	r 102.5	104.6	+2.0
Coal	r 107.1	116.2	+8.5
Anthracite	99.6	108.7	+9.1
Bituminous	r 108.0	117.0	+8.3
Coke	116.0	122.0	+5.2
Gas fuels [2]	r 123.9	124.5	+ .5
Electric power [2]	r 101.6	102.7	+1.1
Petroleum products, refined	100.3	101.8	+1.5
Crude petroleum	99.4	103.7	+4.3
All commodities other than farm and food	109.0	112.7	+3.4
All commodities	r 108.8	113.0	+3.9

r Revised.
[1] Publication discontinued.
[2] January 1958 =100.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Wholesale Prices and Price Indexes. January 1969–February 1970. Tables 2 and 2A.

Table 33.—Comparative mineral energy resource prices

Fuel	1967	1968	1969
Bituminous coal: Average prices per net ton at merchant coke ovens	r $10.33	r $10.58	r $10.75
Anthracite, average sales realization per net ton at preparation plants, excluding dredge coal:			
Chestnut	$12.03	$13.02	$14.12
Pea	$9.75	$10.80	$12.14
Buckwheat No. 1	r $9.19	$10.13	$11.53
Petroleum and petroleum products:			
Crude petroleum, average price per barrel at well	$2.92	$2.94	$3.09
Gasoline, average dealers' net price (excluding taxes) of gasoline in 55 U.S. cities [1] cents per gallon	16.31	16.51	17.11
Residual fuel oil:			
No. 6 fuel, average of high and low prices per barrel (refinery) at Philadelphia [1]	$3.10	$3.10	$3.10
Bunker C, average price per barrel for all Gulf ports [1]	$1.98	$1.67	$1.47
Distillate fuel oil:			
No. 2 distillate, average of high and low prices at Philadelphia [1] cents per gallon (refinery)	10.57	10.90	10.90
No. 2 distillate, average price for all Gulf ports [1] do	9.48	9.40	9.24
Natural gas:			
Average U.S. value at well cents per thousand cubic feet	16.0	16.4	16.7
Average U.S. value at point of consumption do	51.9	50.4	51.5

r Revised.
[1] Platt's Oil Price Handbook.

Table 34.—Cost of fuel in steam-electrical power generation

(Cents per million Btu)

Region	1966			1967			1968		
	Coal	Oil	Gas	Coal	Oil	Gas	Coal	Oil	Gas
New England	33.6	32.9	33.8	34.3	30.5	32.2	34.3	30.5	32.2
Middle Atlantic	26.5	31.8	34.4	27.8	33.2	35.4	27.8	33.2	35.4
East North-Central	24.4	59.8	25.9	24.7	62.9	26.7	24.7	62.9	26.7
West North-Central	26.4	49.9	24.2	25.6	51.6	24.0	25.6	51.6	24.0
South Atlantic	25.6	33.6	31.8	26.6	32.5	31.7	26.6	32.5	31.7
East South-Central	19.3	52.1	22.7	20.1	53.2	23.4	20.1	53.2	23.4
West South-Central	------	40.7	19.8	------	42.4	19.9	------	42.4	19.9
Mountain	20.4	25.4	26.7	20.1	26.1	26.2	20.1	26.1	26.2
Pacific	------	31.5	31.5	------	31.4	30.8	------	31.4	30.8
United States	24.7	32.4	25.0	25.2	32.2	24.7	25.2	32.2	24.7

Source: National Coal Association. Steam-Electric Plant Factors. 1966 through 1968, table 2.

Table 35.—Cost of electrical energy

(Cents per kilowatt hour)

Region	1966			1967			1968		
	Total	Residential	Commercial and industrial	Total	Residential	Commercial and industrial	Total	Residential	Commercial and industrial
New England	2.3	2.9	1.9	2.3	2.9	1.9	2.2	2.7	1.9
Middle Atlantic	1.9	2.7	1.5	1.8	2.6	1.5	1.9	2.6	1.5
East North-Central	1.7	2.4	1.3	1.6	2.4	1.3	1.6	2.3	1.3
West North-Central	2.0	2.5	1.7	2.0	2.5	1.7	1.9	2.4	1.6
South Atlantic	1.6	2.1	1.3	1.6	2.0	1.3	1.5	2.0	1.3
East South-Central	.9	1.3	.7	.9	1.3	.7	.9	1.3	.8
West South-Central	1.6	2.3	1.2	1.5	2.3	1.2	1.5	2.2	1.2
Mountain	1.5	2.2	1.2	1.5	2.2	1.3	1.5	2.2	1.2
Pacific	1.2	1.7	1.0	1.2	1.7	1.0	1.2	1.7	1.0
Alaska and Hawaii	2.5	2.9	2.2	2.5	2.9	2.2	2.4	2.9	2.2
United States	1.6	2.2	1.3	1.6	2.2	1.3	1.5	2.1	1.3

Source: Edison Electric Institute. Statistical Yearbook of the Electric Utilities Industry. 1966 through 1968.

Table 36.—Indexes of principal metal mining expenses [1]

(1957–59 = 100)

Year	Total	Labor	Supplies	Fuel	Electrical energy
1965	[2] 102	[2] 101	103	99	101
1966	[2] 104	[2] 103	105	101	100
1967	109	[r] 111	107	104	101
1968	110	113	109	102	102
1969 [p]	114	116	113	105	103

[p] Preliminary. [r] Revised.
[1] Indexes constructed using the following weights derived from the 1963 Census of Mineral Industries: Labor, 54.11; explosives, 2.35; steel mill shapes and forms, 6.40; all other supplies, 26.75; fuels, 4.86; electric energy, 5.53; and data from U.S. Department of Labor, Bureau of Labor Statistics, Wholesale Prices and Price Indexes. The index is computed for iron and copper ores only because sufficient data are not available for other mining sectors.
[2] Revised because of the change in weight values.

Table 37.—Index of major input expenses for bituminous coal and crude petroleum and natural gas mining [1]

(1957–59 = 100)

Year	Bituminous coal	Crude petroleum and natural gas	Year	Bituminous coal	Crude petroleum and natural gas
1965	86	100	1968	NA	NA
1966	86	100	1969	NA	NA
1967 [p]	87	100			

[p] Preliminary. NA Not available.
[1] Indexes constructed by using data from the U.S. Department of Labor, Bureau of Labor Statistics, Wholesale Prices and Price Indexes, annual and monthly, and weights derived from data shown in the 1963 Census of Mineral Industries, U.S. Department of Commerce, Bureau of the Census. Weights used are as follows: Bituminous coal—labor, 62.98, explosives, 1.77, steel mill shapes and forms, 3.88, all other supplies, 24.92, fuels, 1.76, electric energy, 4.69; crude petroleum and natural gas—labor, 46.3, fuel, 2.6, electric energy, 3.5, and all other, 47.6.

Table 38.—Indexes of relative labor costs and productivity for iron ore, copper, bituminous coal, and petroleum mining [1]

(1957–59 = 100)

Year	Iron ore [2]	Copper [2]	Bituminous coal	Petroleum
	INDEX OF LABOR COSTS PER UNIT OF OUTPUT			
1965	91	110	76	98
1966	r 93	112	75	94
1967	97	123	p 77	p 93
1968	98	126	NA	NA
1969 p	101	129	NA	NA
	INDEX OF VALUE OF PRODUCT PER MAN-PERIOD			
1965	119	145	140	124
1966	r 120	148	151	136
1967	115	146	p 163	p 147
1968	121	165	NA	NA
1969 p	125	194	NA	NA
	INDEX OF LABOR COSTS PER DOLLAR OF PRODUCT			
1965	97	90	85	102
1966	r 100	91	82	98
1967	105	93	p 79	p 95
1968	105	87	NA	NA
1969 p	108	78	NA	NA

p Preliminary. r Revised. NA Not available.

[1] Index of labor costs per unit of output: Iron ore and copper indexes are computed from data found in U.S. Department of Labor, Employment and Earnings and Wholesale Price Indexes. Bituminous coal index based upon net tons per man per day (see chapter on Bituminous Coal) and index of average earnings derived from Bureau of Labor Statistics data on hourly earnings; petroleum index based on barrels per year (see chapter on Petroleum) and Bureau of Employment Security data on total wages in petroleum production.

Index of value of product per man-period: Iron ore and copper indexes are computed from data found in U.S. Department of Labor, Employment and Earnings and Wholesale Price Indexes. Bituminous coal index based on net tons per man per day and mine value of production; petroleum index based on average employment and total value of production.

Index of labor costs per dollar of product: Iron ore and copper indexes are computed from data found in U.S. Department of Labor, Employment and Earnings and Wholesale Price Indexes. Bituminous coal index based on index of value per man per day and index of average earnings; petroleum index based on total value of production and total wages.

[2] Indexes are for recoverable metal.

Table 39.—Price indexes for selected cost items in minerals and mineral fuels production

(1957–59 = 100, unless otherwise specified)

Commodity	1969 January	1969 December	Change from January (percent)	Annual average 1968	Annual average 1969	Change from 1968 (percent)
Coal	112.7	124.6	+10.6	r 107.1	116.2	+8.5
Coke	120.3	126.9	+5.5	116.0	122.0	+5.2
Gas fuels (January 1958 = 100)	124.4	131.8	+5.9	r 123.9	124.5	+.5
Petroleum products, refined	98.9	102.2	+3.3	100.3	101.8	+1.5
Industrial chemicals	98.1	97.8	−.3	98.4	97.7	−.7
Lumber	147.9	128.2	−13.3	r 127.3	142.6	+12.0
Explosives	114.8	117.7	+2.5	114.8	117.0	+1.9
Construction machinery and equipment	133.5	139.8	+4.7	r 130.2	135.5	+4.1

r Revised.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Wholesale Prices and Price Indexes, January–February 1969, tables 2 and 2B; January 1970, table 2A, January–December 1969 issues, table 2, used to figure annual average for explosives.

Table 40.—Price indexes for mining, construction, and material handling machinery and equipment

(1957-59 = 100)

Year	Construction machinery and equipment	Mining machinery and equipment	Oilfield machinery and tools	Power cranes, draglines, shovels, etc.	Specialized construction machinery	Portable air compressors	Scrapers and graders	Mixers, pavers, spreaders, etc.	Tractors other than farm
1965	115.3	113.3	104.7	113.7	110.3	128.7	114.2	119.6	117.6
1966	118.9	116.8	106.2	118.3	114.5	133.8	117.1	123.7	120.8
1967	123.2	120.3	110.0	122.3	117.0	134.9	120.1	128.5	126.1
1968 r	130.2	124.4	117.0	128.3	123.1	130.8	126.5	134.2	134.7
1969	135.5	127.9	123.7	133.0	128.9	123.9	132.0	139.1	140.9

r Revised.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Wholesale Prices and Price Indexes, January 1970, and previous years, table 2A.

Table 41.—National income originated in the mineral industries

Industry	Income, millions 1967 r	1968	1969 p	Change from 1968 (percent)
Mining	$6,345	$6,787	$7,157	+5.5
Metal mining	667	838	915	+9.2
Coal mining	1,453	1,462	1,615	+10.5
Crude petroleum and natural gas	2,995	3,195	3,370	+5.5
Mining and quarrying of nonmetallic minerals	1,230	1,292	1,257	−2.7
Manufacturing	195,192	213,009	226,227	+6.2
Chemicals and allied products	14,068	15,440	16,392	+6.2
Petroleum refining and related industries	6,494	6,451	6,672	+3.4
Stone, clay, and glass products	5,785	6,504	7,118	+9.4
Primary metal industries	15,348	16,023	16,848	+5.1
All industries	653,580	712,686	769,505	+8.0

p Preliminary. r Revised.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 50, No. 7, July 1970.

Table 42.—Annual average profit rates on shareholders' equity, after taxes, and total dividends, selected mineral manufacturing corporations

Industry	Annual profit rate (percent) 1968	1969	Change from 1968	Total dividends (millions) 1968	1969	Change from 1968 (percent)
All manufacturing [1]	12.1	11.5	−0.6	$14,189	$15,058	+6.1
Primary metals	8.9	9.5	+.6	1,205	1,195	−.8
Primary iron and steel	7.6	7.6	-----	640	615	−3.9
Primary nonferrous metals	10.7	12.2	+1.5	565	579	+2.5
Stone, clay, and glass products	9.2	9.2	-----	353	352	−.3
Chemicals and allied products	13.3	12.8	−.5	1,844	1,890	+2.5
Petroleum refining and related industries	12.2	11.7	−.5	2,876	3,082	+7.2
Petroleum refining	12.3	11.7	−.6	2,866	3,076	+7.3

[1] Except newspapers.

Source: Federal Trade Commission, Securities and Exchange Commission. Quarterly Financial Report for Manufacturing Corporations. 1st Quarter and 4th Quarter 1969, tables 4, 8.

Table 43.—Industrial and commercial failures and liabilities in mining and manufacturing

Industry	1967	1968	1969
Mining: [1]			
Number of failures	71	57	34
Current liabilities thousands	$24,576	$28,773	$15,104
Manufacturing:			
Number of failures	1,761	1,456	1,459
Current liabilities thousands	$301,293	$262,927	$391,346
All industrial and commercial industries:			
Number of failures	12,364	9,636	9,154
Current liabilities thousands	$1,265,227	$940,996	$1,142,113

[1] Including fuels.

Source: Dun & Bradstreet, Inc., Business Economics Department. Monthly Failure Report K–11, No. 12, Jan. 31, 1970, 4 pp.

Table 44.—Expenditures for new plant and equipment by firms in mining and selected mineral manufacturing industries

(Billions)

Industry	1967 [r]	1968 [r]	1969
Mining [1]	$1.65	$1.63	$1.86
Manufacturing:			
Primary iron and steel	1.92	2.00	1.83
Primary nonferrous metals	1.07	1.09	1.10
Stone, clay, and glass products	.96	.86	1.07
Chemical and allied products	3.06	2.83	3.10
Petroleum and coal products	5.08	5.25	5.63
All manufacturing	28.51	28.37	31.68

[r] Revised.
[1] Including fuels.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 50, No. 1, January 1970, p. 29, table 1; v. 50, No. 6, June 1970, p. 18, table 5.

Table 45.—Plant and equipment expenditures of foreign affiliates of U.S. companies by area and industry

(Millions)

Area and country	1967			1968			1969 [1]		
	Mining and smelting	Petroleum	Manufacturing	Mining and smelting	Petroleum	Manufacturing	Mining and smelting	Petroleum	Manufacturing
Canada	[r] $332	$636	[r] $1,001	$340	$669	$846	$358	$722	$1,081
Latin America	[r] 288	[r] 306	[r] 505	456	415	574	556	622	716
Europe	8	[r] 1,045	[r] 2,332	10	834	2,012	12	1,067	2,720
All other areas	293	[r] 1,012	687	227	1,367	746	297	1,741	829
Total [2]	[r] 920	[r] 3,000	[r] 4,525	1,033	3,285	4,178	1,223	4,152	5,346

[r] Revised.
[1] Estimated in June 1969.
[2] Details may not add to total because of rounding.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 49, No. 9, September 1969, p. 18.

Table 46.—Estimated gross proceeds of new corporate securities offered for cash in 1969 [1]

Type of security	Total corporate		Manufacturing		Extractive [2]	
	Millions	Percent	Millions	Percent	Millions	Percent
Bonds	$18,348	68.6	$4,451	70.0	$377	21.9
Preferred stock	682	2.6	65	1.0	1	.1
Common stock	7,714	28.8	1,840	29.0	1,343	78.0
Total	26,744	100.0	6,356	100.0	1,721	100.0

[1] Substantially all new issues of securities offered for cash sale in the United States in amounts over $100,000 and with terms of maturity of more than 1 year are covered in these data.
[2] Including fuels.

Source: U.S. Securities and Exchange Commission. Statistical Bulletin. V. 29, No. 4, April 1970, p. 12.

Table 47.—Direct private investment of U.S. companies in foreign petroleum industries in 1968 [p]

(Millions; net inflows to the United States designated by —)

	Petroleum				All industries			
	Book value beginning of year	Net capital outflows	Undistributed earnings of subsidiaries	Book value end of year	Book value beginning of year	Net capital outflows	Undistributed earnings of subsidiaries	Book value end of year
Canada	$3,819	$163	$107	$4,088	$18,097	$594	$762	$19,488
Latin American Republics, all	2,903	59	25	2,976	10,265	461	297	11,010
Other Western Hemisphere	569	81	17	667	1,779	111	59	1,979
Europe	4,423	321	—112	4,640	17,926	995	442	19,386
Africa	1,219	313	15	1,567	2,273	308	71	2,673
Middle East	1,608	39	13	1,654	1,749	37	23	1,803
Far East	992	123	31	1,146	2,540	197	160	2,891
Oceania	592	36	19	646	2,520	164	132	2,821
International [1]	1,279	46	124	1,451	2,336	158	196	2,705
Total [2]	17,404	1,181	239	18,835	59,486	3,025	2,142	64,756

[p] Preliminary.
[1] Comprised of international trading and shipping companies.
[2] Data may not add to totals shown because of independent rounding.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 49, No. 10, October 1969, pp. 28–29.

Table 48.—Direct private investments of the United States in foreign mining and smelting industries in 1968 p

(Millions)

	Value	Net capital outflow	Undistributed earnings of subsidiaries	Earnings[1]	Income[2]
Canada	$2,636	$194	$102	$285	$180
Latin America, total	1,402	119	7	294	275
Mexico	112	5	7	17	9
Panama	19	-------	-------	-------	-------
Brazil	81	(3)	-------	(3)	(3)
Chile	586	78	−8	134	131
Peru	421	22	1	85	83
Europe	61	−2	2	8	6
Africa, total	387	−15	2	69	63
South Africa, Republic of	78	−14	−7	31	32
Far East	42	1	(4)	(4)	(4)
Oceania, total	367	33	12	34	23
Australia	365	33	12	33	23
All other countries[5]	476	54	1	98	99
Total, all areas[6 7]	5,370	383	126	789	645

p Preliminary.
1 Earnings is the sum of the U.S. share in net earnings of subsidiaries, and branch profits.
2 Income is the sum of dividends, interest, and branch profits.
3 Combined in "other" industries in source reference.
4 Less than ½ unit.
5 "All other countries" includes other Western Hemisphere, Middle East, and International.
6 Excludes Communist countries.
7 Data may not add to total shown because of independent rounding.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 49, No. 10, October 1969, pp. 28–29.

Table 49.—Value of foreign direct investments in the United States

(Millions)

Industry	1964	1965	1966	1967	1968
Total	$8,363	$8,797	$9,065	$9,054	$10,815
Petroleum	1,612	1,710	1,740	1,885	2,261

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 49, No. 10, October 1969, p. 36, table 15.

Table 50.—Rail and water transportation of selected minerals and mineral energy products in the United States

(Thousand short tons)

Products	Rail[1] 1967	Rail[1] 1968	Rail[1] Change from 1967 (percent)	Water[2] 1967	Water[2] 1968	Water[2] Change from 1967 (percent)
Metals and minerals except fuels:						
Iron ore and concentrates	92,784	94,096	+1.4	68,291	69,002	+1.0
Iron and steel scrap	25,469	26,716	+4.9	1,551	1,577	+1.7
Pig iron	3,727	4,296	+15.3	698	648	-7.2
Iron and steel ingot, plates, bars, rods, tubing, and other primary products	49,841	54,291	+8.9	7,738	8,184	+5.8
Bauxite and other aluminum ores and concentrates	4,322	4,060	-6.1	907	904	-.3
Other nonferrous ores and concentrates	11,867	13,515	+13.9	1,378	438	-68.2
Nonferrous metals and alloys	r 8,626	9,508	+10.2	686	631	-8.0
Nonferrous metal scrap	3,035	3,201	+5.5	36	46	+27.8
Slag	1,943	2,047	+5.4	519	465	-10.4
Sand and gravel	57,544	58,966	+2.5	66,136 (Sand and gravel and stone combined)	72,291	+9.3
Stone, crushed and broken	63,279	63,202	-.1			
Limestone flux and calcareous stone	---------	---------	---------	31,743	33,520	+5.6
Cement, building	25,135	25,309	+.7	8,719	10,658	+22.2
Phosphate rock	34,015	32,973	-3.1	4,738	4,763	+.5
Clays, ceramic and refractory minerals	3,249	3,202	-1.5	2,180	2,154	-1.2
Sulfur, dry	3,514 (dry and liquid combined)	3,160	-10.1	157	101	-35.7
Sulfur, liquid				8,747	8,485	-3.0
Gypsum and plaster rock	672	749	+11.5	787	765	-2.8
Other nonmetallic minerals except fuels	r 8,179	8,405	+2.8	6,194	5,898	-4.8
Fertilizer and fertilizer materials	18,790	18,382	-2.2	2,933	3,673	+25.2
Total	415,991	426,078	+2.4	214,138	224,203	+4.7
Mineral energy resources and related products:						
Coal:						
Anthracite	7,879	7,471	-5.2	164,378 (Anthracite and bituminous combined)	156,103	-5.0
Bituminous and lignite	376,704	371,654	-1.3			
Coke	293	262	-10.6	485	483	-.4
Crude petroleum	660	566	-14.2	103,301	107,010	+3.6
Gasoline	3,257 (Gasoline and jet fuel combined)	2,777	-14.7	83,653	82,720	-1.1
Jet fuel				12,152	12,566	+3.4
Kerosine	260	253	-2.7	8,413	8,539	+1.5
Distillate fuel oil	1,777	1,748	-1.6	79,585	74,612	-6.3
Residual fuel oil	4,181	4,456	+6.6	44,032	55,599	+26.3
Asphalt, tar, and pitches	2,917	2,933	+.5	7,566	8,207	+8.5
Liquefied petroleum gases and coal gases	6,395	6,998	+9.4	730	1,036	+41.9
Other petroleum and coal products[3]	r 8,924	9,468	+6.1	10,385	10,713	+3.2
Total	r 413,247	408,586	-1.1	514,680	517,588	+.6
Total mineral products	r 829,238	834,664	+.7	728,818	741,791	+1.8
Grand total, all commodities	1,406,668	1,430,441	+1.7	870,634	887,889	+2.0
Mineral products, percent of grand total:						
Metals and minerals, except fuels	r 29.6	29.8	+.7	24.6	25.3	+2.8
Mineral energy resources and related products	29.4	28.6	-2.7	59.1	58.3	-1.4
Total mineral products	r 59.0	58.4	-1.0	83.7	83.6	-.1

r Revised.

[1] Revenue freight originated on respondent's road and terminated on line by originating carrier or delivered to connecting carrier.

[2] Domestic traffic includes all commercial movements between points in the United States, Puerto Rico, and the Virgin Islands.

[3] Includes lubricants, naphtha, and other petroleum solvents, and miscellaneous petroleum and coal products.

Sources: Interstate Commerce Commission, Bureau of Accounts. Freight Commodity Statistics, Class I Railroads in the United States for the Years Ended December 31, 1967 and 1968. Statements No. 69100 and No. 69100-A. Department of the Army, Corps of Engineers. Waterborne Commerce of the United States, Part 5, National Summaries. Calendar Years 1967 and 1968, table 2.

Table 51.—Percentage distribution of mine shipments of bitumnious coal and lignite by method of shipment and mine use

Year	Shipped by rail and trucked to rail	Shipped by water and trucked to water	Trucked to final destination	Used at mines [1]	Total production
1965	72.6	11.8	13.3	2.3	100.0
1966	72.5	11.6	12.6	3.3	100.0
1967	73.2	12.1	11.2	3.5	100.0
1968	72.7	12.3	11.3	3.7	100.0
1969	71.0	12.7	11.8	4.5	100.0

[1] Includes coal used at mine for power and heat, made into beehive coke at mine, used by mine employees, used for all other purposes at mine, and transported from mine to point of use by conveyor, tram, or pipeline.

Table 52.—Miles of utility gas main by type of gas and by type of main [1]

Type of gas and type of main	1964	1965	1966	1967	1968
All types:					
Field and gathering	61,010	61,760	62,980	63,710	64,440
Transmission	205,400	211,240	216,980	225,360	234,450
Distribution	469,810	494,520	519,610	539,200	562,750
Total	736,220	767,520	799,570	828,270	861,640
Natural gas:					
Field and gathering	61,010	61,760	62,980	63,710	64,440
Transmission	204,730	210,660	216,410	224,790	233,940
Distribution	458,770	484,260	509,840	529,340	554,030
Total	724,510	756,680	789,230	817,840	852,410
Manufactured gas:					
Transmission	(2)	10	---------	---------	---------
Distribution	1,460	1,420	1,180	1,140	1,070
Total	1,460	1,430	1,180	1,140	1,070
Mixed gas:					
Transmission	670	570	570	570	510
Distribution	8,310	7,810	7,800	7,950	6,980
Total	8,980	8,380	8,370	8,520	7,490
Liquefied petroleum gas: Distribution	1,270	1,030	790	770	670

[1] Excludes service pipe. Data not adjusted to common diameter equivalent. Mileage shown as of end of each year.
[2] Less than 5 miles.

Source: American Gas Association. Gas Facts, a Statistical Record of the Gas Utility Industry in 1968, p. 61. For earlier years, see Historical Statistics of the Gas Industry.

Table 53.—Petroleum pipelines, selected years

(Miles)

Year	Trunklines		Gathering lines	Total
	Crude	Products		
1956	78,594	36,420	73,526	188,540
1959	70,317	44,483	75,182	189,982
1962	70,355	53,200	76,988	200,543
1965	72,383	61,443	77,041	210,867
1968	70,825	64,529	74,124	209,478

Table 54.—Research and development activity

(Millions)

	Total		Company		Federal Government	
	1966	1967 p	1966	1967 p	1966	1967 p
Petroleum refining and extraction	$430	$469	$383	$431	$47	$38
Percent of all industries	2.7	2.9	5.3	5.4	0.6	0.5
Chemicals and allied products	$1,461	$1,565	$1,271	$1,353	$190	$212
Percent of all industries	9.4	9.5	17.8	16.8	2.3	2.5
All industries	$15,548	$16,420	$7,216	$8,032	$8,332	$8,388

p Preliminary.

Source: National Science Foundation. Reviews of Data on Science Resources. No. 12, January 1969, table 1.

Table 55.—Federal obligated funds for metallurgy and mineral research

(Thousands)

Federal agency	Fiscal year 1969 e			Fiscal year 1970 e		
	Basic research	Applied research	Total research	Basic research	Applied research	Total research
Department of Defense	$17,407	$49,017	$66,424	$20,340	$60,172	$80,512
Atomic Energy Commission	11,972	15,208	27,180	12,284	15,080	27,364
National Aeronautics and Space Administration	14,638	7,200	21,838	15,524	6,322	21,846
Bureau of Mines	-------	11,810	11,810	-------	12,238	12,238
National Science Foundation	2,494	-------	2,494	2,445	514	2,959
Department of Agriculture	-------	-------	-------	-------	-------	-------
Department of Commerce	1,450	46	1,496	1,527	46	1,573
Other	1,459	1,844	3,303	1,509	3,386	4,895
Total	49,420	85,125	134,545	53,629	97,758	151,387

e Estimate.

Source: National Science Foundation. Federal Funds for Research, Development, and other Scientific Activities. NSF 69-31, v. 18, August 1969, tables C-24, C-25, C-43, C-44, C-62, C-63.

Table 56.—Bureau of Mines obligations for mining and mineral research and development

(Thousands)

Fiscal year	Applied research	Basic research	Development	Total
1966	$20,836	$4,636	$3,390	$28,862
1967	23,148	4,841	4,423	32,412
1968	24,215	4,893	5,136	34,244
1969	25,934	4,051	5,033	35,018
1970 e	27,168	6,298	12,558	46,024

e Estimate.

Table 57.—Bureau of Mines obligations for total research, by field of science

(Thousands)

	Fiscal year		
	1968	1969	1970 e
Engineering sciences	$20,032	$19,547	$23,673
Physical sciences	6,999	8,192	7,452
Mathematical sciences	595	689	557
Environmental sciences	1,482	1,557	1,784
Total	29,108	29,985	33,466

e Estimate.

Table 58.—Summary of government inventories of strategic and critical materials December 31, 1969

	Acquisition cost	Market value [1]
Total inventories:		
National stockpile	$4,321,671,300	$5,196,071,700
Supplemental stockpile	1,443,878,200	1,507,874,200
Defense Production Act	848,990,600	519,059,800
Commodity Credit Corporation	23,600	22,400
Total on hand	6,614,563,700	7,223,028,100
On order	83,764,900	114,380,500
Inventories within objective: Total on hand	3,773,446,700	4,467,164,300
Inventories excess to objective: Total on hand	2,841,117,000	2,755,863,800

[1] Market values are estimated from prices at which similar materials are being traded; or in the absence of trading data, at an estimate of the price which would prevail in the market. Prices used are unadjusted for normal premiums and discounts relating to contained qualities or for normal freight allowances. The market values do not necessarily reflect the amount that would be realized at time of sale. Stockpile value is based on inventories in storage and includes quantities sold but not shipped.

Source: Executive Office of the President, Office of Emergency Preparedness. Stockpile Report to the Congress, July–December 1969, p. 8.

Table 59.—U.S. Government stockpile disposal of mineral commodities, 1969

Commodity	Sales commitments	
	Quantity	Sales value
NATIONAL AND SUPPLEMENTAL STOCKPILE INVENTORIES		
Aluminum short tons	108,411	$58,500,614
Aluminum oxide do	400	43,400
Antimony do	2,395	2,013,791
Asbestos, amosite do	2,294	404,532
Asbestos, crocidolite do	2,663	540,862
Beryl ore do	1,946	1,139,805
Bismuth pounds	334,130	1,336,630
Cadmium do	2,655,892	7,960,457
Celestite short tons	12,199	226,919
Chromite, chemical short dry tons	5,320	68,350
Chromite, metallurgical do	44,339	995,209
Fluorspar, acid-grade do	200	[1] 2,978
Graphite short tons	1,893	248,705
Lead do	25,629	8,467,622
Magnesium do	26,481	17,030,172
Manganese, metallurgical do	26,909	406,432
Manganese, battery, synthetic dioxide do	1,000	339,966
Mica pounds	572,964	700,334
Molybdenum do	9,958,549	17,177,757
Quartz crystals do	140,510	634,757
Rare earths short dry tons	760	337,437
Thorium pounds	1,585	4,777
Tin long tons	2,046	7,523,480
Vanadium short tons	677	3,492,941
Zinc do	17,355	5,071,126
Total	----------	134,669,053
DEFENSE PRODUCTION ACT (DPA) INVENTORY		
Aluminum short tons	28,899	15,726,505
Asbestos, chrysotile do	336	62,401
Cobalt pounds	9,068,176	18,165,540
Columbium do	1,564,362	2,491,479
Fluorspar, acid-grade short dry tons	9,131	399,486
Manganese, metallurgical do	7,627	73,512
Mica pounds	276,643	318,758
Mica, muscovite block do	15,068	37,007
Titanium short tons	1,247	2,620,020
Titanium sponge do	6	11,775
Tungsten pounds	38,376,547	100,962,895
Total	----------	140,869,378
OTHER		
Asbestos, crocidolite short tons	1	25
Bauxite long dry tons	110,000	500,000
Lithium pounds	3,885	1,339
Mercury flasks	3,078	1,597,420
Nickel pounds	9,000,000	10,295,761
Silver (fine) [2] troy ounces	----------	39,270,561
Total	----------	51,665,106
Grand total	----------	327,203,537

[1] Includes a credit of $2,022.
[2] Represents that portion of the total proceeds in excess of the U.S. monetary value based on $1.2929. 48,468,570 ounces of silver were sold at an average price of $1.896, and 40,620,361 ounces were sold at an average price of $1.74.

Source: Executive Office of the President, Office of Emergency Preparedness. Stockpile Report to the Congress. January–June 1969, pp. 13–14; July–December 1969, pp. 20–21.

Table 60.—United Nations indexes of world[1] mineral industry production

(1963 = 100)

Industry sector and geographic area	1967	1968	1969	1969 by quarters: 1st	2nd	3rd	4th
EXTRACTIVE INDUSTRIES							
Metals:							
Non-Communist world	115	121	126	121	129	128	127
Industrialized countries [2]	114	121	125	120	129	125	126
United States and Canada	115	122	125	121	130	123	125
Europe	108	117	123	123	128	119	123
European Economic Community [3]	92	95	96	97	100	91	95
Less industralized countries [4]	118	121	129	122	127	135	130
Latin America [5]	122	124	131	123	131	139	131
Asia, East and Southeast [6]	119	120	127	121	121	134	130
Communist Europe [7]	149	161	170	170	170	172	167
World	123	130	136	132	138	138	136
Coal:							
Non-Communist world	94	91	90	92	90	85	91
Industrialized countries [2]	92	89	87	90	88	82	89
United States and Canada	117	114	114	111	117	110	118
Europe	84	80	77	83	77	71	78
European Economic Community [3]	83	80	79	83	77	75	82
Less industrialized countries [4]	112	114	118	116	120	117	118
Latin America [5]	121	131	135	NA	NA	NA	NA
Asia, East and Southeast [6]	112	116	117	116	119	115	118
Communist Europe [7]	111	114	118	118	115	118	120
World	101	100	101	103	100	98	103
Crude petroleum and natural gas:							
Non-Communist world	126	135	144	139	143	144	150
Industrialized countries [2]	116	121	124	122	124	123	127
United States and Canada	116	120	123	120	124	122	126
Europe	124	133	144	146	136	137	159
European Economic Community [3]	122	133	147	149	139	139	163
Less industrialized countries [4]	140	155	171	163	169	173	179
Latin America [5]	106	109	109	107	107	111	112
Asia, East and Southeast [6]	141	155	169	160	167	171	178
Communist Europe [7]	145	157	164	163	166	164	163
World	130	140	148	144	149	148	152
Total extractive industry:							
Non-Communist world	118	124	130	126	131	130	134
Industrialized countries [2]	111	115	118	115	119	117	121
United States and Canada	117	120	124	119	125	123	126
Europe	99	102	105	106	104	100	108
European Economic Community [3]	99	105	111	112	108	106	117
Less industrialized countries [4]	133	146	159	152	157	161	165
Latin America [5]	111	113	116	112	114	120	117
Asia, East and Southeast [6]	137	149	161	153	160	163	169
Communist Europe [7]	132	141	144	144	144	144	144
World	122	129	134	132	135	134	137
PROCESSING INDUSTRIES							
Base metals:							
Non-Communist world	123	133	147	144	149	141	150
Industrialized countries [2]	123	132	146	144	149	140	149
United States and Canada	117	122	132	132	137	125	131
Europe	118	131	145	145	148	137	149
European Economic Community [3]	119	133	148	147	150	143	152
Less industrialized countries [4]	127	141	156	150	154	160	162
Latin America [5]	127	141	162	150	161	171	169
Asia, East and Southeast [6]	129	139	151	155	148	147	157
Communist Europe [7]	136	147	156	156	155	156	156
World	127	137	149	148	151	145	152
Nonmetallic mineral products:							
Non-Communist world	123	131	141	126	144	148	145
Industrialized countries [2]	122	130	138	123	143	146	142
United States and Canada	118	124	132	120	136	141	133
Europe	122	130	137	118	144	145	141
European Economic Community [3]	117	126	133	111	141	145	138
Less industrialized countries [4]	133	142	157	142	156	161	168
Latin America [5]	130	146	149	140	151	150	156
Asia, East and Southeast [6]	135	142	166	146	163	173	183
Communist Europe [7]	143	153	164	162	167	161	168
World	131	140	150	137	152	152	154

See footnotes at end of table.

Table 60.—United Nations indexes of world [1] mineral industry production—Continued

(1963 = 100)

Industry sector and geographic area	1967	1968	1969	1969 by quarters 1st	2nd	3rd	4th
PROCESSING INDUSTRIES—Continued							
Chemicals, petroleum, and coal products:							
Non-Communist world	137	152	167	162	167	166	172
Industrialized countries [2]	138	153	168	163	169	166	172
United States and Canada	132	143	153	150	154	153	155
Europe	143	161	181	177	183	175	187
European Economic Community [3]	145	166	187	182	190	183	193
Less industrialized countries [4]	133	148	159	152	156	162	166
Latin America [5]	133	147	159	NA	NA	NA	NA
Asia, East and Southeast [6]	133	148	162	155	155	164	172
Communist Europe [7]	159	176	196	192	196	198	196
World	142	157	173	168	173	172	177
Overall industrial production:							
Non-Communist world	127	135	145	142	145	143	151
Industrialized countries [2]	126	135	144	141	145	142	150
United States and Canada	127	133	139	137	140	139	140
Europe	119	128	139	137	140	132	148
European Economic Community [3]	117	127	141	138	142	135	151
Less industrialized countries [4]	131	141	152	148	150	154	157
Latin America [5]	126	134	142	NA	NA	NA	NA
Asia, East and Southeast [6]	133	145	157	153	155	158	163
Communist Europe [7]	139	151	162	162	163	160	162
World	130	140	150	147	150	148	154

NA Not available.
[1] Excludes a number of countries of the Near East and Africa as well as mainland China, North Korea, and North Vietnam.
[2] All countries having a per capita value added in manufacturing in 1958 equivalent to US$125 or more.
[3] Belgium, France, West Germany, Italy, Luxembourg, and the Netherlands.
[4] Countries having a per capita value added in manufacturing in 1958 of less than US$125.
[5] Central and South America and the Caribbean Islands.
[6] Afghanistan, Brunei, Burma, Ceylon, Hong Kong, India, Indonesia, Iran, South Korea, Malaysia (excluding Sabah), Mongolia, Pakistan, Philippines, Singapore, Taiwan, Thailand, and South Vietnam.
[7] Albania, Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, Rumania, and U.S.S.R.

Source: United Nations Monthly Bulletin of Statistics, August 1970, pp. 10–21.

Table 61.—Comparisons of world and U.S. production and U.S. imports of principal minerals and mineral fuels in 1969

Mineral	World production (thousand short tons unless otherwise stated) p	U.S. production (percentage of world total)	U.S. imports (percentage of world production)	Total U.S. production and imports (percentage of world total 1969)	Total U.S. production and imports (percentage of world total 1968) r
METALLIC ORES AND CONCENTRATES					
Bauxite thousand long tons	51,113	3.6	23.8	27.4	28.0
Chromite	5,689	----------	19.4	19.4	20.3
Copper (content of ore and concentrate)	6,655	23.2	3.7	26.9	25.9
Iron ore thousand long tons	712,950	12.4	5.7	18.1	19.2
Lead (content of ore and concentrate)	3,523	14.4	3.3	17.7	13.8
Mercury thousand 76-pound flasks	285	10.3	11.2	21.5	20.4
Molybdenum (content of ore and concentrates) short tons	71,134	70.2	(1)	70.2	74.3
Nickel (content of ore and concentrate)	530	3.2	24.4	27.6	30.2
Platinum group (Pt, Pd, etc.) thousand troy ounces	3,337	.6	23.4	24.0	46.8
Silver do	288,601	14.5	24.9	39.4	37.6
Titanium concentrates:					
Ilmenite [2]	3,531	25.3	9.0	34.3	37.0
Rutile [2]	414	----------	49.4	49.4	51.5
Tungsten concentrate (60-percent tungsten dioxide) short tons	35,821	13.0	2.1	15.1	16.4
Zinc (content of ore and concentrate)	5,827	9.5	9.7	19.2	13.0
METALS, SMELTER BASIS					
Aluminum	10,019	37.9	5.5	43.4	45.6
Copper	7,304	21.2	1.8	23.0	24.1
Iron, pig	460,000	20.7	(1)	20.7	.2
Lead	3,671	17.4	10.8	28.2	24.3
Magnesium	222	45.1	1.6	46.7	48.2
Steel ingots and castings	633,000	2.2	2.2	4.4	6.1
Tin thousand long tons	229	(1)	24.0	24.1	25.5
Uranium oxide [2] short tons	21,632	28.6	6.9	35.5	34.3
Zinc	5,586	19.9	6.1	26.0	27.7
NONMETALS					
Asbestos	NA	NA	NA	NA	26.1
Cement [3] thousand barrels	3,138,394	13.0	.3	13.3	13.7
Diamond thousand carats	42,544	----------	44.1	44.1	44.2
Feldspar thousand long tons	2,267	29.7	.2	29.9	30.9
Fluorspar	4,174	12.8	27.5	40.3	46.1
Gypsum	54,194	17.9	10.6	28.5	29.0
Mica (including scrap) short tons	179	74.3	2.8	77.1	75.6
Nitrogen, agricultural [3 4]	39,556	26.8	4.5	31.3	33.3
Phosphate rock thousand long tons	NA	NA	NA	NA	44.7
Potash (K_2O equivalent)	18,311	15.3	12.8	28.1	27.4
Salt [3]	144,555	30.6	2.3	32.9	32.3
Sulfur, elemental thousand long tons	19,655	48.6	9.1	57.7	61.5
MINERAL ENERGY RESOURCES					
Crude petroleum thousand barrels	15,220,221	22.1	3.4	25.5	27.0
Natural gas million cubic feet	33,999,154	60.9	2.0	62.9	64.0
Bituminous coal and lignite	3,171,390	17.7	3.4	21.1	24.9
Anthracite	196,281	5.3	----------	NA	NA

r Revised. NA Not available. p Preliminary.
[1] Less than ½ unit.
[2] World total exclusive of U.S.S.R.
[3] Including Puerto Rico.
[4] Year ended June 30 of year stated.

Table 62.—Value of world export trade in major mineral commodity groups

(Million U.S. dollars)

Commodity group [1]	1964	1965	1966	1967	1968
Metals:					
All ores concentrates and scrap	4,370	4,580	r 4,770	5,050	5,580
Iron and steel	8,640	9,700	9,670	10,330	11,410
Nonferrous metals	5,630	6,690	8,020	8,030	9,480
Subtotal	18,640	20,970	22,460	23,410	26,470
Nonmetals (crude only)	1,530	1,760	1,900	2,010	2,120
Mineral fuels	17,010	17,920	18,890	20,660	22,950
Total	37,180	40,650	43,250	46,080	51,540
All commodities	172,160	186,390	203,400	r 214,190	238,680

r Revised.

[1] Data presented are for selected major commodity groups of the Standard International Trade Classification—Revised (SITC-R) and as such exclude some mineral commodities classified in that data array together with other (nonmineral) commodities. SITC-R categories included are as follows: ores, concentrates and scrap—SITC Division 28; iron and steel—SITC Division 67; nonferrous metals—SITC Division 68; nonmetals (crude only)—SITC Division 27; Mineral fuels—SITC Section 3. Major items not included are: the metals, metalloids and metal oxides of SITC Group 513; mineral tar and crude chemicals from coal, petroleum and natural gas of SITC Division 52; manufactured fertilizers of SITC Division 56; and nonmetallic mineral manufactures of SITC Groups 661, 662, 663 and 667.

Table 63.—Mineral commodity export price indexes

(1963 = 100)

Year and quarter	Metal ores	Fuels	All crude minerals
1967	109	101	103
1968	r 108	100	102
1969:			
First quarter	112	101	103
Second quarter	117	100	104
Third quarter	113	100	103
Fourth quarter	116	101	104
Annual average	114	100	104

r Revised.

Source: United Nations. Monthly Bulletin of Statistics. New York, June 1970, p. 19.

Table 64.—Analysis of export price indexes

(1963 = 100)

Year and quarter	Developed areas		Less developed areas	
	Total minerals	Nonferrous base metals	Total minerals	Nonferrous base metals
1967	105	135	102	156
1968	104	142	102	165
1969:				
First quarter	106	148	102	169
Second quarter	106	155	103	182
Third quarter	106	163	102	195
Fourth quarter	109	169	103	203
Annual average	107	158	103	187

Source: United Nations. Monthly Bulletin of Statistics. New York, June 1970, p. 19.

Technologic Trends in the Mineral Industries (Metals and Nonmetals Except Fuels)

By John L. Morning [1]

A banner year was enjoyed by the mining industry as value of metals and nonmetals reached $8.96 billion. To accomplish this, nearly 4 billion tons of material was handled, including 2.6 billion tons of crude ore.

In the battle for lower unit costs, wheel tractor scrapers have found wider application owing to improved design, which has added versatility and increased production capability of these units.[2]

The development of larger size front-end loaders during the past 10 years has resulted in a change in their use from strictly stockpile loading to competition with electric shovels for primary pit loading applications.[3] Also, during the past 10 years there has been an improvement in the cost performance of off-highway haulage trucks with the increase in truck size from 22- to 40-ton capacity in 1960 to the present-day 85 to 120 tons and larger.[4]

A comparison of various construction and mining earth-moving equipment made by various manufacturers was published.[5] Tractor shovels ranged to 22-ton carrying capacity; self-propelled scrapers to 72 tons; and off-highway haulers to 200-ton maximum carrying capacity.

Surveys were conducted by the Engineering and Mining Journal on the use of trucks in the metal and nonmetal mining industries.[6] According to one study, an estimated 8,930 off-highway trucks were in use in the United States in 1968. Over 67 percent of the trucks in use were over 30-ton capacity; 28 percent were over 70-ton capacity. The great majority were equipped with automatic transmissions and power steering. Vehicle availability averaged 82 percent and operating costs averaged $15.64 per hour. The survey indicated continued mining industry expansion and forecasts major growth in truck haulage, and increasing use of over 100-ton units.

According to the second survey, over 30,000 on-highway trucks were in use at domestic metal and nonmetal mines in 1968. More than half of these trucks were pickup or panel types, and over 60 percent had a gross weight of over 10,000 pounds. In contrast to off-highway trucks, comparatively few on-highway trucks were equiped with automatic transmissions and power steering. Operating costs averaged $5.39 per hour. The survey indicated that the use of this type vehicle will grow at the same rate as the mining industry.

Big hole drilling continued to hold the interest of miners, contractors, and manufacturers as the Second Symposium on Rapid Excavation was held late in the year.[7] It was indicated that raise boring as a method for creating mine openings has accounted for 90,000 to 100,000 feet of big

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[1] Physical scientist, Division of Ferrous Metals.
[2] Fites, Donald V. Tractor Scrapers Break New Ground. Min. Eng., v. 21, No. 5, May 1969, pp. 69–71.
[3] Haley, W. A. Trends In Front End Loaders. Min. Cong. J., v. 55, No. 5, May 1969, pp. 58–60.
[4] Halls, J. L., and R. E. Buckley. Open-pit Mining. Min. Ann. Rev., 1970 ed. (London), June 1970, pp. 149–165.
[5] Construction Methods and Equipment. Specs. For Your Files 1969. V. 51, No. 11, November 1969, pp. CM1–CM24.
[6] Engineering and Mining Journal. E&MJ Survey of On-Highway Trucks in the U.S. Metal and Nonmetallic Mining Industry. 1969, 19 pp.
Engineering and Mining Journal. E&MJ Survey of Off-Highway Trucks in the Metal and Nonmetallic Mining Industry. 1969, 20 pp.
[7] World Mining. Big Hole Drilling, Progress and Costs. V. 6, No. 1, January 1970, pp. 28–31.

hole raises in all parts of the world to date. Canada heads the list of raise drilling machines in operation with 16 and the United States was next with 12. The worldwide total was 51.

The International Nickel Co. Inc., a pioneer in bore hole raising, reported a 40-percent decline in mining costs and a 60-percent increase in mining rate.[8]

Mining minerals from the ocean continued to interest many individuals and concerns. At the First Annual Offshore Technology Conference, sponsored by nine professional technological socities, a prototype underwater mining system suitable for commercial exploitation of sea resources was described.[9]

Surface mines continued to account for 95 percent of total material handled and 94 percent of the crude ore produced. Underground mining was responsible for substantial percentage of crude ore production in five States; 19 States reported no underground activity.

Lower ratios for crude ore to marketable product were the trend compared with 1968, but were generally higher than those in 1964. Ratios for material handled to marketable product for various mineral commodities were generally slightly higher than in 1968, but large-volume commodities were substantially higher.

Exploration and development activities continued to accelerate owing primarily to increased activities at copper, lead, and uranium properties. Stripping operations for copper in Arizona accounted for 35 percent of total material handled by exploration and development activities. Arizona also reported over 500 million tons of material handled. This is the first time that any State reported reaching this milestone.

In 1968 the use of ammonium nitrate blasting agents continued to increase, whereas the use of permissible explosives continued to decline. The industrial consumption of explosives in 1968 was 2 percent higher than in 1967, but was lower than the record year of 1966.

Material Handled.—Total material handled at metal and nonmetal mines and quarries in the United States, approached 4 billion tons during 1969. The quantity of material handled during the past 10 years has increased at an average annual rate of 3.6 percent. A significant portion of this increase was in waste material handled at surface mines which indicated an increase of 5.9 percent annually; crude ore production increased 2.5 percent.

Waste material accounted for one-third of the yearly total of material handled owing primarily to stripping activities in the copper industry. For metal operations, copper mines led in waste and total material handled, and iron mines led in crude ore production. The States of Arizona and Florida continued to be the leaders in material handled as they have been since 1965. The quantity of material handled in Arizona, Nevada, and New Mexico was more than twice as much as the quantity in 1960. Mineral commodities that indicated a significant gain in material handled, compared with 1968, were copper, manganiferous ore, molybdenum, uranium, and sand and gravel. Total material handled decreased for placer gold and dimension stone.

Surface mines accounted for 95 percent of total material handled during the year; the same as in 1964. However, the quantity of material handled at surface metal mines increased to 93 percent compared with 90 percent in 1964.

Magnitude of the Mining Industry.—In 1969, the number of mines reporting crude ore production to the Bureau of Mines totaled 1,831. In addition, there were 1,423 clay mines, 4,704 crushed and broken stone operations, and 638 dimension stone mines in operation. The 1969 grand total was 8,596 mines, compared with 8,555 mines in 1968; both years exclude sand and gravel operations. Reporting metal mines decreased by 258 mines, of which 50 percent were uranium operations. Nonmetal reporting mines increased by 43 and were spread over a number of mineral commodities.

Three iron mines joined the list of those mines producing over 10 million tons of crude ore, but two phosphate rock mines dropped from this category. The Utah copper mine of Kennecott Copper Corp. was the metal mine leader in both output of ore and of total material handled, whereas the Noralyn mine of International Minerals and Chemicals Co. was the leader of nonmetal mines in both categories.

[8] Scott, James J. Underground Mining. Min. Cong. J., v. 56, No. 2, February 1970, pp. 35–41.
[9] Flipe, John E. An Engineering Approach to Ocean Mining. Paper Number OTC 1035, Offshore Technology Conference, May 18–21, 1969, 16 pp.

Comparison of Production From Surface and Underground Mines.—Surface mining accounted for 94 percent of the total crude ore production and 95 percent of the total material handled. Although the percentages remained the same as in 1968, some minor shifting occurred for the various mineral commodities. Five metal commodities, registered an increase, but four registered a decrease for surface crude ore output. For nonmetal commodities, five indicated an increase, but four decreased in crude ore output.

Crude ore production at surface metal mines was more than five times higher than at underground mines; total material handled at surafce mines was 14 times higher than at underground mines. Of the nearly 2.5 million tons of material handled at nonmetal mines, only 82,000 tons were from underground operations.

Underground mining accounted for substantial percentage of crude ore handled in five States: Colorado, 43 percent; New Mexico, 40 percent; Missouri, 29 percent; Wyoming, 24 percent; and Kentucky, 23 percent. Nineteen States reported no underground activity.

Ratio of Ore to Marketable Product.—The trend for most mineral commodities for the year was toward lower ratios of ore to marketable product compared with 1968, but ratios were generally higher than for 1964. At surface metal mines the ratios were mixed compared with 1968, with about equal distribution of gains and losses. Of the large-volume commodities, copper registered an increased ratio, and iron ore indicated a reduced ratio. In general, surface nonmetal mines indicated smaller ratios compared with 1968 with only feldspar and vermiculite registering increased ratios.

Ratios of material handled to marketable product for various mineral commodities indicated increased ratios for nearly one-half of the listed commodities compared with 1968. Copper continued to have the highest ratio as stripping continued to develop new properties and expand other operations. Compared with 1964, the ratio increased 53 percent for copper, 25 percent for iron, and 35 percent for phosphate rock, and marketable units increased 28 percent, 6 percent, and 47 percent, respectively.

Most metal commodities indicated an increase in average value per ton compared with 1968 with only mercury and uranium showing a decrease in value. Of the 27 listed nonmetal commodities, 16 indicated increased values, compared with the previous year. Total average value of metal commodities rose to $6.15 from $5.61 in 1968. Total average value data for nonmetal commodities are not comparable with previous published data.

Exploration and Development.—The upward trend in exploration and development accelerated in 1969 and totaled 31.7 million feet, compared with 25 million feet in 1968. The data, however, is not comparable because clay and stone mines were not included in the 1969 total. Exploration and development work for clay and stone mines totaled 1.5 million feet in 1966, 1.6 million feet in 1967, and 1.2 million feet in 1968. For metals, a significant increased activity was noted for copper, iron, and uranium mines. Rotary drilling accounted for most of the gain at copper and uranium mines, whereas percussion drilling was largely responsible for the increase at iron mines.

Arizona, Colorado, Idaho, New Mexico, Texas, Utah, and Wyoming accounted for 86 percent of total footage of exploration and development and were also the only States reporting over 1 million feet. This compares with 1968 when five States reported over 1 million feet each. Rotary drilling accounted for 76 percent of the total activity, and all categories, except trenching and diamond drilling, registered increased footage.

Stripping operations for copper in Arizona accounted for 35 percent of total material produced by exploration and development activities. The total tonnage produced increased 28 percent compared with 1968.

Increased mining activity in Arizona resulted in the total material handled exceeding 500 million tons of for the first time. Montana and Wyoming joined the list of States reporting over 100 million tons; New York and Pennsylvania dropped from the list.

Explosives.—Explosive statistics for the year of review are released too late for incorporation in this chapter. For 1968, 1,948 million pounds of industrial explosives were reported consumed in the United States. This total was 2 percent higher compared with 1967, but was slightly lower than the record high of 1,970 million pounds in 1966. The coal mining industry used 35 percent of the total, metal mines used 21 percent, and quarrying and nonmetal mines, 20 percent. This is in contrast to 1963, when coal mining accounted for 35 perccent, metal mining, 17 percent, and quarrying and nonmetal mining, 22 percent of the industrial consumption.

The use of ammonium nitrate blasting agents continued to increase, whereas the use of permissible explosives continued to decline. There was no reported use of liquid oxygen explosives during 1968.

The five top ranking States in order of total quantity of explosives and blasting agents consumed were as follows: Pennsylvania, Kentucky, Ohio, Arizona, and Illinois. This was in contrast to 1963 when the ranking order was Pennsylvania, Ohio, Kentucky, Illinois, and Minnesota. In 1968, the explosive consumption of the ranking States totaled 751 million pounds, or 39 percent of industrial explosives and blasting agents used in the United States. In 1963 the ranking States used 545 million pounds or 37 percent of all industrial explosives consumed.

More detailed explosive information is published by the Bureau of Mines in the Annual Explosive issue of Mineral Industry Surveys prepared by Andris Viksne.

Table 1.—Material handled at surface and underground mines, by commodities, in 1969

(Thousand short tons)

Commodity	Surface			Underground			All mines		
	Crude ore	Waste	Total	Crude ore	Waste	Total	Crude ore	Waste	Total
METALS									
Bauxite	[1] 2,501	[1] 3,437	[1] 5,938	W	W	W	2,501	3,437	5,938
Beryllium	176	507	683	2	----------	2	178	507	685
Copper	198,439	621,726	820,165	27,486	452	27,938	225,925	622,178	848,103
Gold:									
Lode	1,614	8,980	10,594	2,104	355	2,459	3,718	9,335	13,053
Placer	2,195	772	2,967	----------	1	1	2,195	773	2,968
Iron ore	213,997	168,593	382,590	14,877	2,413	17,290	228,874	171,006	399,880
Lead	6	32	38	9,507	749	10,256	9,513	781	10,294
Manganiferous ore	1,009	2,832	3,841	----------	----------	----------	1,009	2,832	3,841
Mercury	278	535	813	204	19	223	482	554	1,036
Molybdenum	5,339	36,579	41,918	15,861	156	16,017	21,200	36,735	57,935
Nickel	1,184	362	1,546	----------	----------	----------	1,184	362	1,546
Silver	128	75	203	653	298	951	781	373	1,154
Titanium: Ilmenite	22,204	3,529	25,733	----------	----------	----------	22,204	3,529	25,733
Tungsten	26	3	29	442	20	462	468	23	491
Uranium	1,823	89,307	91,130	3,497	1,306	4,803	5,320	90,613	95,933
Zinc	571	1,319	1,890	10,032	7,926	17,958	10,603	9,245	19,848
Other [2]	4,082	2,328	6,410	12	----------	12	4,094	2,328	6,422
Total metals	455,000	941,000	1,396,000	85,000	13,000	98,000	540,000	954,000	1,494,000
NONMETALS									
Abrasives [3]	396	141	537	48	----------	48	444	141	585
Asbestos	2,178	1,363	3,541	22	3	25	2,200	1,366	3,566
Barite	6,038	3,157	9,195	115	17	132	6,153	3,174	9,327
Boron minerals	12,461	12,010	24,471	----------	----------	----------	12,461	12,010	24,471
Clays	57,524	[e] 50,000	107,524	1,063	[e] 16	1,079	58,587	50,016	108,603
Diatomite	1,042	7,701	8,743	268	----------	268	1,310	7,701	9,011
Feldspar	1,698	389	2,087	9	----------	9	1,707	389	2,096
Fluorspar	62	40	102	470	1	471	532	41	573
Gypsum	7,691	11,968	19,659	2,328	73	2,401	10,019	12,041	22,060
Mica	661	463	1,124	----------	----------	----------	661	463	1,124
Perlite	612	1	613	----------	----------	----------	612	1	613
Phosphate rock	126,056	278,411	404,467	671	20	691	126,727	278,431	405,159
Potassium salts	----------	----------	----------	16,989	819	17,808	16,989	819	17,808
Pumice	3,952	136	4,088	----------	----------	----------	3,952	136	4,088
Salt	5,400	3	5,403	14,371	636	15,007	19,771	639	20,410
Sand and gravel	936,906	----------	936,906	----------	----------	----------	936,906	----------	936,906
Sodium carbonate (natural)	----------	----------	----------	4,072	124	4,196	4,072	124	4,196
Stone:									
Crushed and broken	822,077	[e] 68	822,145	38,935	[e] 270	39,205	861,012	338	861,350
Dimension	[e] 4,000	[e] 900	[e] 4,900	29	----------	29	4,029	900	4,929

See footnotes at end of table.

Table 1.—Material handled at surface and underground mines, by commodities, in 1969—Continued

(Thousand short tons)

Commodity	Surface			Underground			All mines		
	Crude ore	Waste	Total	Crude ore	Waste	Total	Crude ore	Waste	Total
NONMETALS—Continued									
Sulfur:									
Frasch-process mines	8,003	----------	8,003	----------	----------	----------	8,003	----------	8,003
Other mines	----------	2	2	----------	----------	----------	----------	2	2
Talc, soapstone, and pyrophyllite	553	1,235	1,788	519	14	533	1,072	1,249	2,321
Vermiculite	1,505	4,150	5,655	----------	----------	----------	1,505	4,150	5,655
Other [4]	1,946	2,836	4,782	85	----------	85	2,031	2,836	4,867
Total nonmetals	2,001,000	375,000	2,376,000	80,000	2,000	82,000	2,081,000	377,000	2,458,000
Grand total	2,456,000	1,316,000	3,772,000	165,000	15,000	180,000	2,621,000	1,331,000	3,952,000

[e] Estimated. W Withheld to avoid disclosing individual company confidential data.
[1] Includes underground; Bureau of Mines not at liberty to publish separately.
[2] Magnesium, manganese, platinum-group metals, rare-earth metals, and vanadium.
[3] Emery, garnet, and tripoli.
[4] Aplite, graphite, greensand marl, kyanite, lithium minerals, magnesite, olivine, pyrites, and wollastonite.

Table 2.—Material handled at surface and underground mines (including sand and gravel and stone), by States, in 1969 [1]

(Thousand short tons)

State	Surface			Underground			All mines		
	Crude ore	Waste	Total	Crude ore	Waste	Total	Crude ore	Waste	Total
Alabama	32,257	18,251	50,508	1,974	248	2,222	34,231	18,499	52,730
Alaska	22,627	1,475	24,102	----------	----------	----------	22,627	1,475	24,102
Arizona	135,273	353,935	489,208	16,639	384	17,023	151,912	354,319	506,231
Arkansas	32,465	4,574	37,039	946	17	963	33,411	4,591	38,002
California	195,658	56,729	252,389	2,103	36	2,139	197,761	56,765	254,526
Colorado	23,523	125	23,648	17,777	1,323	19,100	41,300	1,448	[e] 42,748
Connecticut	16,817	42	16,859	----------	----------	----------	16,817	42	16,859
Florida	183,565	245,043	428,608	----------	----------	----------	183,565	245,043	428,608
Georgia	40,531	61	40,592	995	----------	995	41,526	61	41,587
Idaho	16,385	12,795	29,180	1,755	323	2,078	18,140	13,118	31,258
Illinois	99,102	1	99,103	2,429	----------	2,429	101,531	1	101,532
Indiana	53,047	----------	53,047	905	34	939	53,952	34	53,986
Iowa	45,722	6,218	51,940	1,306	----------	1,306	47,028	6,218	53,246
Kansas	27,804	195	27,999	2,671	6,000	8,671	30,475	6,195	36,670
Kentucky	32,683	12	32,695	7,350	1	7,351	40,033	13	40,046
Louisiana	33,045	----------	33,045	5,914	----------	5,914	38,959	----------	38,959
Maine	12,642	1,187	13,829	6	----------	6	12,648	1,187	13,835
Maryland	30,409	16	30,425	57	----------	57	30,466	16	30,482
Massachusetts	27,635	----------	27,635	----------	----------	----------	27,635	----------	27,635

Michigan	130,789	14,104	144,893	14,090	379	14,469	144,879	14,483	159,362
Minnesota	206,133	91,412	297,545	----------	----------	----------	206,133	91,412	297,545
Mississippi	13,909	----------	13,909	----------	----------	----------	13,909	----------	13,909
Missouri	51,300	2,348	53,648	21,277	462	21,739	72,577	2,810	75,387
Montana	41,566	59,071	100,637	868	15	883	42,434	59,086	101,520
Nebraska	17,540	----------	17,540	33	----------	33	17,573	----------	17,573
Nevada	33,265	61,223	94,488	353	108	461	33,618	61,331	94,949
New Hampshire	6,683	----------	6,683	----------	----------	----------	6,683	----------	6,683
New Jersey	37,428	286	37,714	150	1	151	37,578	287	37,865
New Mexico	28,819	117,087	145,906	18,790	1,241	20,031	47,609	118,328	165,937
New York	86,225	5,148	91,373	5,938	214	6,152	92,163	5,362	97,525
North Carolina	46,866	16,817	63,683	52	10	62	46,918	16,827	63,745
North Dakota	7,174	----------	7,174	----------	----------	----------	7,174	----------	7,174
Ohio	103,886	----------	103,886	5,654	400	6,054	109,540	400	109,940
Oklahoma	24,950	5,525	30,475	1,178	----------	1,178	26,128	5,525	31,653
Oregon	29,811	472	30,283	1	1	2	29,812	473	30,285
Pennsylvania	84,682	----------	84,682	7,207	1,836	9,043	91,889	1,836	93,725
Rhode Island	2,900	----------	2,900	----------	----------	----------	2,900	----------	2,900
South Carolina	17,713	869	18,582	----------	----------	----------	17,713	869	18,582
South Dakota	13,501	1,606	15,107	1,924	179	2,103	15,425	1,785	17,210
Tennessee	43,074	4,870	47,944	9,970	766	10,736	53,044	5,636	58,680
Texas	90,787	5,066	95,853	460	9	469	91,247	5,075	96,322
Utah	68,434	89,554	157,988	2,687	398	3,085	71,121	89,952	161,073
Vermont	6,563	48	6,611	215	----------	215	6,778	48	6,826
Virginia	46,024	168	46,192	2,811	708	3,519	48,835	876	49,711
Washington	50,737	787	51,524	284	116	400	51,021	903	51,924
West Virginia	13,478	----------	13,478	1,918	----------	1,918	15,396	----------	15,396
Wisconsin	62,298	1,943	64,241	858	48	906	63,156	1,991	65,147
Wyoming	16,480	85,831	102,311	5,285	143	5,428	21,765	85,974	107,739
Other States [2]	9,796	30	9,826	----------	----------	----------	9,796	30	9,826
Total	2,454,000	1,265,000	3,719,000	165,000	15,000	180,000	2,619,000	1,280,000	3,899,000

[1] Partially estimated data in table 1 not included in State totals.
[2] Delaware and Hawaii.

Table 3.—Value of principal mineral products and byproducts of surface and underground ores mined in the United States, in 1969

(Value per ton)

Ore	Surface			Underground			All mines		
	Principal mineral product	Byproducts	Total	Principal mineral product	Byproducts	Total	Principal mineral product	Byproducts	Total
METALS									
Bauxite	[1] $10.40	--	[1] $10.40	W	W	W	$10.40	--	$10.40
Beryllium	9.26	$0.05	9.31	--	--	--	9.42	$0.05	9.47
Copper	6.02	.42	6.44	$9.14	$0.94	$10.08	6.40	.49	6.89
Gold:									
Lode	10.92	.02	10.94	13.69	2.74	16.43	12.54	1.61	14.15
Placer	.47	--	.47	--	--	--	.47	--	.47
Iron ore	3.79	--	3.79	7.45	.27	7.72	4.04	.02	4.06
Lead	40.00	19.00	59.00	13.69	5.58	19.27	13.70	5.59	19.29
Mercury	19.50	--	19.50	43.00	--	43.00	29.30	--	29.30
Molybdenum	4.43	--	4.43	6.64	.29	6.93	6.16	.23	6.39
Platinum-group metals	.54	--	.54	--	--	--	.54	--	.54
Silver	5.48	2.64	8.12	39.95	8.13	48.08	34.57	7.28	41.85
Titanium: Ilmenite	.84	.27	1.11	--	--	--	.84	.27	1.11
Tungsten	13.92	--	13.92	46.57	4.17	50.74	44.69	3.93	48.62
Uranium	27.22	.01	27.23	21.53	.03	21.56	23.97	.02	23.99
Zinc	12.67	4.41	17.08	11.92	2.93	14.85	11.96	3.01	14.97
Average value [2]	4.89	.20	5.09	10.33	1.53	11.86	5.73	.42	6.15
NONMETALS									
Asbestos	4.61	--	4.61	24.81	--	24.81	4.81	--	4.81
Barite	2.28	--	2.28	16.10	--	16.10	2.53	--	2.53
Clays	4.43	--	4.43	8.13	--	8.13	4.49	--	4.49
Diatomite	41.54	--	41.54	9.32	--	9.32	33.59	--	33.59
Emery	19.85	--	19.85	--	--	--	19.85	--	19.85
Feldspar	4.90	.22	5.12	4.66	--	4.66	4.90	.22	5.12
Fluorspar	22.51	.01	22.52	14.41	3.80	18.21	15.33	3.37	18.70
Garnet	25.09	--	25.09	--	--	--	25.09	--	25.09
Graphite	328.33	--	328.33	--	--	--	328.33	--	328.33
Gypsum	3.52	--	3.52	4.81	--	4.81	3.82	--	3.82
Kyanite	11.82	.24	12.06	--	--	--	11.82	.24	12.06
Lithium minerals	5.81	.76	6.57	--	--	--	5.81	.76	6.57
Magnesite	2.75	.12	2.87	--	--	--	2.75	.12	2.87
Mica: Flake	3.69	.01	3.70	--	--	--	3.69	.01	3.70
Olivine	16.73	--	16.73	--	--	--	16.73	--	16.73
Perlite	8.24	--	8.24	--	--	--	8.24	--	8.24
Phosphate rock	1.60	--	1.60	11.70	--	11.70	1.62	--	1.62
Potassium salts	--	--	--	4.00	--	4.00	4.00	--	4.00
Pumice	1.35	--	1.36	--	--	--	1.35	--	1.35
Salt	16.37	.75	17.12	6.39	.67	7.06	9.39	.69	10.08
Sand and gravel	1.14	--	1.14	--	--	--	1.14	--	1.14
Stone:									
Crushed and broken	1.52	--	1.52	1.63	--	1.63	1.52	--	1.52
Dimension	51.06	--	51.06	156.51	--	156.51	52.69	--	52.69

Sulfur: Frasch	24.09	--------	24.09	--------	--------	--------	24.09	--------	24.09
Talc, soapstone, and pyrophyllite	6.32	--------	6.32	7.92	--------	7.92	7.10	--------	7.10
Tripoli	14.13	--------	14.13	4.10	--------	4.10	8.53	--------	8.53
Vermiculite	4.49	--------	4.49	--------	--------	--------	4.49	--------	4.49
Average value [2]	1.69	.01	1.70	3.87	.13	4.00	1.77	.02	1.79
Average value—metal and nonmetals [2]	2.28	.05	2.33	7.16	.85	8.01	2.59	.10	2.69
Average value—nonmetals (excluding stone, sand, and gravel) [2]	3.97	.12	4.09	5.77	.26	6.03	4.24	.14	4.38
Average value—metals and nonmetals (excluding stone, sand and gravel) [2]	4.57	.18	4.75	8.83	1.12	9.95	5.23	.32	5.55

W Withheld to avoid disclosing individual company confidential data.
[1] Includes underground; Bureau of Mines not at liberty to publish separately.
[2] Including unpublished data.

Table 4.—Crude ore and total material handled at surface and underground mines, by commodities, in 1969

(Percent)

Commodity	Crude ore		Total material	
	Surface	Underground	Surface	Underground
METALS				
Bauxite	94	6	97	3
Beryllium	99	1	100	---
Copper	88	12	97	3
Gold:				
Lode	43	57	81	19
Placer	100	---	100	---
Iron ore	94	6	96	
Lead	---	100	---	100
Manganese ore	---	100	---	100
Mercury	55	45	78	22
Molybdenum	25	75	72	28
Nickel	100	---	100	---
Rare-earth metals and thorium	100	---	100	---
Silver	4	96	18	82
Titanium: Ilmenite	100	---	100	---
Tungsten	6	94	6	94
Uranium	34	66	95	5
Zinc	4	96	10	90
Total metals	84	16	93	7
NONMETALS				
Abrasives:				
Emery	100	---	100	---
Garnet	100	---	100	---
Tripoli	44	56	55	45
Asbestos	99	1	99	1
Barite	98	2	99	1
Boron minerals	100	---	100	---
Clays	98	2	98	2
NONMETALS—Continued				
Diatomite	80	20	97	3
Feldspar	100	---	100	---
Fluorspar	9	91	18	82
Graphite	100	---	100	---
Gypsum	77	23	89	11
Kyanite	100	---	100	---
Lithium minerals	100	---	100	---
Magnesite	100	---	100	---
Marl, greensand	100	---	100	---
Mica: Flake	100	---	100	---
Olivine	100	---	100	---
Perlite	100	---	100	---
Phosphate rock	100	---	100	---
Potassium salts	---	100	---	100
Pumice	100	---	100	---
Salt	27	73	26	74
Sand and gravel	100	---	100	---
Sodium carbonate (natural)	---	100	---	100
Stone:				
Crushed and broken	95	5	95	5
Dimension	98	2	98	2
Sulfur: Frasch process mines	100	---	100	---
Talc, soapstone and pyrophyllite	52	48	77	23
Vermiculite	100	---	100	---
Wollastonite	2	98	2	98
Total nonmetals	96	4	97	3
Grand total	94	6	95	5

Table 5.—Crude ore and total material handled at surface and underground mines, by States, in 1969

(Percent)

	Crude ore		Total material	
	Surface	Underground	Surface	Underground
STATE				
Alabama	94	6	96	4
Alaska	100	---	100	---
Arizona	89	11	97	3
Arkansas	96	4	96	4
California	99	1	99	1
Colorado	57	43	55	45
Connecticut	100	---	100	---
Delaware	100	---	100	---
Florida	100	---	100	---
Georgia	98	2	98	2
Hawaii	100	---	100	---
Idaho	84	16	91	9
Illinois	98	2	98	2
Indiana	98	2	98	2
Iowa	97	3	98	2
Kansas	91	9	76	24
Kentucky	77	23	77	23
Louisiana	85	15	85	15
Maine	100	---	100	---
Maryland	100	---	100	---
Massachusetts	100	---	100	---
Michigan	90	10	91	9
Minnesota	100	---	100	---
Mississippi	100	---	100	---
Missouri	71	29	71	29
Montana	98	2	99	1
Nebraska	100	---	100	---
Nevada	99	1	99	1
New Hampshire	100	---	100	---
New Jersey	100	---	100	---
New Mexico	60	40	88	12
New York	94	6	94	6
North Carolina	100	---	100	---
North Dakota	100	---	100	---
Ohio	95	5	95	5
Oklahoma	95	5	96	4
Oregon	100	---	100	---
Pennsylvania	92	8	90	10
Rhode Island	100	---	100	---
South Carolina	100	---	100	---
South Dakota	88	12	88	12
Tennessee	82	18	82	18
Texas	100	---	100	---
Utah	96	4	98	2
Vermont	97	3	97	3
Virginia	94	6	93	7
Washington	99	1	99	1
West Virginia	88	12	88	12
Wisconsin	99	1	99	1
Wyoming	76	24	95	5
Total	94	6	95	5

Table 6.—Number of domestic metal and nonmetal mines in 1969, by commodity and magnitude of crude ore production

Commodity	Total number of mines	Less than 1,000 tons	1,000 to 10,000 tons	10,000 to 100,000 tons	100,000 to 1,000,000 tons	1,000,000 to 10,000,000 tons	More than 10,000,000 tons
METALS							
Bauxite	11	-------	2	5	2	2	-------
Beryllium	10	8	-------	1	1	-------	-------
Copper	123	58	8	15	16	19	7
Gold:							
Lode	72	63	4	1	2	2	-------
Placer	80	44	18	11	6	1	-------
Iron ore	90	3	9	11	31	31	5
Lead	102	75	9	4	12	2	-------
Manganese ore	2	1	-------	1	-------	-------	-------
Mercury	90	57	20	13	-------	-------	-------
Molybdenum	3	-------	-------	-------	-------	2	1
Silver	135	102	27	4	2	-------	-------
Titanium: Ilmenite	6	-------	-------	-------	1	5	-------
Tungsten	38	33	3	1	1	-------	-------
Uranium	270	71	68	40	91	-------	-------
Zinc	88	16	6	42	24	-------	-------
Other [1]	16	8	1	1	4	2	-------
Total metals	1,136	539	175	150	193	66	13
NONMETALS							
Abrasives [2]	20	8	7	4	1	-------	-------
Asbestos	7	-------	1	3	2	1	-------
Barite	47	3	9	19	15	1	-------
Boron minerals	8	6	-------	-------	-------	2	-------
Diatomite	11	2	2	3	4	-------	-------
Feldspar	52	22	16	7	7	-------	-------
Fluorspar	19	7	6	3	3	-------	-------
Gypsum	77	4	10	25	38	-------	-------
Kyanite	3	-------	-------	-------	3	-------	-------
Marl, greensand	2	1	1	-------	-------	-------	-------
Mica: Flake	24	9	6	6	3	-------	-------
Olivine	4	-------	2	2	-------	-------	-------
Perlite	19	6	6	5	2	-------	-------
Phosphate rock	55	3	3	7	22	16	4
Potassium salts	9	-------	-------	-------	1	8	-------
Pumice	168	28	46	68	26	-------	-------
Salt	56	2	8	14	26	6	-------
Sodium carbonate (natural)	3	-------	-------	-------	1	2	-------
Sulfur: Frasch-process mines	21	-------	-------	5	13	3	-------
Talc, soapstone, and pyrophyllite	70	16	28	25	1	-------	-------
Vermiculite	6	2	-------	2	1	1	-------
Wollastonite	2	-------	1	1	-------	-------	-------
Other [3]	12	2	1	1	7	1	-------
Total nonmetals	[4] 695	121	153	200	176	41	4
Grand total	1,831	660	328	350	369	107	17

[1] Antimony, magnesium, manganiferous ore, nickel, rare-earth metals, tin, and vanadium.
[2] Emery, garnet, and tripoli.
[3] Aplite, graphite, lithium minerals, magnesite, and pyrites.
[4] In addition, there were 1,423 clay mines, 4,704 crushed and broken stone, and 638 dimension stone operations.

Table 7.—Twenty-five leading metal and nonmetel [1] mines in the United States in 1969, in order of output of crude ore

Mine	State	Operator	Commodity	Mining method
		METALS		
Utah Copper	Utah	Kennecott Copper Corp	Copper	Open pit.
Peter Mitchell	Minn	Reserve Mining Co	Iron ore	Do.
Hoyt Lake	do	Pickands Mather & Co	do	Do.
Minntac	do	United States Steel Corp	do	Do.
Morenci	Ariz	Phelps Dodge Corp	Copper	Do.
Berkeley Pit	Mont	The Anaconda Company	do	Do.
San Manuel	Ariz	Magma Copper Co	do	Caving.
Pima	do	Pima Mining Co	do	Open pit.
Climax	Colo	American Metal Climax, Inc.	Molybdenum	Caving.
Eagle Mountain	Calif	Kaiser Steel Corp	Iron ore	Open pit.
Ray Pit	Ariz	Kennecott Copper Corp	Copper	Do.
Empire	Mich	Cleveland Cliffs Iron Co	Iron ore	Do.
New Cornelia	Ariz	Phelps Dodge Corp	Copper	Do.
Inspiration	do	Inspiration Consolidated Copper Co.	do	Do.
Yerington	Nev	The Anaconda Company	do	Do.
Butler	Minn	Hanna Mining Co	Iron ore	Do.
Republic	Mich	Cleveland Cliffs Iron Co	do	Do.
White Pine	do	White Pine Copper Co	Copper	Open stopes.
Tripp-Veteran	Nev	Kennecott Copper Corp	do	Open pit.
Chino	N. Mex	do	do	Do.
Mission	Ariz	The American Smelting and Refining Company.	do	Do.
Trail Ridge	Fla	E. I. du Pont de Nemours Co., Inc.	Ilmenite	Dredging.
Highland	do	do	do	Do.
Mineral Park	Ariz	Duval Corp	Copper	Open pit.
Groveland	Mich	Hanna Mining Co	Iron ore	Do.
		NONMETALS		
Noralyn	Fla	International Minerals & Chemical Co.	Phosphate rock	Do.
Kingsford	do	do	do	Do.
Suwannee	do	Occidental Chemical Co	do	Do.
Ft. Meade	do	Mobil Chemical Co	do	Do.
Payne Creek	do	Agrico Chemical Co	do	Do.
Rockland	do	U.S.S. Agri-Chemicals Inc	do	Do.
Chicora	do	American Cyanamid Co	do	Do.
Silver City	do	Swift Agricultural Chemicals Corp.	do	Do.
Lee Creek	N. C	Texas Gulf Sulphur Co	do	Dredging.
Saddle Creek	Fla	Agrico Chemical Co	do	Open pit.
Palmetto	do	do	do	Do.
Tenoroc	do	Borden Chemical Co	do	Do.
Watson	do	Swift Agricultural Chemicals Corp.	do	Do.
Bartow	do	U.S.S. Agric-Chemicals Inc	do	Do.
Sydney	do	American Cyanamid Co	do	Do.
Tencor	do	U.S. Phosphoric Products Co	do	Do.
Bonny Lake	do	W. R. Grace & Co	do	Do.
Shafts I	N. Mex	Southwest Potash Co	Potassium salts	Open stopes.
Retsof	N.Y	International Salt Co	Salt	Do.
Clear Spring	Fla	International Minerals & Chemical Co.	Phosphate rock	Open pit.
International	N. Mex	do	Potassium salts	Open stopes.
Boron	Calif	United States Borax & Chemical Co.	Boron minerals	Open pit.
	N. Mex	Potash Co. of America	Potassium salts	Open stopes.
	do	Kerr-McGee Corp	do	Do.
Gay	Idaho	J. R. Simplot Co	Phosphate rock	Open pit.

[1] Clay, sand and gravel, stone, brines, and materials from wells, etc. excepted.

Table 8.—Twenty-five leading metal and nonmetal[1] mines in the United States in 1969, in order of output of total materials handled

Mines	State	Operator	Commodity	Mining method
METALS				
Utah Copper	Utah	Kennecott Copper Corp	Copper	Open pit.
Berkeley Pit	Mont	The Anaconda Company	do	Do.
Sierrita	Ariz	Duval Sierrita Corp	do	Do.
Twin Buttes	do	The Anaconda Company	do	Do.
Morenci	do	Phelps Dodge Corp	do	Do.
Pima	do	Pima Mining Co	do	Do.
Tyrone	N. Mex	Phelps Dodge Corp	do	Do.
Peter Mitchell	Minn	Reserve Mining Co	Iron ore	Do.
Eagle Mountain	Calif	Kaiser Steel Corp	do	Do.
Hoyt Lake	Minn	Pickands Mather & Co	do	Do.
Questa	N. Mex	Molybdenum Corp. of America.	Molybdenum	Do.
Ray Pit	Ariz	Kennecott Copper Corp	Copper	Do.
Mintac	Minn	United States Steel Corp	Iron ore	Do.
Chino	N. Mex	Kennecott Copper Corp	Copper	Do.
Mission	Ariz	American Smelting and Refining Co.	do	Do.
Lavender Pit	do	Phelps Dodge Corp	do	Do.
New Cornelia	do	do	do	Do.
Shirley	Wyo	Utah Construction & Mining Co.	Uranium	Do.
Inspiration	Ariz	Inspiration Consolidation Copper Co.	Copper	Do.
Dave Pit	Wyo	Petrotomics Co	Uranium	Do.
Lucky Mc	do	Utah Construction & Mining Co.	do	Open pit, open stopes.
Ruth	Nev	Kennecott Copper Corp	Copper	Open pit.
Tripp-Veteran	do	do	do	Do.
Yerington	do	The Anaconda Company	do	Do.
Sherman	Minn	United States Steel Corp	Iron ore	Do.
NONMETALS				
Noralyn	Fla	International Minerals & Chemicals Co.	Phosphate rock	Do.
Kingsford	do	do	do	Do.
Suwannee	do	Occidental Chemical Co	do	Do.
Ft. Meade	do	Mobil Chemical Co	do	Do.
Payne Creek	do	Agrico Chemical Co	do	Do.
Silver City	do	Swift Agricultural Chemicals Corp.	do	Do.
Lee Creek	N. C	Texas Gulf Sulphur Co	do	Dredging.
Rockland	Fla	U.S.S. Agric-Chemicals Inc	do	Open pit.
Chicora	do	American Cyanamid Co	do	Do.
Tenoroc	do	Borden Chemical Co	do	Do.
Bonny Lake	do	W. R. Grace & Co	do	Do.
Saddle Creek	do	Agrico Chemical Co	do	Do.
Boron	Calif	United States Borax & Chemical Co.	Boron minerals	Do.
Sydney	Fla	American Cyanamid Co	Phosphate rock	Do.
Tencor	do	U.S. Phosphoric Products Co	do	Do.
Bartow	do	U.S.S. Agric-Chemicals Inc	do	Do.
Watson	do	Swift Agricultural Chemicals Corp.	do	Do.
Palmetto	do	Agrico Chemical Co	do	Do.
Gay	Idaho	J. R. Simplot Co	do	Do.
Clear Spring	Fla	International Minerals & Chemical Co.	do	Do.
Lompoc	Calif	Johns Manville Products Corp.	Diatomite	Do.
Libby	Mont	W. R. Grace & Co	Vermiculite	Do.
Shafts I	N. Mex	Southwest Potash Co	Potassium salts	Open stopes.
Retsof	N.Y	International Salt Co	Salt	Do.
Fort Dodge	Iowa	United States Gypsum Co	Gypsum	Open pit.

[1] Clay, sand and gravel, stone, brines, and materials from wells, etc. excepted.

Table 9.—Kind of surface mining operation, by commodities and States, in 1969

(Percent of crude ore)

	Strip and single bench	Multiple bench		Strip and single bench	Multiple bench
COMMODITY					
METALS			NONMETALS—Continued		
Bauxite	65	35	Diatomite	---	100
Copper	13	87	Feldspar	69	31
Gold: Lode	35	65	Fluorspar	44	56
Iron ore	13	87	Gypsum	89	11
Mercury	47	53	Kyanite	---	100
Nickel	---	100	Lithium minerals	---	100
Rare-earth metals and thorium	---	100	Marl, greensand	100	---
Uranium	41	59	Mica: Flake	100	---
Zinc	2	98	Olivine	100	---
NONMETALS			Perlite	99	1
Abrasives:			Phosphate rock	97	3
Emery	100	---	Pumice	99	1
Garnet	3	97	Salt	100	---
Tripoli	100	---	Sand and gravel	100	---
Aplite	76	24	Stone:		
Asbestos	33	67	Crushed and broken	100	---
Barite	86	14	Dimension	100	---
Boron minerals	---	100	Talc, soapstone, and pyrophyllite	45	55
Clays	100	---	Vermiculite	17	83

	Strip and single bench	Multiple bench		Strip and single bench	Multiple bench
STATE					
Alabama	99	1	Montana	24	76
Alaska	100	---	Nebraska	100	---
Arizona	25	75	Nevada	19	81
Arkansas	91	9	New Hampshire	100	---
California	69	31	New Jersey	100	---
Colorado	100	---	New Mexico	37	63
Connecticut	100	---	New York	87	13
Delaware	100	---	North Carolina	96	4
Florida	100	---	North Dakota	100	---
Georgia	100	---	Ohio	100	---
Hawaii	100	---	Oklahoma	100	---
Idaho	64	36	Oregon	95	5
Illinois	100	---	Pennsylvania	100	---
Indiana	100	---	Rhode Island	100	---
Iowa	100	---	South Carolina	98	2
Kansas	100	---	South Dakota	100	---
Kentucky	100	---	Tennessee	100	---
Louisiana	100	---	Texas	99	1
Maine	90	10	Utah	19	81
Maryland	100	---	Vermont	100	---
Massachusetts	100	---	Virginia	99	1
Michigan	73	27	Washington	98	2
Minnesota	22	78	West Virginia	100	---
Mississippi	100	---	Wisconsin	100	---
Missouri	100	---	Wyoming	56	44

Table 10.—Ore treated or sold per unit of marketable product as surface and underground mines in the United States, by commodities, in 1969

Commodity	Unit of marketable product	Surface: Ore (thousand short tons)	Surface: Marketable product, units	Surface: Ratio of units of ore to units of marketable product	Underground: Ore (thousand short tons)	Underground: Marketable product, units	Underground: Ratio of units of ore to units of marketable product	Total: Ore (thousand short tons)	Total: Marketable product, units	Total: Ratio of units of ore to units of marketable product
METALS										
Bauxite	Thousand long tons	[1] 2,501	[1] 1,843	[1] 1.3:1	W	W	W	[1] 2,501	[1] 1,843	[1] 1.3:1
Copper	Thousand short tons	198,439	1,183	167.2:1	27,486	263	104.0:1	225,925	1,446	155.7:1
Gold:										
Lode	Thousand troy ounces	1,614	392	3.8:1	2,104	689	3.0:1	3,718	1,081	3.3:1
Placer	do	2,195	26	84.4:1	---	---	---	2,195	26	84.4:1
Iron ore	Thousand long tons	213,997	79,421	2.7:1	115,677	9,585	122.1:1	329,674	89,006	3.7:1
Lead	Thousand short tons	6	---	---	9,507	436	21.8:1	9,513	436	21.8:1
Mercury	Thousand flasks	278	10	28.4:1	204	18	11.3:1	482	28	17.4:1
Nickel	Thousand short tons	1,184	17	69.6:1	---	---	---	1,184	17	69.6:1
Platinum-group metals	Thousand troy ounces	2,348	9	260.9:1	---	---	---	2,348	9	260.9:1
Rare earth minerals	Thousand short tons	259	19	13.6:1	---	---	---	259	19	13.6:1
Silver	Thousand troy ounces	128	377	0.3:1	653	14,839	0.04:1	781	15,216	0.05:1
Titanium: Ilmenite	Thousand short tons	22,204	893	24.8:1	---	---	---	22,204	893	24.8:1
Zinc	do	571	26	23.1:1	10,032	411	24.4:1	10,603	437	24.3:1
NONMETALS										
Aplite	Thousand long tons	232	123	1.9:1	---	---	---	232	123	1.9:1
Asbestos	Thousand short tons	2,178	122	17.9:1	22	4	5.5:1	2,200	126	17.5:1
Barite	do	6,038	993	6.1:1	115	84	1.3:1	6,153	1,077	5.7:1
Boron minerals	do	12,461	978	12.6:1	---	---	---	12,461	978	12.6:1
Clays	do	57,524	57,618	1.0:1	1,063	1,075	1.0:1	58,587	58,693	1.0:1
Emery	do	7	7	1.0:1	---	---	---	7	7	1.0:1
Feldspar	Thousand long tons	1,698	627	2.7:1	9	4	2.2:1	1,707	631	2.7:1
Fluorspar	Thousand short tons	62	40	1.5:1	470	144	3.4:1	532	184	3.0:1
Garnet	do	73	18	4.0:1	---	---	---	73	18	4.0:1
Gypsum	do	7,691	7,477	1.0:1	2,328	2,317	1.0:1	10,019	9,794	1.0:1
Kyanite	do	357	183	1.9:1	---	---	---	357	183	1.9:1
Magnesite	do	600	609	1.0:1	---	---	---	600	609	1.0:1
Mica, flake	do	661	102	6.5:1	---	---	---	661	102	6.5:1
Olivine	do	82	52	1.4:1	---	---	---	82	52	1.4:1
Perlite	do	612	472	1.3:1	---	---	---	612	472	1.3:1
Phosphate rock	Thousand long tons	126,056	33,236	3.8:1	671	448	1.5:1	126,728	33,684	3.8:1
Potassium salts	Thousand short tons	---	---	---	16,989	2,595	6.5:1	16,989	2,595	6.5:1
Pumice	do	3,952	3,903	1.0:1	---	---	---	3,952	3,903	1.0:1
Salt	do	5,400	5,516	1.0:1	14,371	12,208	1.1:1	19,771	17,724	1.1:1
Sand and gravel	do	936,906	936,906	1.0:1	---	---	---	936,906	936,906	1.0:1
Sodium carbonate (natural)	do	---	---	---	4,072	2,220	1.8:1	4,072	2,220	1.8:1
Stone:										
Dimension	do	1,841	1,841	1.0:1	29	29	1.0:1	1,870	1,870	1.0:1
Crushed and broken	do	822,077	822,324	1.0:1	38,935	38,688	1.0:1	861,012	861,012	1.0:1
Sulfur: Frasch	Thousand long tons	8,003	6,551	1.1:1	---	---	---	8,003	6,551	1.1:1
Talc, soapstone and pyrophyllite	Thousand short tons	553	553	1.0:1	519	477	1.1:1	1,072	1,030	1.1:1
Tripoli	do	38	38	1.0:1	48	48	1.0:1	86	86	1.0:1
Vermiculite	do	1,505	310	4.9:1	---	---	---	1,505	310	4.9:1

W Withheld to avoid disclosing individual company confidential data.
[1] Includes underground data; Bureau of Mines not at liberty to publish separately.

Table 11.—Material handled per unit of marketable product at surface and underground mines in the United States by commodities, in 1969

Commodity	Unit of marketable product	Surface: Total material handled (thousand short tons)	Surface: Marketable product, units	Surface: Ratio of units of material handled to units of marketable products	Underground: Total material handled (thousand short tons)	Underground: Marketable product, units	Underground: Ratio of units of material handled to units of marketable products	Total: Total material handled (thousand short tons)	Total: Marketable product, units	Total: Ratio of units of material handled to units of marketable products
METALS										
Bauxite	Thousand long tons	[1] 5,938	[1] 1,843	[1] 3.2:1	W	W	W	5,938	1,843	3.2:1
Copper	Thousand short tons	820,165	1,183	693.3:1	27,938	263	106.2:1	848,103	1,446	586.5:1
Gold:										
Lode	Thousand troy ounces	10,594	392	27.0:1	2,459	689	3.6:1	13,053	1,081	12.1:1
Placer	do	2,968	26	114.2:1	---	---	---	2,968	26	114.2:1
Iron ore	Thousand long tons	382,590	79,421	4.8:1	17,290	9,585	1.8:1	399,880	89,006	4.5:1
Lead	Thousand short tons	38	---	---	10,256	436	23.5:1	10,294	436	23.6:1
Mercury	Thousand flasks	813	10	81.3:1	223	18	12.4:1	1,036	28	37.0:1
Nickel	Thousand short tons	1,546	17	90.9:1	---	---	---	1,546	17	90.9:1
Platinum-group metals	Thousand troy ounces	3,165	9	351.7:1	---	---	---	3,165	9	351.7:1
Rare earth minerals	Thousand short tons	345	19	18.1:1	---	---	---	345	19	18.1:1
Silver	Thousand troy ounces	203	377	0.5:1	951	14,839	0.1:1	1,154	15,216	0.1:1
Titanium: Ilmenite	Thousand short tons	25,733	893	28.8:1	---	---	---	25,733	893	28.8:1
Zinc	do	1,890	26	72.7:1	17,958	411	43.7:1	19,848	437	45.4:1
NONMETALS										
Aplite	Thousand long tons	244	123	2.0:1	---	---	---	244	123	2.0:1
Asbestos	Thousand short tons	3,541	122	29.0:1	25	4	6.2:1	3,566	126	28.3:1
Barite	do	9,195	993	9.2:1	132	84	1.6:1	9,327	1,077	8.7:1
Boron minerals	do	24,471	978	25.0:1	---	---	---	24,471	978	25.0:1
Clays	do	57,524	57,618	1.0:1	1,063	1,075	1.0:1	58,587	58,693	1.0:1
Emery	do	7	7	1.0:1	---	---	---	7	7	1.0:1
Feldspar	Thousand long tons	2,087	627	3.3:1	9	4	2.2:1	2,096	631	3.3:1
Fluorspar	Thousand short tons	102	40	2.5:1	471	144	3.3:1	573	184	3.1:1
Garnet	do	194	18	10.8:1	---	---	---	194	18	10.8:1
Gypsum	do	19,659	7,477	2.6:1	2,401	2,317	1.0:1	22,060	9,794	2.2:1
Kyanite	do	667	183	3.6:1	---	---	---	667	183	3.6:1
Magnesite	do	1,874	609	3.1:1	---	---	---	1,874	609	3.1:1
Mica, flake	do	1,124	102	11.0:1	---	---	---	1,124	102	11.0:1
Olivine	do	82	52	1.6:1	---	---	---	82	52	1.6:1
Perlite	do	613	472	1.3:1	---	---	---	613	472	1.3:1
Phosphate rock	Thousand long tons	404,467	33,236	12.2:1	691	448	1.5:1	405,158	33,684	12.0:1
Potassium salts	Thousand short tons	---	---	---	17,808	2,595	6.9:1	17,808	2,595	6.9:1
Pumice	do	4,088	3,903	1.0:1	---	---	---	4,088	3,903	1.0:1
Salt	do	5,403	5,516	1.0:1	15,007	12,208	1.2:1	20,410	17,724	1.1:1
Sand and gravel	do	936,906	936,906	1.0:1	---	---	---	936,906	936,906	1.0:1
Sodium carbonate (natural)	do	---	---	---	4,196	2,220	1.9:1	4,196	2,220	1.9:1
Stone:										
Dimension	do	1,841	1,841	1.0:1	29	29	1.0:1	1,870	1,870	1.0:1
Crushed and broken	do	822,077	822,324	1.0:1	38,935	38,688	1.0:1	861,012	861,012	1.0:1
Sulfur: Frasch	Thousand long tons	8,003	6,551	1.2:1	---	---	---	8,003	6,551	1.2:1
Talc, soapstone, and pyrophyllite	Thousand short tons	1,788	553	3.2:1	533	477	1.1:1	2,321	1,030	2.2:1
Tripoli	do	58	38	1.5:1	48	48	1.0:1	106	86	1.2:1
Vermiculite	do	5,655	810	18.2:1	---	---	---	5,655	810	18.2:1

W Withheld to avoid disclosing individual company confidential data.
[1] Includes underground data; Bureau of Mines not at liberty to publish separately.

Table 12.—Mining methods used in open-pit mining, by commodities, in 1969

(Percent)

Commodity	Total material handled	
	Preceded by drilling and blasting	Not preceded by drilling and blasting
METALS		
Bauxite	91	8
Beryllium	---	100
Copper	92	8
Gold:		
Lode	96	4
Placer	---	100
Iron ore	83	17
Lead	72	28
Mercury	40	60
Molybdenum	100	---
Nickel	31	69
Platinum-group metals	---	100
Rare-earth metals	100	---
Silver	26	74
Titanium: Concentrate	23	77
Uranium	9	91
Zinc	89	11
NONMETALS		
Abrasive stone	10	90
Aplite	24	76
Asbestos	91	9
Barite	15	85
Clays	---	100
NONMETALS—Continued		
Diatomite	---	100
Emery	100	---
Feldspar	68	32
Fluorspar	73	27
Graphite	98	2
Gypsum	94	6
Kyanite	94	6
Lithium minerals	22	78
Magnesite	100	---
Mica: Flake	83	17
Olivine	42	58
Perlite	52	48
Phosphate rock	1	99
Pumice	3	97
Sand and gravel	---	100
Stone:		
Crushed and broken	---	100
Dimension	---	100
Talc, soapstone and pyrophyllite	58	42
Vermiculite	62	38
Total	32	68

Table 13.—Exploration and development activity in the United States, by methods

Method	Metals		Nonmetals		Total	
	Feet	Percent of total [r]	Feet	Percent of total [r]	Feet	Percent of total [r]
1968						
Shaft and winze sinking	22,842	0.1	1,962	0.1	24,804	0.1
Raising	183,071	.8	8,937	.5	192,008	.8
Drifting and crosscutting	830,816	3.6	30,393	1.7	861,209	3.4
Diamond drilling	2,422,242	10.4	129,712	7.2	2,551,954	10.2
Churn drilling	370,063	1.6	6,191	.3	376,254	1.5
Rotary drilling	16,428,468	70.8	1,043,740	58.0	17,472,208	69.9
Percussion drilling	2,635,803	11.4	410,042	22.8	3,045,845	12.2
Trenching	110,541	.5	11,255	.6	121,796	.5
Other	182,906	.8	158,758	8.8	341,664	1.4
Total	23,186,752	100.0	1,800,990	100.0	24,987,742	100.0
1969						
Shaft and winze sinking	23,708	0.1	2,469	0.3	26,177	0.1
Raising	183,671	.6	11,612	1.2	195,283	.6
Drifting and crosscutting	870,558	2.8	24,922	2.8	895,480	2.8
Diamond drilling	2,155,272	7.0	88,905	9.9	2,244,177	7.1
Churn drilling	462,689	1.5	----------	-----	462,689	1.5
Rotary drilling	23,442,268	76.1	608,978	68.1	24,051,246	75.8
Percussion drilling	3,435,209	11.1	147,480	16.5	3,582,689	11.3
Trenching	101,099	.3	689	.1	101,788	.3
Other	141,181	.5	9,242	1.0	150,423	.5
Total	30,815,655	100.0	894,297	100.0	31,709,952	100.0

[r] Revised for 1968 only.

Table 14.—Exploration and development by methods and selected metals and nonmetals, in 1969

(Feet)

Commodity	Shaft and winze sinking	Raising	Drifting and cross-cutting	Trenching	Diamond drilling	Churn drilling	Rotary drilling	Percussion drilling	Other	Total
METALS										
Beryllium	----------	----------	600	----------	1,200	----------	25,661	3,000	1	30,462
Copper	6,337	64,658	144,341	4,014	953,750	56,158	1,539,374	101,587	516	2,870,735
Gold	3,159	15,910	44,125	31,566	91,233	460	35,216	4,959	124	226,752
Iron ore	----------	35,210	90,221	----------	152,710	4,053	75,237	17,937	----------	375,368
Lead	1,099	14,267	84,989	34,171	234,396	68,608	26,458	546,280	108,348	1,118,616
Mercury	837	5,172	20,725	5,295	8,369	14,006	15,335	106,024	848	176,611
Molybdenum	714	292	61,472	----------	114,871	----------	----------	----------	2	177,351
Silver	2,331	6,721	45,933	23,715	130,373	4,041	11,608	66,090	2,562	293,374
Tungsten	725	2,145	12,436	1,373	32,175	----------	6	4,350	500	53,710
Uranium	3,331	16,670	275,602	265	262,319	275,993	21,366,638	1,660,421	11,832	23,873,071
Zinc	5,175	22,626	80,640	----------	168,929	33,859	20,151	924,561	----------	1,255,941
Other [1]	----------	----------	9,474	700	4,947	5,511	326,584	----------	16,448	363,664
Total	23,708	183,671	870,558	101,099	2,155,272	462,689	23,442,268	3,435,209	141,181	30,815,655
NONMETALS										
Asbestos	----------	425	825	----------	----------	----------	----------	----------	1	1,251
Barite	----------	803	4,373	----------	8,000	----------	1,340	31,530	4,740	50,786
Fluorspar	130	1,450	4,390	----------	45,971	----------	506	----------	1	52,448
Gypsum	20	800	5,645	----------	9,747	----------	195,895	50,000	----------	262,107
Phosphate rock	----------	4,090	2,982	600	10,134	----------	379,913	1,000	----------	398,719
Talc, soapstone, and pyrophyllite	2,144	4,044	6,657	----------	10,765	----------	16,389	60,000	----------	99,999
Other [2]	175	----------	50	89	4,288	----------	14,935	4,950	4,500	28,987
Total	2,469	11,612	24,922	689	88,905	----------	608,978	147,480	9,242	894,297
Grand total	26,177	195,283	895,480	101,788	2,244,177	462,689	24,051,246	3,582,689	150,423	31,709,952

[1] Bauxite, columbium-tantalum, ilmenite, manganese ore, nickel, platinum metals, rare earths, and vanadium.
[2] Aplite, boron minerals, diatomite, feldspar, mica, (scrap), pumice, salt.

Table 15.—Exploration and development by methods and States, in 1969

(Feet)

State	Shaft and winze sinking	Raising	Drifting and cross-cutting	Trenching	Diamond drilling	Churn drilling	Rotary drilling	Percussion drilling	Other	Total
Alabama	--	--	--	--	--	156	262,617	--	--	262,773
Alaska	--	40	10	--	8,000	5,355	--	800	3,957	18,162
Arizona	6,136	55,306	104,235	893	483,512	34,235	808,870	88,516	13	1,581,716
Arkansas	--	803	13,817	--	3,027	--	55,304	--	1,125	74,076
California	2,872	8,989	40,814	10,900	50,804	11,226	118,099	123,473	2,387	369,064
Colorado	4,138	11,383	167,813	3,635	307,116	--	847,214	763,891	10,684	2,115,874
Florida	--	--	--	--	--	--	19,800	--	--	19,800
Georgia	--	--	--	--	--	--	--	--	6,300	6,300
Idaho	2,489	12,332	40,705	640	97,214	--	226,633	1,276,706	1,249	1,657,968
Illinois	80	690	1,510	--	42,099	--	1,654	--	--	46,033
Iowa	--	--	--	--	--	--	5,300	--	--	5,300
Kansas	1,432	--	1,450	--	--	140	915	--	--	3,937
Kentucky	50	200	890	--	9,128	--	--	2,000	--	12,268
Michigan	--	9,107	30,461	--	108,125	--	--	--	--	147,693
Minnesota	--	--	--	--	223,977	--	2,954	2,937	--	229,868
Missouri	--	12,223	89,957	29,301	167,179	73,874	21,442	20,000	95,250	509,226
Montana	372	6,353	15,225	7,690	9,691	16,490	16,680	61,909	1,500	135,910
Nevada	2,955	1,312	11,362	42,100	107,932	3,625	739,658	56,769	1,200	966,913
New Jersey	--	1,277	585	--	--	--	--	--	5,065	6,927
New Mexico	529	17,237	208,054	1,414	168,447	530	4,606,517	631,118	508	5,634,354
New York	280	15,971	11,738	--	18,614	--	--	--	--	46,603
North Carolina	1,175	37	1,150	--	4,600	--	8,000	--	--	14,962
Ohio	--	--	--	--	2,115	--	6,382	--	--	8,497
Oregon	--	71	465	20	150	--	7,939	100	2,961	11,706
Pennsylvania	--	6,969	7,197	--	--	--	--	--	--	14,166
South Dakota	--	14,013	31,857	12	91,036	--	433,040	2,500	--	572,458
Tennessee	--	2,201	24,789	--	67,196	268	137,040	167,897	--	399,391
Texas	88	1,370	3,170	--	--	--	5,776,803	20,200	--	5,801,631
Utah	3,301	11,469	54,055	783	202,404	8,503	1,058,294	308,263	505	1,647,577
Vermont	--	1,200	1,335	--	800	--	--	--	--	3,335
Virginia	--	3,261	8,720	--	888	--	39,046	--	--	51,915
Washington	--	545	4,555	4,400	12,460	--	26,132	5,000	17,317	70,409
Wisconsin	--	--	3,298	--	27,555	32,294	13,585	8,782	--	85,514
Wyoming	--	753	16,160	--	18,105	275,993	8,787,430	41,828	402	9,140,671
Other	280	171	603	--	12,003	--	23,898	--	--	36,955
Total	26,177	195,283	895,480	101,788	2,244,177	462,689	24,051,246	3,582,689	150,423	31,709,952

Table 16.—Total material (ore and waste) produced by exploration and development in the United States, by commodities and States, in 1969

(Thousand short tons)

	Shaft and winze sinking	Raising	Drifting and cross-cutting	Trenching	Stripping	Total
COMMODITIES						
METALS						
Bauxite	---	---	29	---	2,630	2,659
Beryllium	---	---	2	---	506	508
Copper	73	93	420	10	371,820	372,416
Gold:						
Lode	6	31	81	566	47	731
Placer	---	---	1	5	39	45
Iron ore	---	42	435	---	95,249	95,726
Lead	1	25	383	109	16	534
Mercury	1	8	34	13	464	520
Molybdenum	8	1	232	---	---	241
Silver	9	17	113	147	145	431
Tungsten	2	4	46	2	10	64
Uranium	7	21	606	2	79,838	80,474
Zinc	29	27	307	---	---	363
Other [1]	---	---	---	1	2,869	2,870
Total metals [2]	141	272	2,694	858	553,638	557,603
NONMETALS						
Barite	---	1	7	---	308	316
Feldspar	---	---	---	---	128	128
Fluorspar	---	5	12	---	12	29
Gypsum	---	2	30	---	11,029	11,061
Phosphate rock	---	9	10	7	192,163	192,189
Talc, soapstone & pyrophyllite	15	6	29	---	1,107	1,157
Other [1]	---	---	1	---	1,197	1,198
Total nonmetals [2]	15	23	90	7	205,947	206,082
Grand total [2]	156	297	2,783	865	759,585	763,686
STATE						
Alabama	---	---	---	---	100	100
Alaska	---	---	---	---	12	12
Arizona	72	61	308	2	266,308	266,751
Arkansas	---	1	36	---	2,733	2,770
California	15	15	144	28	799	1,001
Colorado	20	19	447	7	69	562
Florida	---	---	---	---	165,613	165,613
Georgia	---	---	---	---	61	61
Idaho	15	30	105	7	10,587	10,744
Illinois	---	2	6	---	---	8
Indiana	---	---	---	---	34	34
Iowa	---	---	---	---	6,218	6,218
Kansas	11	---	14	---	195	220
Kentucky	---	---	2	---	12	14
Michigan	---	9	97	---	14,104	14,210
Minnesota	---	---	---	---	86,734	86,734
Missouri	---	21	560	92	---	673
Montana	1	23	35	40	30,266	30,365
Nevada	6	2	23	681	20,005	20,717
New Jersey	---	1	1	---	286	288
New Mexico	1	27	476	1	58,081	58,586
New York	1	15	35	---	---	51
North Carolina	4	---	3	---	12,835	12,842
Pennsylvania	---	4	29	---	---	33
South Carolina	---	---	---	---	10	10
South Dakota	---	25	58	---	756	839
Tennessee	---	2	131	---	3,062	3,195
Texas	---	1	4	---	2,813	2,818
Utah	10	30	154	3	1,529	1,726
Vermont	---	2	3	---	---	5
Virginia	---	4	35	---	2	41
Washington	---	2	9	4	---	15
Wisconsin	---	---	27	---	83	110
Wyoming	---	1	39	---	70,773	70,813
Other [4]	---	---	2	---	5,505	5,507
Total	156	297	2,783	865	759,585	763,686

[1] Manganiferous ore, ilmenite, and rare earths.
[2] Data may not add to totals shown because of rounding.
[3] Asbestos, diatomite, graphite, mica, salt, and scrap.
[4] Maine, Oklahoma, and Oregon.

Table 17.—U.S. consumption of industrial explosives

(Thousand pounds)

	Black blasting powder		High explosives		Blasting agents	Liquid oxygen explosives	Total
	Granular	Pellets	Permissible	Other than permissible	Ammonium nitrate processed and unprocessed		
1964	451	495	77,406	481,451	1,103,563	2,184	1,665,550
1965	464	372	76,040	542,318	1,260,107	5,598	1,884,899
1966	240	223	74,527	[1] 538,968	1,343,104	13,094	1,970,156
1967	242	182	68,770	[1] 537,997	1,287,506	10,017	1,904,714
1968	257	170	64,130	535,364	1,347,816	------	1,947,737

[1] Includes blasting agents, rigidly cartridged and water gels and slurries.

Table 18.—U.S. consumption of explosives in the minerals industry

(Thousand pounds)

Year	Coal mining	Metal mining	Quarrying and nonmetal mining	Total
PERMISSIBLE EXPLOSIVES				
1964	75,950	117	741	76,808
1965	73,564	79	1,520	75,163
1966	71,091	95	1,957	73,143
1967	65,284	161	2,238	67,683
1968	60,943	267	1,394	62,604
OTHER HIGH EXPLOSIVES				
1964	23,557	119,782	133,022	276,361
1965	22,090	123,862	141,050	287,002
1966	19,591	118,900	141,117	279,608
1967	r 30,942	161,181	146,018	r 338,141
1968	29,482	195,315	144,663	369,460
AMMONIUM NITRATE BLASTING AGENTS [1]				
1964	447,145	198,395	227,290	872,830
1965	493,571	232,770	228,284	954,625
1966	514,549	234,336	252,794	1,001,679
1967	555,303	166,250	261,145	982,698
1968	593,741	207,859	251,832	1,053,432
PELLET BLACK BLASTING POWDER				
1964	341	-------	48	389
1965	126	-------	61	187
1966	77	-------	25	102
1967	32	1	23	56
1968	-------	-------	11	11
GRANULAR BLACK BLASTING POWDER				
1964	108	6	145	259
1965	15	4	120	139
1966	245	-------	390	635
1967	3	3	101	107
1968	-------	3	98	101
TOTAL EXPLOSIVES				
1964	547,101	318,300	361,246	1,226,647
1965	589,366	356,715	371,035	1,317,116
1966	605,553	353,331	396,283	1,355,167
1967	r 651,564	327,596	409,525	r 1,388,685
1968	684,166	403,444	397,998	1,485,608

r Revised.
[1] Includes blasting agents, rigidly cartridged and water gels and slurries.

Statistical Summary

By Julia Muscal [1]

This summary appears in Minerals Yearbook volumes I-II, and III, which cover mineral production in the United States, its island possessions, the Canal Zone, and the Commonwealth of Puerto Rico, as well as the principal minerals exported from and imported into the United States. The sections of this chapter and the area chapters in volume III contain further details on production. A summary table comparing world and U.S mineral production also is included.

Mineral production may be measured at any of several stages of extraction and processing. The stage of measurement used in the chapter is normally what is termed "mine output." It usually refers to minerals in the form in which they are first extracted from the ground, but customarily includes for some minerals the product of auxiliary processing operations at or near mines.

Because of inadequacies in the statistics available, some series deviate from the foregoing definition. The quantities of gold, silver, copper, lead, zinc, and tin are recorded on a mine basis (as the recoverable content of ore sold or treated). The values assigned to these quantities, however, are based on the average selling price of refined metal, not the mine value. Mercury is measured as recovered metal and valued at the average New York price for metal.

The weight or volume units shown are those customary in the particular industries producing the respective commodities. No adjustment has been made in dollar values for changes in purchasing power of the dollar.

[1] Statistical assistant, Minerals Yearbook.

Table 1.—Value of mineral production [1] in the United States, by mineral groups

(Millions)

Year	Mineral fuels	Nonmetals (except fuels)	Metals	Total [2]
1965	$14,047	$4,933	$2,544	$21,524
1966	15,088	5,176	2,703	22,968
1967	16,195	r 5,200	2,333	r 23,729
1968	16,820	r 5,448	2,703	r 24,971
1969	17,965	5,625	3,338	26,928

r Revised.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2] Data may not add to totals shown because of independent rounding.

Table 2.—Mineral production [1] in the United States

Mineral	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)
Mineral fuels:								
Asphalt and related bitumens (native):								
Bituminous limestone and sandstone and gilsonite short tons	2,041,271	$8,438	1,866,666	$8,136	r 1,797,219	r $8,179	1,918,748	$8,561
Carbon dioxide, natural (estimate) thousand cubic feet	1,140,907	153	1,142,374	165	1,118,027	176	1,194,836	144
Coal:								
Bituminous and lignite [2] thousand short tons	533,881	2,421,293	552,626	2,555,377	545,245	2,546,340	560,505	2,795,509
Pennsylvania anthracite do	12,941	100,663	12,256	96,160	11,461	97,245	10,473	100,769
Helium:								
Crude thousand cubic feet	3,654,700	41,556	3,697,300	42,800	3,788,400	44,700	3,992,600	46,843
Grade A do	951,400	32,541	1,015,000	29,657	1,066,400	28,355	759,800	21,599
Natural gas million cubic feet	17,206,628	2,702,759	18,171,325	2,898,741	19,322,400	3,168,688	20,698,240	3,455,615
Natural gas liquids:								
Natural gasoline and cycle products thousand 42-gallon barrels	179,248	520,635	187,840	546,927	199,049	571,679	201,784	603,084
LP gases do	288,912	527,223	326,616	632,994	351,262	552,335	378,457	498,927
Peat short tons	605,858	6,501	619,687	6,768	619,161	7,230	565,760	7,055
Petroleum (crude) thousand 42-gallon barrels	3,027,763	8,726,423	3,216,715	9,377,516	3,329,042	9,794,826	3,371,751	10,426,680
Total mineral fuels	XX	15,088,000	XX	16,195,000	XX	16,820,000	XX	17,965,000
Nonmetals (except fuels):								
Abrasive stones [3] short tons	3,806	$515	2,701	$574	3,141	$629	3,311	$600
Asbestos do	125,928	11,056	123,189	11,102	120,690	10,406	125,936	10,648
Barite thousand short tons	947	11,259	962	11,604	927	13,706	1,077	15,753
Boron minerals do	866	68,209	r 892	r 69,819	r 963	r 76,535	1,020	81,261
Bromine thousand pounds	326,498	78,883	349,757	85,391	362,452	86,787	391,883	87,990
Calcium-magnesium chloride short tons	(4)	(4)	608,965	11,983	(4)	(4)	(4)	(4)
Cement:								
Portland thousand 376-pound barrels	373,091	1,162,984	365,570	1,148,208	388,525	1,227,942	400,883	1,284,600
Masonry thousand 280-pound barrels	22,367	63,407	21,700	62,168	23,167	66,259	23,253	69,106
Natural and slag thousand 376-pound barrels	109	415	94	360	86	332	(4)	(4)
Clays thousand short tons	56,713	221,714	54,664	223,987	r 57,348	r 246,938	58,694	264,415
Diatomite short tons	(4)	(4)	(4)	(4)	(4)	(4)	598,482	36,484
Emery do	11,102	210	(4)	(4)	(4)	(4)	(4)	(4)
Feldspar long tons	655,452	7,020	615,397	7,086	667,679	8,265	673,985	8,869
Fluorspar short tons	253,068	10,841	295,643	13,164	252,411	11,656	182,567	8,411
Garnet (abrasive) do	21,952	2,092	20,494	1,849	22,136	1,922	20,458	1,874
Gem stones (estimate)	NA	2,437	NA	2,430	NA	2,497	NA	2,390
Gypsum thousand short tons	9,647	35,681	9,393	34,383	10,018	36,775	5 9,905	5 38,354
Lime do	18,057	239,588	17,985	240,216	18,637	249,639	20,209	280,736
Magnesium compounds from sea water and brine (except for metals) short tons, MgO equivalent	651,187	46,690	544,428	41,883	525,210	43,449	625,618	53,308

Mica:								
Scrap ... short tons	113,133	3,733	118,503	2,876	125,323	3,014	133,058	2,893
Sheet ... pounds	4,500	1	20,500	(4)	15,000	(4)	(4)	3
Perlite ... short tons	404,160	3,907	413,001	3,973	427,574	4,221	471,454	5,100
Phosphate rock ... thousand short tons	39,044	261,092	39,770	265,947	41,251	250,692	37,725	208,689
Potassium salts thousand short tons, K_2O equivalent	3,320	122,210	3,299	105,313	2,722	75,664	2,804	73,572
Pumice ... thousand short tons	3,218	6,765	3,446	5,131	3,530	5,570	3,609	5,050
Pyrites ... thousand long tons	873	5,088	861	7,943	872	(4)	(4)	(4)
Salt ... thousand short tons	36,463	229,985	38,946	251,210	41,274	272,275	44,245	287,680
Sand and gravel ... do	934,481	984,982	r 905,899	r 980,619	r 917,468	r 1,020,107	936,906	1,070,302
Sodium carbonate (natural) ... short tons	1,737,511	40,674	1,726,071	40,539	2,043,405	42,104	2,513,435	50,922
Sodium sulfate (natural) ... do	640,329	11,271	636,843	10,710	699,706	12,729	672,118	12,427
Stone [6] ... thousand short tons	813,374	1,260,715	785,592	1,240,244	r 819,597	r 1,317,911	862,895	1,424,694
Sulfur:								
Frasch process mines ... thousand long tons	7,721	201,292	7,682	251,670	6,645	268,146	6,551	176,659
Other mines ... long tons	557	5	568	3	3,125	46	---------	---------
Talc, soapstone, and pyrophyllite ... short tons	895,045	6,479	902,512	6,871	958,262	6,656	1,029,238	7,508
Tripoli ... do	66,163	328	70,984	377	85,534	796	84,673	734
Vermiculite ... thousand short tons	262	4,954	255	4,974	290	5,684	310	6,805
Value of items that cannot be disclosed: Aplite, brucite, calcite (1966), graphite, iodine, kyanite, lithium minerals, magnesite, greensand marl, olivine, staurolite, wollastonite, and values indicated by footnote 4	XX	69,911	XX	55,734	XX	79,309	XX	46,940
Total nonmetals	XX	5,176,000	XX	r 5,200,000	XX	r 5,448,000	XX	5,625,000
Metals:								
Antimony ore and concentrate short tons, antimony content	927	(7)	892	(7)	856	(7)	938	(7)
Bauxite ... thousand long tons, dried equivalent	1,796	$20,095	1,654	$19,079	1,665	$23,752	1,843	$25,725
Beryllium concentrate ... short tons, gross weight	(7)	(7)	(7)	(7)	168	81	(7)	(7)
Copper (recoverable content of ores, etc.) short tons	1,429,152	1,033,850	954,064	729,401	1,204,621	1,008,195	1,544,579	1,468,400
Gold (recoverable content of ores, etc.) troy ounces	1,803,420	63,119	1,584,187	55,447	1,478,292	[8] 58,038	1,733,176	[8] 71,944
Iron ore, usable (excluding byproduct iron sinter) thousand long tons, gross weight	90,040	854,134	82,415	817,511	81,934	836,433	89,854	929,293
Lead (recoverable content of ores, etc.) short tons	327,368	98,964	316,931	88,741	359,156	94,903	509,013	151,635
Manganese ore (35 percent or more Mn) short tons, gross weight	14,406	(7)	12,585	(7)	11,378	(7)	5,630	157
Manganiferous ore (5 to 35 percent Mn) ... do	324,926	(7)	289,160	(7)	244,590	(7)	430,637	(7)
Mercury ... 76-pound flasks	22,008	9,722	23,784	11,639	28,874	15,464	29,360	14,828
Molybdenum (content of concentrate) thousand pounds	91,670	144,327	81,596	133,604	93,245	151,000	103,009	173,819
Nickel (content of ore and concentrate) short tons	15,036	(7)	15,287	(7)	17,294	(7)	17,056	(7)
Silver (recoverable content of ores, etc.) thousand troy ounces	43,669	56,463	32,345	50,135	32,729	70,191	41,906	75,040
Tin (content of concentrate) ... long tons	97	265	(7)	(7)	(7)	(7)	(7)	(7)
Titanium concentrate, ilmenite short tons, gross weight	868,436	17,608	882,414	18,519	960,118	19,484	893,034	18,636

See footnotes at end of table.

Table 2.—Mineral production[1] in the United States—Continued

Mineral	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)
Metals—Continued								
Tungsten ore and concentrate short tons, 60 percent WO_3 basis	8,912	$17,620	9,088	$20,895	10,704	$25,197	9,883	$24,624
Uranium (recoverable content U_3O_8) thousand pounds	19,037	152,281	20,655	165,239	24,139	182,698	23,748	142,161
Vanadium (recoverable in ore and concentrate) short tons	5,166	22,210	4,963	21,331	6,483	23,143	5,577	26,334
Zinc (recoverable content of ores, etc.) do	572,558	166,044	549,413	151,562	529,446	142,950	553,124	161,512
Value of items that cannot be disclosed: Cobalt, columbium-tantalum concentrate (1967, 1969), magnesium chloride for magnesium metal, manganiferous residuum, platinum-group metals (crude), rare-earth metal concentrates, titanium concentrate (rutile 1966–68), zirconium concentrate, and values indicated by footnote 7	XX	46,615	XX	50,190	XX	51,030	XX	54,148
Total metals	XX	2,703,000	XX	2,333,000	XX	2,703,000	XX	3,338,000
Grand total mineral production	XX	22,968,000	XX	r 23,729,000	XX	r 24,971,000	XX	26,928,000

r Revised. NA Not available. XX Not applicable.
1 Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
2 Includes small quantity of anthracite mined in States other than Pennsylvania.
3 Grindstones, pulpstones, millstones (weight not recorded), grinding pebbles, sharpening stones, and tube mill liners.
4 Figure withheld to avoid disclosing individual company confidential data; value included with "Nonmetal items that cannot be disclosed."
5 Final figure; supersedes figure given in commodity section.
6 Excludes abrasive stone, bituminous limestone, bituminous sandstone, and ground soapstone, all included elsewhere in table.
7 Figure withheld to avoid disclosing individual company confidential data; value included with "Metal items that cannot be disclosed."
8 Based on average U.S. Treasury price ($35.00) Jan. 1, 1968 through Mar. 15, 1968; and Engelhard selling quotations Mar. 20, 1968 through 1969.

Table 3.—Minerals produced in the United States and principal producing States in 1969

Mineral	Principal producing States in order of quantity	Other producing States
Antimony	Idaho, Alaska, Nev.	
Aplite	Va.	
Asbestos	Calif., Vt., Ariz., N.C.	
Asphalt	Tex., Utah, Ala., Mo.	
Barite	Nev., Mo., Ark., Ga	Alaska, Calif., Tenn.
Bauxite	Ark., Ala., Ga.	
Beryllium	Colo., S. Dak., Maine, N. Mex.	
Boron	Calif.	
Bromine	Mich., Ark., Tex., Calif.	
Brucite	Nev.	
Calcium-magnesium chloride	Mich., Calif.	
Carbon dioxide	N. Mex., Colo., Utah, Calif.	
Cement	Calif., Pa., Tex., Mich	Ala., Ariz., Ark., Colo., Fla., Ga., Hawaii., Idaho, Ill., Ind., Iowa, Kans., Ky., La., Maine, Md., Minn., Miss., Mo., Mont., Nebr., Nev., N. Mex., N.Y., N.C., Ohio, Okla., Oreg., S.C., S. Dak., Tenn,. Utah, Va., Wash., W. Va., Wis., Wyo.
Clays	Ga., Ohio, Tex., N.C	All other States except Alaska, R.I.
Coal	W. Va., Ky., Pa., Ill	Ala., Alaska, Ark., Colo., Ind., Iowa, Kans., Md., Mo., Mont., N. Mex., N. Dak., Ohio., Okla., Tenn., Utah, Va., Wash., Wyo.
Cobalt	Pa.	
Columbium-tantalum	S. Dak.	
Copper	Ariz., Utah, N. Mex., Nev	Calif., Colo., Idaho, Maine, Mich., Mo., Mont., Okla., Oreg., Pa., Tenn., Wash., Wyo.
Diatomite	Calif., Nev., Wash., Ariz	Md., Oreg.
Emery	N.Y.	
Feldspar	N.C., Calif., Conn., S.C	Ariz., Colo., Ga., Maine, N.H., N. Mex., S. Dak., Va.
Fluorspar	Ill., Colo., Nev., Mont	Ky., N. Mex., Utah.
Garnet, abrasive	N.Y., Idaho.	
Gold	S. Dak., Nev., Utah, Ariz	Alaska, Calif., Colo., Idaho, Mont., N. Mex., Oreg., Pa., Tenn., Wash., Wyo.
Graphite	Tex.	
Gypsum	Mich., Tex., Calif., Iowa	Ariz., Ark., Colo., Ind., Kans., La., Mont., Nev., N. Mex., N.Y., Ohio, Okla., S. Dak., Utah, Va., Wash., Wyo.
Helium	Kans., Tex., Okla., Ariz	N. Mex.
Iodine	Mich.	
Iron Ore	Minn., Mich., Calif., Mo	Ala., Ariz., Colo., Ga., Idaho, Mont., Nev., N. Mex., N.Y., N.C., Pa., Tex., Utah, Va., Wis., Wyo.
Kyanite	Va., Ga., S.C., Fla.	
Lead	Mo., Idaho, Utah, Colo	Alaska, Ariz., Calif., Ill., Kans., Mont., Nev., N. Mex., N.Y., Okla., Oreg., S. Dak., Va., Wash., Wis.
Lime	Ohio, Pa., Mo., Tex	Ala., Ariz., Ark., Calif., Colo., Conn., Fla., Hawaii, Idaho, Ill., Ind., Iowa, Kans., La., Md., Mass., Mich., Minn., Miss., Mont., Nebr., Nev., N.J., N. Mex., N.Y., N. Dak., Okla., Oreg., S. Dak., Tenn., Utah, Vt., Va., Wash., W. Va., Wis., Wyo., P.R.
Lithium	N.C., Nev., Calif., S. Dak.	
Magnesite	Nev.	
Magnesium Chloride	Tex.	
Magnesium Compounds	Mich., Tex., Calif., N.J	Fla., Miss., Utah.
Manganese ore	N. Mex., Mont.	
Manganiferous ore	Minn., N. Mex.	
Manganiferous residuum	N.J.	
Marl, greensand	N.J., Md.	
Mercury	Calif., Nev., Tex., Idaho	Alaska, Ariz., Oreg.
Mica:		
Scrap	N.C., Ala., Ga., Ariz	Conn., N.H., N. Mex., Pa., S.C., S. Dak.
Sheet	N.C.	
Molybdenum	Colo., Utah, Ariz., N. Mex	Calif., Nev.
Natural gas	Tex., La., Okla., N. Mex	Ala., Alaska, Ariz., Ark., Calif., Colo., Fla., Ill., Ind., Kans., Ky., Md., Mich., Miss., Mo., Mont., Nebr., N.Y., N. Dak., Ohio, Pa., Tenn., Utah, Va., W. Va., Wyo.

Table 3.—Minerals produced in the United States and principal producing States in 1969—Continued

Mineral	Principal producing States in order of quantity	Other producing States
Natural gas liquids	Tex., La., Okla., N. Mex	Ala., Alaska, Ark., Calif., Colo., Fla., Ill., Kans., Ky., Mich., Miss., Mont., Nebr., N. Dak., Pa., Utah, W. Va., Wyo.
Nickel	Oreg.	
Olivine	Wash., N.C.	
Peat	Mich., Ill., Fla., N.J	Calif., Colo., Ga., Idaho, Ind., Iowa, Maine, Md., Mass., Minn., Mont., N. Mex., N.Y., Ohio, Pa., S.C., Vt., Wash., Wis.
Perlite	N. Mex., Ariz., Calif., Nev	Colo., Idaho, Utah.
Petroleum	Tex., La., Calif., Okla	Ala., Alaska, Ariz., Ark., Colo., Fla., Ill., Ind., Kans., Ky., Mich., Miss., Mo., Mont., Nebr., Nev., N. Mex., N.Y., N. Dak., Ohio, Pa., S. Dak., Tenn., Utah, Va., W. Va., Wyo.
Phosphate rock	Fla., Idaho, Tenn., N.C	Ala., Calif., Mont., Utah, Wyo.
Platinum-group metals	Alaska.	
Potassium salts	N. Mex., Utah, Calif., Mich.	Md.
Pumice	Ariz., Oreg., Calif., Hawaii	Colo., Idaho, Kans., Mont., Nebr., Nev., N. Mex., Okla., Tex., Utah, Wash., Wyo.
Pyrites	Tenn., Pa., Colo., Nev	Ariz., S.C.
Rare-earth metals	Calif., Ga., Colo.	
Salt	La., Tex., Ohio, N.Y	Ala., Calif., Colo., Hawaii, Kans., Mich., Nev., N. Mex., N. Dak., Okla., Utah, Va., W. Va.
Sand and gravel	Calif., Mich., Ohio, Minn	All other States.
Silver	Idaho, Ariz., Utah, Mont	Alaska, Calif., Colo., Maine, Mich., Mo., Nev., N. Mex., N.Y., Okla., Oreg., Pa., S. Dak., Tenn., Wash., Wyo.
Sodium carbonate	Wyo., Calif.	
Sodium sulfate	Calif., Wyo.	
Staurolite	Fla.	
Stone	Pa., Ill., Ohio, Tex	All other States except Del.
Sulfur (Frasch)	La., Tex.	
Talc, soapstone, and pyrophyllite	N.Y., Tex., Vt., Calif	Ala., Ark., Ga., Md., Mont., Nev., N.C., Oreg., Pa., Va., Wash.
Tin	Colo., S. Dak., Alaska, N. Mex.	
Titanium	N.Y., Fla., N.J., Ga	Va.
Tripoli	Ill., Okla., Ark., Pa.	
Tungsten	Calif., Colo., Mont., Nev	Ariz., Idaho, Utah.
Uranium	N. Mex., Wyo., Colo., Tex	Ariz., S. Dak., Utah.
Vanadium	Colo., Idaho, Ark., Utah	Ariz., N. Mex.
Vermiculite	Mont., S.C., Tex., Ariz.	
Wollastonite	N.Y., Calif.	
Zinc	Tenn., N.Y., Idaho, Colo	Ariz., Calif., Ill., Kans., Ky., Maine., Mo., Mont., Nev., N.J., N. Mex., Okla., Oreg., Pa., Utah, Va., Wash., Wis.
Zirconium	Fla., Ga.	

Table 4.—Value of mineral production in the United States and principal minerals produced in 1969

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals in order of value
Alabama	$284,736	22	1.06	Coal, cement, stone, petroleum.
Alaska	257,776	24	.96	Petroleum, sand and gravel, natural gas, coal.
Arizona	859,303	8	3.19	Copper, molybdenum, sand and gravel, cement.
Arkansas	208,126	27	.77	Petroleum, bromine and bromine compounds, natural gas, bauxite.
California	1,850,517	3	6.87	Petroleum, natural gas, cement, sand and gravel.
Colorado	368,494	17	1.37	Molybdenum, petroleum, coal, sand and gravel.
Connecticut	27,767	45	.10	Stone, sand and gravel, feldspar, lime.
Delaware	2,086	50	.01	Sand and gravel, clays, gem stones.
Florida	295,376	21	1.10	Phosphate rock, stone, cement, sand and gravel.
Georgia	190,902	29	.71	Clays, stone, cement, sand and gravel.
Hawaii	29,539	44	.11	Stone, cement, sand and gravel, pumice.
Idaho	118,309	32	.44	Silver, phosphate rock, lead, zinc.
Illinois	659,815	10	2.45	Coal, petroleum, stone, sand and gravel.
Indiana	241,871	26	.90	Coal, cement, stone, sand and gravel.
Iowa	119,930	31	.45	Cement, stone, sand and gravel, gypsum.
Kansas	577,816	15	2.15	Petroleum, natural gas, helium, natural gas liquids.
Kentucky	591,048	13	2.19	Coal, stone, petroleum, natural gas.
Louisiana	4,685,326	2	17.40	Petroleum, natural gas, natural gas liquids, sulfur.
Maine	20,188	47	.07	Cement, sand and gravel, stone, zinc.
Maryland	83,483	36	.31	Stone, cement, sand and gravel, coal.
Massachusetts	49,843	43	.18	Sand and gravel, stone, lime, clays.
Michigan	668,247	9	2.48	Iron ore, cement, copper, sand and gravel.
Minnesota	635,636	12	2.36	Iron ore, sand and gravel, stone, cement.
Mississippi	243,184	25	.90	Petroleum, natural gas, sand and gravel, clays.
Missouri	367,232	18	1.36	Lead, cement, stone, iron ore.
Montana	282,631	23	1.05	Petroleum, copper, sand and gravel, cement.
Nebraska	78,030	39	.29	Petroleum, cement, sand and gravel, stone.
Nevada	168,295	30	.62	Copper, gold, sand and gravel, diatomite.
New Hampshire	8,120	48	.03	Sand and gravel, stone, clays, feldspar.
New Jersey	83,107	37	.31	Stone, sand and gravel, zinc, magnesium compounds.
New Mexico	935,746	7	3.48	Petroleum, natural gas, copper, uranium.
New York	302,339	20	1.12	Cement, stone, salt, sand and gravel.
North Carolina	90,455	34	.34	Stone, sand and gravel, phosphate rock, cement.
North Dakota	91,048	33	.34	Petroleum, coal, sand and gravel, natural gas.
Ohio	580,667	14	2.16	Coal, stone, sand and gravel, lime.
Oklahoma	1,090,809	4	4.05	Petroleum, natural gas, natural gas liquids, stone.
Oregon	60,164	40	.22	Sand and gravel, stone, cement, nickel.
Pennsylvania	976,367	5	3.63	Coal, cement, stone, sand and gravel.
Rhode Island	4,433	49	.02	Sand and gravel, stone, gem stones.
South Carolina	55,864	41	.21	Cement, stone, clays, sand and gravel.
South Dakota	54,921	42	.20	Gold, stone, sand and gravel, cement.
Tennessee	205,451	28	.76	Stone, zinc, cement, coal.
Texas	5,769,970	1	21.43	Petroleum, natural gas, natural gas liquids, cement.
Utah	543,282	16	2.02	Copper, petroleum, coal, molybdenum.
Vermont	27,759	46	.10	Stone, asbestos, sand and gravel, talc.
Virginia	317,527	19	1.18	Coal, stone, cement, sand and gravel.
Washington	88,626	35	.33	Sand and gravel, cement, stone, zinc.
West Virginia	948,430	6	3.52	Coal, natural gas, stone, cement.
Wisconsin	79,792	38	.30	Sand and gravel, stone, zinc, cement.
Wyoming	647,442	11	2.40	Petroleum, natural gas, sodium salts, uranium.
Total	26,927,827	----	100.00	Petroleum, natural gas, coal, copper.

Table 5.—Mineral production [1] in the United States, by States

Mineral	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)
ALABAMA								
Cement: [2]								
Portland ... thousand 376-pound barrels	16,394	$49,537	15,364	$46,510	15,514	$48,147	16,527	$51,251
Masonry ... thousand 280-pound barrels	2,570	7,613	2,377	6,938	2,523	7,309	2,600	8,520
Clays ... thousand short tons	2,448	5,142	2,724	7,422	2,793	6,995	3,097	7,083
Coal (bituminous) ... do	14,219	100,112	15,486	110,696	16,440	115,815	17,456	130,405
Iron ore (usable) ... thousand long tons, gross weight	1,508	8,702	1,472	8,286	1,151	6,730	1,125	6,435
Lime ... thousand short tons	699	8,442	624	7,719	773	8,933	747	9,870
Natural gas ... million cubic feet	252	32	248	31	230	30	180	24
Petroleum (crude) ... thousand 42-gallon barrels	8,030	20,878	7,348	19,500	7,635	20,385	7,701	20,793
Sand and gravel ... thousand short tons	7,082	7,953	7,229	7,969	8,140	9,130	8,323	9,427
Stone ... do	[4] 20,744	[4] 36,839	18,371	33,346	20,643	33,847	19,854	37,512
Value of items that cannot be disclosed: Native asphalt, bauxite, slag cement, scrap mica, natural gasoline 1969, liquefied petroleum gases 1969, phosphate rock 1969, salt, stone (dimension limestone 1966, dimension marble 1966, crushed sandstone 1966, and talc	XX	4,528	XX	2,974	XX	2,300	XX	3,416
Total	XX	249,778	XX	251,391	XX	259,621	XX	284,736
ALASKA								
Antimony ore and concentrate ... short tons, antimony content	8	W	10	W	3	W	12	$13
Barite ... thousand short tons	W	W	W	W	91	W	W	W
Coal (bituminous) ... do	927	$6,953	925	$7,296	750	$4,502	667	4,366
Gold (recoverable content of ores, etc.) ... troy ounces	27,325	956	22,948	803	21,262	[5] 835	21,227	[5] 881
Lead (recoverable content of ores, etc.) ... short tons	14	4	---	---	W	W	2	1
Natural gas ... million cubic feet	11,267	2,794	14,438	3,610	17,343	4,388	50,864	12,665
Peat ... short tons	W	W	1,528	12	---	---	---	---
Petroleum (crude) ... thousand 42-gallon barrels	14,358	44,007	29,126	91,164	66,204	186,695	73,953	214,464
Sand and gravel ... thousand short tons	17,457	21,793	22,370	26,248	18,013	20,366	16,205	18,615
Silver (recoverable content of ores, etc.) ... thousand troy ounces	7	9	6	9	4	8	2	4
Stone ... thousand short tons	W	W	W	W	W	W	1,954	3,902
Value of items that cannot be disclosed: Copper (1966–68), gem stones, LP gases (1969), mercury, platinum-group metals, tin, and values indicated by symbol W	XX	6,167	XX	4,924	XX	4,923	XX	2,865
Total	XX	82,683	XX	134,066	XX	221,717	XX	257,776
ARIZONA								
Clays ... thousand short tons	[3] 89	[3] $121	[3] 67	[3] $37	77	$347	120	$394
Coal (bituminous) ... do	---	---	1	5	---	---	---	---
Copper (recoverable content of ores, etc.) ... short tons	739,569	535,004	501,741	383,591	627,961	525,566	801,363	761,840
Diatomite ... do	1,353	36	W	W	W	W	725	W
Fluorspar ... do	---	---	10,000	280	---	---	---	---

Gem stones	NA	120	NA	150	NA	149	NA	153
Gold (recoverable content of ores, etc.) troy ounces	142,528	4,988	80,844	2,830	95,999	[5] 3,769	110,878	[5] 4,603
Gypsum thousand short tons	75	394	W	W	W	W	83	424
Helium, grade A thousand cubic feet	63,500	2,222	73,800	2,066	64,800	1,600	56,300	1,126
Iron ore (usable) thousand long tons, gross weight	W	W	W	W	16	124	18	136
Lead (recoverable content of ores, etc.) short tons	5,211	1,575	4,771	1,336	1,704	450	217	65
Lime thousand short tons	218	3,721	186	3,142	260	4,561	283	5,074
Mercury 76-pound flasks	363	160	W	W	192	103	W	W
Molybdenum (content of concentrate) thousand pounds	10,161	17,812	9,261	15,385	12,127	19,207	12,699	20,947
Natural gas million cubic feet	3,161	436	1,255	193	881	142	1,136	199
Petroleum (crude) thousand 42-gallon barrels	132	370	2,924	8,188	3,370	9,606	2,433	7,056
Pumice thousand short tons	1,103	1,674	1,064	904	1,033	974	910	814
Sand and gravel do	18,730	20,448	r 17,317	r 17,280	13,981	14,423	16,481	18,066
Silver (recoverable content of ores, etc.) thousand troy ounces	6,339	8,196	4,588	7,112	4,958	10,633	6,141	10,997
Stone thousand short tons	2,271	4,091	1,910	3,491	3,293	6,239	2,827	5,812
Tungsten ore and concentrate short tons, 60-percent WO_3 basis	2	5	W	W	1	3	1	2
Uranium (recoverable content U_3O_8) thousand pounds	437	3,492	83	666	295	1,923	W	W
Vanadium (recoverable in ore and concentrate) short tons	W	453	W	W	W	W	W	W
Zinc (recoverable content of ores, etc.) do	15,985	4,636	14,330	3,967	5,441	1,469	9,039	2,639
Value of items that cannot be disclosed: Asbestos, cement, clays (bentonite 1966–67), feldspar, scrap mica, perlite, pyrites, vermiculite (1967–69), and values indicated by symbol W	XX	12,125	XX	13,503	XX	16,253	XX	18,956
Total	XX	622,079	XX	r 464,126	XX	617,541	XX	859,303
ARKANSAS								
Barite thousand short tons	233	$2,266	229	$2,266	166	$3,839	210	$4,616
Bauxite thousand long tons, dried equivalent	1,718	19,439	1,571	18,269	1,582	23,058	1,755	24,706
Bromine and bromine in compounds thousand pounds	42,307	10,467	64,450	14,885	95,499	20,790	145,100	28,287
Clays thousand short tons	[3] 775	[3] 776	941	1,740	919	2,134	992	2,426
Coal (bituminous) do	236	1,640	189	1,427	211	1,576	228	1,802
Gem stones	NA	35	NA	35	NA	30	NA	24
Lime thousand short tons	207	3,004	187	2,723	206	3,058	184	2,748
Natural gas million cubic feet	105,174	16,407	116,522	17,828	156,627	24,456	169,257	26,743
Natural gas liquids:								
Natural gasoline and cycle products thousand 42-gallon barrels	763	1,923	656	1,780	753	2,192	692	2,049
LP gases do	1,540	3,233	1,279	3,009	1,435	2,899	1,279	2,098
Petroleum (crude) do	23,824	63,372	21,075	56,902	19,464	53,137	18,049	51,079
Sand and gravel thousand short tons	16,056	21,038	14,239	15,531	12,997	14,643	12,674	14,949
Stone do	19,109	24,588	17,454	23,236	16,322	22,256	16,463	23,134
Value of items that cannot be disclosed: Abrasive stones, cement, clays (kaolin and fire clay 1966), gypsum, mercury (1966–67), phosphate rock (1966), soapstone, tripoli, vanadium (1968–69), and values indicated by symbol W	XX	21,939	XX	19,822	XX	24,655	XX	23,465
Total	XX	190,127	XX	179,453	XX	198,723	XX	208,126

See footnotes at end of table.

Table 5.—Mineral production [1] in the United States, by States—Continued

Mineral	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)
CALIFORNIA								
Antimony ore and concentrate .... short tons, antimony content	1	(6)	----------	----------	----------	----------	----------	----------
Asbestos .... short tons	81,671	$6,945	77,091	$6,726	75,592	$6,139	75,828	$5,956
Barite .... thousand short tons	15	104	10	71	W	W	W	W
Boron minerals .... do	866	68,209	r 892	r 69,819	r 963	r 76,535	1,020	81,261
Cement .... thousand 376-pound barrels	45,387	146,302	42,034	137,961	47,595	151,961	50,610	170,612
Clays .... thousand short tons	2,984	6,708	2,609	6,037	2,755	6,630	2,993	7,443
Copper (recoverable content of ores, etc.) .... short tons	1,078	780	788	602	1,182	989	1,129	1,073
Feldspar .... long tons	100,915	W	94,769	W	W	W	W	W
Gem stones	NA	200	NA	200	NA	200	NA	200
Gold (recoverable content of ores, etc.) .... troy ounces	64,764	2,267	40,570	1,420	15,682	5 616	7,904	5 328
Gypsum .... thousand short tons	1,207	3,064	1,241	3,150	1,360	3,603	1,210	3,339
Lead (recoverable content of ores, etc.) .... short tons	1,976	597	1,735	486	4,001	1,057	2,518	750
Lime .... thousand short tons	552	8,764	539	8,696	568	9,301	585	9,666
Magnesium compounds from sea water and bitterns (partly estimated) short tons, MgO equivalent	87,816	7,413	76,592	6,882	81,622	7,229	76,220	7,143
Mercury .... 76-pound flasks	16,070	7,100	16,385	8,018	21,417	11,470	18,480	9,333
Natural gas .... million cubic feet	689,607	204,059	681,080	202,290	714,893	221,077	677,689	207,440
Natural gas liquids:								
Natural gasoline and cycle products ... thousand 42-gallon barrels	15,110	48,867	14,605	46,620	13,403	42,963	12,954	39,944
LP gases .... do	8,409	17,304	8,730	19,065	8,589	18,749	8,238	17,646
Peat .... short tons	29,235	384	30,014	396	W	W	11,395	106
Perlite .... do	W	W	W	W	8,806	80	11,419	105
Petroleum (crude) .... thousand 42-gallon barrels	345,295	812,834	359,219	829,133	375,496	883,644	375,291	920,060
Pumice .... thousand short tons	580	1,763	866	1,357	776	1,312	866	1,229
Salt .... do	1,693	W	1,732	W	1,901	W	1,895	W
Sand and gravel .... do	120,692	139,157	116,125	139,212	124,655	153,360	124,718	155,883
Silver (recoverable content of ores, etc.) .... thousand troy ounces	190	246	145	224	598	1,282	492	881
Stone .... thousand short tons	43,051	61,336	37,186	55,263	36,125	52,671	38,033	57,757
Sulfur ore .... long tons	557	5	568	3	3,125	46	----------	----------
Talc, soapstone, and pyrophyllite .... short tons	138,340	1,847	143,466	1,945	165,396	2,075	145,158	2,329
Tin (content of concentrate) .... long tons	13	21	W	W	----------	----------	----------	----------
Zinc (recoverable content of ores, etc.) .... short tons	335	97	441	122	3,525	952	3,327	971
Value of items that cannot be disclosed: Bromine, calcite (optical grade, 1966), calcium-magnesium chloride, carbon dioxide, coal (lignite), diatomite, iodine (1966), iron ore, lithium minerals, scrap mica (1966–68), molybdenum, phosphate rock (1968–69), platinum group metals (crude) (1966–68), potassium salts, rare-earth metal concentrates, sodium carbonates and sulfates, tungsten concentrate, uranium (1966), wollastonite, and values indicated by symbol W	XX	141,449	XX	143,722	XX	150,914	XX	149,062
Total	XX	1,687,822	XX	r 1,689,420	XX	r 1,804,855	XX	1,850,517

COLORADO								
Beryllium concentrates, short tons	W	W	W	W	W	W	46	W
Carbon dioxide, natural, thousand cubic feet	147,292	$25	182,701	$31	200,657	$34	175,787	$30
Clays, thousand short tons	599	1,315	596	1,274	616	1,222	732	1,619
Coal (bituminous), do	5,222	26,075	5,439	25,920	5,558	26,785	5,530	29,121
Copper (recoverable content of ores, etc.), short tons	4,237	3,065	3,993	3,053	3,451	2,888	3,598	3,421
Feldspar, long tons	891	6	300	2	W	W	358	3
Gem stones	NA	80	NA	118	NA	121	NA	122
Gold (recoverable content of ores, etc.), troy ounces	31,915	1,117	21,181	741	22,638	[5] 889	25,777	[5] 1,070
Gypsum, thousand short tons	75	269	77	265	98	354	94	339
Iron ore (usable), thousand long tons, gross weight	164	1,133	W	W	W	W	W	W
Lead (recoverable content of ores, etc.), short tons	23,082	6,978	21,923	6,138	19,778	5,226	21,767	6,484
Lime, thousand short tons	126	2,327	118	2,028	125	2,375	127	2,449
Manganiferous ore (5 to 35 percent Mn), short tons, gross weight	---	---	321	3	---	---	---	---
Molybdenum (content of concentrate), thousand pounds	57,289	88,851	52,040	84,728	61,684	100,296	62,411	105,346
Natural gas, million cubic feet	136,667	17,767	116,857	15,542	121,424	16,392	118,754	17,219
Natural gas liquids:								
Natural gasoline, thousand 42-gallon barrels	1,415	3,565	1,234	3,215	1,289	3,248	1,076	2,798
LP gases, do	1,747	3,596	1,703	3,649	1,987	3,338	1,782	2,762
Peat, short tons	37,111	278	21,988	204	28,457	250	26,103	160
Petroleum (crude), thousand 42-gallon barrels	33,492	97,462	33,905	99,003	31,937	94,215	28,294	88,277
Pumice, thousand short tons	46	104	18	105	28	234	42	232
Pyrites, thousand long tons	W	W	W	W	23	97	24	120
Sand and gravel, thousand short tons	22,245	23,485	21,810	22,904	23,121	26,608	19,877	27,266
Silver (recoverable content of ores, etc.), thousand troy ounces	2,085	2,697	1,818	2,817	1,646	3,531	2,599	4,653
Stone, thousand short tons	7,031	11,331	2,992	5,485	2,471	5,201	2,245	5,079
Tin (content of concentrate), long tons	44	99	31	59	33	64	44	119
Tungsten concentrate, short tons, 60 percent WO_3 basis	1,494	3,626	1,276	3,039	1,893	4,413	1,941	4,440
Uranium (recoverable content U_3O_8), thousand pounds	2,651	21,205	2,537	20,299	2,706	20,009	2,736	16,935
Vanadium (recoverable in ore and concentrate), short tons	3,697	15,888	3,317	14,260	3,492	12,468	W	W
Zinc (recoverable content of ores, etc.), do	54,822	15,898	52,442	14,519	50,258	13,570	53,715	15,685
Value of items that cannot be disclosed: Cement, fluorspar, scrap mica (1967), perlite, rare-earth metal concentrates, salt, and values indicated by symbol W	XX	14,699	XX	16,834	XX	15,630	XX	32,745
Total	XX	362,941	XX	346,235	XX	359,458	XX	368,494
CONNECTICUT								
Clays, thousand short tons	192	$296	191	$334	195	$325	197	$341
Gem stones	NA	8	NA	8	NA	8	NA	8
Sand and gravel, thousand short tons	9,561	8,963	8,320	8,710	8,752	9,321	8,857	10,359
Stone, do	5,618	10,482	5,097	10,141	6,383	12,729	7,562	15,325
Value of items that cannot be disclosed: Feldspar, lime, scrap mica, and peat (1966)	XX	1,597	XX	1,426	XX	1,493	XX	1,734
Total	XX	21,346	XX	20,619	XX	23,876	XX	27,767

See footnotes at end of table.

Table 5.—Mineral production [1] in the United States, by States—Continued

Mineral	1966		1967		1968		1969	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
DELAWARE								
Clays ---- thousand short tons	11	$11	11	$11	12	$12	11	$11
Gem stones	NA	1	NA	1	NA	1	NA	1
Sand and gravel ---- thousand short tons	1,610	1,443	1,966	1,846	1,596	1,483	2,257	2,074
Stone ---- do	210	525	210	525	200	500	---------	---------
Total	XX	1,980	XX	2,383	XX	1,996	XX	2,086
FLORIDA								
Clays ---- thousand short tons	762	$11,408	756	$11,574	808	$11,699	907	$13,627
Lime ---- do	135	1,966	155	2,425	125	2,059	182	2,712
Natural gas ---- million cubic feet	212	30	123	18	108	16	50	8
Peat ---- short tons	11,500	91	22,180	155	41,213	277	55,265	359
Petroleum (crude) ---- thousand 42-gallon barrels	1,799	W	1,568	W	1,474	W	1,731	W
Sand and gravel ---- thousand short tons	7,403	6,417	6,912	6,479	7,765	7,967	14,409	13,988
Stone ---- do	35,023	38,167	[4] 33,971	[4] 38,723	[4] 36,692	[4] 46,563	[4] 42,332	[4] 56,611
Value of items that cannot be disclosed: Cement, kyanite (1968–69), magnesium compounds, natural gas liquids, phosphate rock, rare-earth metal concentrates, staurolite, stone (dimension limestone 1967–69) titanium concentrate, zirconium concentrate, and values indicated by symbol W	XX	237,368	XX	250,423	XX	236,042	XX	208,071
Total	XX	295,447	XX	309,797	XX	304,623	XX	295,376
GEORGIA								
Barite ---- thousand short tons	W	W	W	W	140	$2,874	124	$3,116
Clays ---- do	5,128	$73,685	4,953	$77,314	5,111	88,632	5,670	98,462
Iron ore (usable) ---- thousand long tons, gross weight	447	2,200	267	1,450	192	1,119	241	1,338
Mica: Scrap ---- short tons	16,608	380	17,158	291	W	W	W	W
Sand and gravel ---- thousand short tons	3,915	4,185	3,787	4,206	3,803	4,314	3,824	4,709
Stone ---- do	24,690	48,193	23,418	49,953	26,903	56,177	27,755	59,451
Talc ---- short tons	41,000	255	46,150	292	45,600	288	47,790	301
Value of items that cannot be disclosed: Bauxite, cement, feldspar, kyanite, peat, rare-earth metal concentrates, titanium concentrate, zirconium concentrate, and values indicated by symbol W	XX	19,699	XX	19,952	XX	19,686	XX	23,525
Total	XX	148,597	XX	153,458	XX	173,090	XX	190,902
HAWAII								
Cement ---- thousand 376-pound barrels	1,749	$9,046	1,395	$7,360	1,841	$9,254	2,075	$10,544
Clays ---- thousand short tons	W	W	W	W	3	4	2	9
Lime ---- do	10	320	8	265	8	268	9	287
Pumice ---- do	374	716	290	562	408	724	403	783

Sand and gravel ... do	511	1,591	469	1,467	546	1,653	552	1,816
Stone ... do	5,079	9,482	4,100	7,207	5,211	11,273	6,534	16,059
Value of items that cannot be disclosed: Other nonmetals and values indicated by symbol W	XX	98	XX	75	XX	49	XX	41
Total	XX	21,253	XX	16,936	XX	23,225	XX	29,539
IDAHO								
Antimony ore and concentrate ... short tons, antimony content	834	W	823	W	853	W	922	W
Clays [3] ... thousand short tons	23	$22	19	$16	12	$14	23	$51
Cobalt ... thousand pounds	1	6	---	---	---	---	---	---
Copper (recoverable content of ores, etc.) ... short tons	4,961	3,589	4,210	3,219	3,525	2,950	3,332	3,168
Gem stones	NA	180	NA	180	NA	200	NA	90
Gold (recoverable content of ores, etc.) ... troy ounces	5,056	177	4,838	169	3,227	[5] 127	3,403	[5] 141
Gypsum ... thousand short tons	---	---	---	---	3	13	---	---
Iron ore (usable) ... thousand long tons, gross weight	11	97	W	W	W	W	W	W
Lead (recoverable content of ores, etc.) ... short tons	72,334	21,867	61,387	17,188	54,790	14,478	65,597	19,541
Mercury ... 76-pound flasks	1,134	501	898	439	W	W	1,012	511
Peat ... short tons	W	W	2,040	16	W	W	1,000	W
Phosphate rock ... thousand short tons	W	W	W	W	3,879	22,721	W	W
Pumice ... do	55	107	W	W	135	259	21	62
Sand and gravel ... do	7,544	6,672	11,246	11,490	8,224	9,133	8,555	7,583
Silver (recoverable content of ores, etc.) ... thousand troy ounces	19,777	25,571	17,033	26,402	15,959	34,225	18,930	33,897
Stone ... thousand short tons	2,694	5,415	1,986	4,833	2,195	5,209	3,750	6,426
Tungsten concentrate ... short tons, 60-percent WO_3 basis	2	1	68	175	W	W	27	63
Zinc (recoverable content of ores, etc.) ... short tons	60,997	17,689	56,528	15,650	57,248	15,457	55,900	16,323
Value of items that cannot be disclosed: Cement, clays, (fire clay, bentonite 1966, kaolin), abrasive garnet, lime, perlite, titanium concentrate 1966, vanadium, and values indicated by symbol W	XX	32,991	XX	29,631	XX	9,467	XX	30,453
Total	XX	114,885	XX	109,408	XX	114,253	XX	118,309
ILLINOIS								
Cement:								
Portland ... thousand 376-pound barrels	9,203	$28,617	9,069	$30,186	9,372	$32,475	8,720	$29,996
Masonry ... thousand 280-pound barrels	614	1,868	591	1,851	602	2,097	603	2,137
Clays [3] ... thousand short tons	1,894	3,996	1,881	3,799	2,327	4,813	1,863	4,321
Coal (bituminous) ... do	63,571	244,837	65,133	252,975	62,441	250,685	64,722	279,712
Fluorspar ... short tons	176,175	8,002	210,207	9,859	188,325	9,134	88,480	4,676
Lead (recoverable content of ores, etc.) ... do	2,285	691	2,384	668	1,467	388	791	236
Natural gas ... million cubic feet	7,230	860	5,144	602	4,380	552	3,800	536
Peat ... short tons	44,374	565	49,716	697	61,520	867	67,330	958
Petroleum (crude) ... thousand 42-gallon barrels	61,661	184,983	60,115	181,581	56,391	173,120	50,724	161,302
Sand and gravel ... thousand short tons	38,237	43,201	38,801	44,175	45,609	52,943	44,138	56,688
Stone ... do	46,157	60,961	48,458	66,757	55,858	80,188	54,857	81,318
Zinc (recoverable content of ores, etc.) ... short tons	15,192	4,406	20,416	5,652	18,182	4,909	13,765	4,019
Value of items that cannot be disclosed: Clay (fuller's earth), gem stones, lime, natural gas liquids, and tripoli	XX	34,362	XX	37,999	XX	35,372	XX	33,916
Total	XX	617,349	XX	636,801	XX	647,543	XX	659,815

See footnotes at end of table.

Table 5.—Mineral production[1] in the United States, by States—Continued

Mineral	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)
INDIANA								
Abrasive stones ... short tons	5	$15	5	$16	5	$16	5	$17
Cement[2] ... thousand 376-pound barrels	15,305	49,826	15,924	53,123	14,774	48,096	14,497	45,264
Clays ... thousand short tons	1,491	2,196	1,489	2,126	1,550	2,355	1,483	2,264
Coal (bituminous) ... do	17,326	67,857	18,772	73,419	18,486	71,680	20,086	82,902
Natural gas ... million cubic feet	215	51	198	46	234	55	171	40
Peat ... short tons	38,111	456	42,962	441	38,763	557	38,214	515
Petroleum (crude) ... thousand 42-gallon barrels	10,617	31,850	10,081	30,041	8,692	26,511	7,841	25,013
Sand and gravel ... thousand short tons	24,992	23,542	26,265	25,588	25,774	26,160	26,218	27,438
Stone ... do	24,323	42,474	26,977	46,725	26,307	46,790	25,559	45,400
Value of items that cannot be disclosed: Cement (masonry), gypsum, and lime	XX	11,743	XX	13,396	XX	13,166	XX	13,018
Total	XX	230,010	XX	244,921	XX	235,386	XX	241,871
IOWA								
Cement:								
Portland ... thousand 376-pound barrels	14,058	$46,736	13,712	$45,394	13,900	$47,275	14,084	$47,265
Masonry ... thousand 280-pound barrels	633	1,890	612	1,853	624	1,986	606	1,912
Clays ... thousand short tons	1,130	1,438	1,208	1,643	1,264	1,747	1,199	1,660
Coal (bituminous) ... do	1,025	3,783	883	3,227	876	3,289	903	3,392
Gypsum ... do	1,285	5,577	1,219	5,186	1,351	5,838	1,169	5,274
Sand and gravel ... do	19,644	18,213	17,734	16,564	16,332	15,192	18,391	17,867
Stone ... do	27,729	40,081	26,133	37,912	26,150	40,397	26,233	40,895
Value of items that cannot be disclosed: Gem stones, lime, and peat	XX	1,595	XX	1,443	XX	1,573	XX	1,665
Total	XX	119,313	XX	113,222	XX	117,297	XX	119,930
KANSAS								
Cement:[2]								
Portland ... thousand 376-pound barrels	8,979	$27,246	8,833	$25,545	9,680	$29,898	9,764	$29,365
Masonry ... thousand 280-pound barrels	395	1,151	350	1,000	383	1,177	348	1,023
Clays ... thousand short tons	847	1,006	935	1,339	932	1,433	[3] 797	[3] 1,070
Coal (bituminous) ... do	1,122	5,355	1,136	5,294	1,268	6,526	1,313	7,108
Helium: Crude ... thousand cubic feet	2,624,200	30,951	2,719,700	32,554	2,749,700	33,600	2,669,400	32,667
Grade A ... do	75,500	1,885	225,000	5,364	291,700	7,300	329,500	7,578
Lead (recoverable content of ores, etc.) ... short tons	1,109	335	1,031	289	1,227	324	395	118
Natural gas ... million cubic feet	847,495	114,412	871,971	116,844	835,555	115,307	883,156	122,759
Natural gas liquids:								
Natural gasoline ... thousand 42-gallon barrels	4,168	9,399	4,623	10,703	4,824	10,977	4,855	11,848
LP gases ... do	15,813	25,902	15,835	31,923	15,748	25,827	19,574	26,229
Petroleum (crude) ... do	103,738	306,027	99,200	297,600	94,505	285,405	88,716	283,891
Pumice ... thousand short tons	W	W	W	W	11	10	W	W
Salt[8] ... do	969	13,388	1,069	14,686	1,128	15,520	1,270	17,090

Sand and gravel ... do	11,627	8,374	12,066	8,650	12,427	10,559	12,029	10,061
Stone ... do	14,027	18,789	13,551	17,806	r 14,372	r 20,650	15,828	22,645
Zinc (recoverable content of ores, etc.) ... short tons	4,769	1,383	4,765	1,319	3,012	813	1,900	555
Value of items that cannot be disclosed: Natural cement, clays (fire 1969), gypsum, lime (1968–69), salt (brine), and values indicated by symbol W	XX	2,789	XX	3,152	XX	3,311	XX	3,808
Total	XX	568,392	XX	574,068	XX	r 568,637	XX	577,816
KENTUCKY								
Clays [3] ... thousand short tons	1,152	$2,277	1,195	$2,066	1,219	$1,952	1,232	$2,076
Coal (bituminous) ... do	93,156	363,440	100,294	396,883	101,156	395,039	109,049	450,950
Fluorspar ... short tons	28,725	1,361	32,952	1,686	17,050	878	W	W
Lead (recoverable content of ores, etc.) ... do	484	146	845	237	W	W	---	---
Natural gas ... million cubic feet	76,536	18,139	89,168	21,400	89,024	22,256	81,304	20,407
Petroleum (crude) ... thousand 42-gallon barrels	18,066	51,488	15,535	45,052	14,036	41,125	12,924	40,194
Sand and gravel ... thousand short tons	8,064	7,524	7,981	7,859	7,478	8,081	8,364	9,628
Silver (recoverable content of ores, etc.) ... thousand troy ounces	1	1	1	1	---	---	---	---
Stone ... thousand short tons	22,667	31,179	24,812	35,481	30,105	43,266	[4] 30,158	[4] 44,644
Zinc (recoverable content of ores, etc.) ... short tons	6,586	1,910	6,317	1,749	W	W	W	W
Value of items that cannot be disclosed: Native asphalt (1966–68), cement, ball clay, natural gas liquids, stone (quartzite, 1969), and values indicated by symbol W	XX	20,899	XX	23,291	XX	22,266	XX	23,149
Total	XX	498,364	XX	535,705	XX	534,863	XX	591,048
LOUISIANA								
Clays ... thousand short tons	1,005	$983	995	$1,260	863	$1,163	1,078	$2,943
Lime ... do	835	9,274	758	9,891	781	10,159	822	10,750
Natural gas ... million cubic feet	5,081,435	929,902	5,716,857	1,057,619	6,416,015	1,212,627	7,227,826	1,387,743
Natural gas liquids:								
Natural gasoline and cycle products ... thousand 42-gallon barrels	37,192	113,802	41,777	130,212	49,928	156,903	53,565	171,434
LP gases ... do	34,993	72,016	43,921	92,234	57,165	91,464	71,867	96,302
Petroleum (crude) ... do	674,318	2,097,129	774,527	2,419,823	817,426	2,570,641	844,603	2,791,269
Salt ... thousand short tons	8,736	44,189	9,585	48,483	10,908	53,854	12,435	61,102
Sand and gravel ... do	18,216	22,504	20,312	27,442	20,411	26,504	18,131	21,895
Stone [4] ... do	8,091	11,253	7,599	11,174	9,387	11,785	9,237	11,892
Sulfur (Frasch process) ... thousand long tons	4,018	104,472	4,233	139,739	4,074	162,664	3,999	108,299
Value of items that cannot be disclosed: Cement, gypsum, and stone (crushed miscellaneous)	XX	24,616	XX	23,873	XX	23,246	XX	21,697
Total	XX	3,430,140	XX	3,961,750	XX	4,321,010	XX	4,685,326
MAINE								
Clays ... thousand short tons	45	$58	42	$54	[3] 42	[3] $65	[3] 42	[3] $56
Gem stones	NA	35	NA	35	NA	35	NA	35
Peat ... short tons	1,600	60	W	W	W	W	W	W
Sand and gravel ... thousand short tons	15,036	7,027	11,627	5,368	11,866	5,978	11,275	6,026
Stone ... do	1,092	3,622	1,159	2,999	1,187	3,205	1,101	3,798

See footnotes at end of table.

Table 5.—Mineral production [1] in the United States, by States—Continued

Mineral	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)
MAINE—Continued								
Value of items that cannot be disclosed: Beryllium 1969, cement, fire clay (1968–69), copper (1968–69), feldspar, silver (1968–69), zinc (1968–69), and values indicated by symbol W	XX	$5,932	XX	$6,426	XX	$8,527	XX	$10,273
Total	XX	16,734	XX	14,882	XX	17,810	XX	20,188
MARYLAND								
Clays ... thousand short tons	[3] 856	[3] $1,084	998	$1,462	[3] 1,078	[3] $1,252	[3] 1,152	[3] $1,369
Coal (bituminous) ... do	1,222	4,367	1,305	4,548	1,447	5,318	1,368	5,261
Gem stones	NA	3	NA	3	NA	3	NA	3
Lime ... thousand short tons	29	386	W	W	W	W	W	W
Natural gas ... million cubic feet	696	181	621	159	864	221	978	248
Peat ... short tons	W	W	W	W	5,554	94	4,481	78
Sand and gravel ... thousand short tons	15,108	20,383	12,868	17,724	11,719	17,157	14,230	21,226
Stone ... do	13,868	27,229	14,479	28,581	13,344	26,606	15,067	30,504
Value of items that cannot be disclosed: Cement, clays (ball clay 1966, 1968–69, fire clay 1968–69), diatomite 1969, greensand marl, potassium salts, talc and soapstone, and values indicated by symbol W	XX	20,528	XX	20,342	XX	21,193	XX	24,794
Total	XX	74,161	XX	72,819	XX	71,844	XX	83,483
MASSACHUSETTS								
Clays ... thousand short tons	202	$260	W	W	257	$314	332	$624
Gem stones	NA	2	NA	$2	NA	2	NA	2
Lime ... thousand short tons	182	2,712	195	3,044	198	3,380	199	3,718
Sand and gravel ... do	17,321	17,846	17,881	19,504	17,799	20,106	19,456	22,950
Stone ... do	6,424	17,624	6,203	17,724	6,917	19,501	7,847	22,521
Value of items that cannot be disclosed: Nonmetals and value indicated by symbol W	XX	29	XX	338	XX	37	XX	28
Total	XX	38,473	XX	40,612	XX	43,340	XX	49,843
MICHIGAN								
Cement:								
Portland ... thousand 376-pound barrels	28,171	$87,413	29,645	$94,515	31,375	$99,158	30,373	$98,425
Masonry ... thousand 280-pound barrels	2,032	5,221	1,995	5,296	2,006	5,527	1,904	5,473
Clays ... thousand short tons	2,450	2,620	2,466	2,636	2,599	2,906	2,667	3,037
Copper (recoverable content of ores, etc.) ... short tons	73,449	53,133	58,458	44,692	74,805	62,607	75,226	71,516
Gypsum ... thousand short tons	1,522	5,489	1,422	5,085	1,405	5,196	1,327	5,384
Iron ore (usable) ... thousand long tons, gross weight	14,377	157,377	14,130	162,610	12,699	148,890	14,058	169,756
Lime ... thousand short tons	1,701	20,016	1,787	21,582	1,630	19,870	1,589	20,372
Magnesium compounds from sea water and brine (except for metal) short tons, MgO equivalent	342,482	28,105	309,446	26,388	266,406	25,087	328,047	30,604

Natural gas million cubic feet	34,120	8,598	33,589	8,296	40,480	10,160	36,163	9,294
Natural gas liquids:								
Natural gasoline thousand 42-gallon barrels	374	1,099	1,139	3,491	1,066	3,177	921	2,481
LP gases do	1,898	4,385	1,414	3,444	1,384	3,432	1,197	2,561
Peat short tons	235,842	2,175	237,107	2,292	237,513	2,919	186,278	2,724
Petroleum (crude) thousand 42-gallon barrels	14,273	40,913	13,664	39,455	12,974	38,287	12,213	37,494
Salt thousand short tons	4,465	38,611	4,789	42,389	4,893	44,481	4,819	45,961
Sand and gravel do	55,123	49,521	52,310	49,616	56,663	54,979	58,092	58,968
Silver (recoverable content of ores, etc.) thousand troy ounces	483	625	302	468	473	1,014	1,009	1,807
Stone thousand short tons	37,864	40,380	36,432	39,910	37,279	41,092	39,186	43,572
Value of items that cannot be disclosed: Bromine, calcium-magnesium chloride, gem stones, iodine, and potassium salts	XX	56,446	XX	58,039	XX	58,293	XX	58,818
Total	XX	602,127	XX	610,204	XX	627,075	XX	668,247
MINNESOTA								
Clays [3] thousand short tons	224	$336	228	$342	240	$359	275	$412
Iron ore (usable) thousand long tons, gross weight	55,133	499,388	49,457	468,623	51,275	508,814	56,957	570,446
Manganiferous ore (5 to 35 percent Mn) short tons, gross weight	275,581	W	236,753	W	191,846	W	381,491	W
Peat short tons	11,366	197	13,968	257	6,400	96	12,026	249
Sand and gravel thousand short tons	39,331	28,972	41,212	33,132	44,674	36,414	48,121	40,191
Stone do	4,901	11,688	4,160	11,442	4,427	13,045	5,035	14,253
Value of items that cannot be disclosed: Abrasive stones, cement, fire clay, gem stones, lime, and values indicated by symbol W	XX	9,696	XX	9,530	XX	8,699	XX	10,085
Total	XX	550,277	XX	523,326	XX	567,427	XX	635,636
MISSISSIPPI								
Clays thousand short tons	1,727	$7,489	1,654	$7,852	1,693	$9,075	1,703	$8,660
Natural gas million cubic feet	156,652	27,257	139,497	24,133	135,051	22,601	131,234	23,097
Natural gas liquids:								
Natural gasoline and cycle products thousand 42-gallon barrels	566	1,483	427	1,167	459	1,277	565	1,572
LP gases do	443	987	424	1,085	518	958	538	799
Petroleum (crude) do	55,227	146,353	57,147	155,726	58,708	164,396	64,283	187,514
Sand and gravel thousand short tons	12,675	13,563	14,039	15,485	11,980	12,669	11,484	12,263
Stone do	[4] 1,532	[4] 1,641	1,879	2,055	747	833	W	W
Value of items that cannot be disclosed: Cement, iron ore (1966–67), lime, magnesium compounds, and stone (dimension sandstone 1966)	XX	12,587	XX	9,055	XX	9,146	XX	9,279
Total	XX	211,360	XX	216,558	XX	220,955	XX	243,184
MISSOURI								
Barite thousand short tons	337	$4,280	332	$4,444	284	$4,102	304	$4,220
Cement:								
Portland thousand 376-pound barrels	13,848	46,228	15,044	52,119	20,081	71,206	21,325	74,368
Masonry thousand 280-pound barrels	382	1,075	372	1,172	405	1,312	427	1,319
Clays thousand short tons	2,329	5,989	2,305	6,220	2,433	6,158	[3] 2,251	[3] 6,405
Coal (bituminous) do	3,582	14,834	3,696	15,573	3,205	13,460	3,301	14,283
Copper (recoverable content of ores, etc.) short tons	3,913	2,831	3,215	2,458	5,494	4,598	12,664	12,039
Iron ore (usable) thousand long tons, gross weight	1,887	26,450	1,871	26,673	1,648	23,585	2,622	35,826
Lead (recoverable content of ores, etc.) short tons	132,255	39,981	152,649	42,742	212,611	56,180	355,452	105,889

See footnotes at end of table.

Table 5.—Mineral production [1] in the United States, by States—Continued

Mineral	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)
MISSOURI—Continued								
Lime ---- thousand short tons	1,494	$17,910	W	W	W	W	W	W
Natural gas ---- million cubic feet	----	----	121	$30	[7] 107	[7] $14	126	$17
Petroleum (crude) ---- thousand 42-gallon barrels	97	W	W	W	W	W	W	W
Sand and gravel ---- thousand short tons	10,702	13,540	9,716	12,556	10,649	14,204	10,940	14,574
Silver (recoverable content of ores, etc.) ---- thousand troy ounces	----	----	226	351	341	731	1,442	2,582
Stone ---- thousand short tons	35,240	53,393	36,585	53,953	r 38,988	r 58,743	41,977	63,251
Zinc (recoverable content of ores, etc.) ---- short tons	3,968	1,151	7,430	2,057	12,301	3,321	41,099	12,001
Value of items that cannot be disclosed: Native asphalt, and values indicated by symbol W	XX	288	XX	16,662	XX	r 18,624	XX	20,458
Total	XX	227,950	XX	237,010	XX	r 276,238	XX	367,232
MONTANA								
Clays [3] ---- thousand short tons	53	$56	46	$50	30	$34	34	$63
Coal (bituminous and lignite) ---- do	419	1,290	371	996	519	1,214	1,030	2,199
Copper (recoverable content of ores, etc.) ---- short tons	128,061	92,639	65,483	50,063	69,480	58,151	103,314	98,219
Gem stones	NA	109	NA	109	NA	109	NA	109
Gold (recoverable content of ores, etc.) ---- troy ounces	25,009	875	9,786	343	13,385	[5] 525	24,189	[5] 1,004
Iron ore (usable) ---- thousand long tons, gross weight	12	93	10	81	12	W	13	W
Lead (recoverable content of ores, etc.) ---- short tons	4,409	1,333	898	251	1,870	494	1,753	522
Lime ---- thousand short tons	225	2,116	143	1,765	179	2,005	255	2,737
Manganese ore (35 percent or more Mn) ---- short tons, gross weight	W	W	W	W	4,649	213	775	26
Manganiferous ore (5 to 35 percent Mn) ---- do	1,755	28	2,763	16	2,063	22	----	----
Natural gas ---- million cubic feet	30,685	2,547	25,866	2,173	19,313	1,757	41,229	4,205
Petroleum (crude) ---- thousand 42-gallon barrels	35,380	86,273	34,959	87,543	48,460	124,488	43,954	118,359
Pumice ---- thousand short tons	22	5	----	----	93	327	134	102
Sand and gravel ---- do	13,816	13,523	12,339	10,655	8,762	7,754	16,595	14,383
Silver (recoverable content of ores, etc.) ---- thousand troy ounces	5,320	6,878	2,066	3,203	2,133	4,574	3,429	6,141
Stone ---- thousand short tons	4,150	5,212	4,782	6,037	3,314	4,878	7,667	10,579
Zinc (recoverable content of ores, etc.) ---- short tons	29,120	8,445	3,341	925	3,778	1,020	6,143	1,794
Value of items that cannot be disclosed: Antimony (1966–67), barite (1966), cement, clays (bentonite), fluorspar, gypsum, natural gas liquids, peat, phosphate rock, talc, tungsten, uranium ore (1966), vermiculite, and values indicated by symbol W	XX	23,846	XX	22,314	XX	20,566	XX	22,189
Total	XX	245,268	XX	186,524	XX	228,131	XX	282,631
NEBRASKA								
Clays ---- thousand short tons	153	$153	126	$142	148	$206	149	$223
Gem stones	NA	5	NA	5	NA	4	NA	5
Lime ---- thousand short tons	W	W	W	W	28	W	35	W
Natural gas ---- million cubic feet	10,196	1,621	8,453	1,454	8,129	1,423	6,989	1,209

Natural gas liquids:								
Natural gasoline____thousand 42-gallon barrels	219	653	186	578	153	456	128	387
LP gases____do	468	1,141	494	1,223	451	911	408	738
Petroleum (crude)____do	13,850	37,673	13,373	36,775	13,183	36,781	12,106	36,075
Sand and gravel____thousand short tons	13,539	14,179	11,739	10,878	r 12,742	r 12,946	12,758	13,592
Stone____do	5,055	7,916	4,846	7,483	4,416	7,435	4,665	9,494
Value of items that cannot be disclosed: Cement, pumice, and values indicated by symbol W	XX	15,180	XX	12,330	XX	14,446	XX	16,307
Total	XX	78,521	XX	70,868	XX	r 74,608	XX	78,030
NEVADA								
Antimony ore and concentrate____short tons, antimony content	68	$63	53	$35	----	----	W	W
Barite____thousand short tons	139	933	154	923	216	$1,511	320	$2,275
Copper (recoverable content of ores, etc.)____short tons	78,720	56,946	50,771	38,815	77,213	64,623	104,924	99,749
Gem stones	NA	100	NA	100	NA	100	NA	100
Gold (recoverable content of ores, etc.)____troy ounces	366,903	12,842	434,993	15,225	317,382	[5] 12,460	456,294	[5] 18,941
Gypsum____thousand short tons	594	2,023	409	1,412	552	1,534	521	1,550
Iron ore (usable)____thousand long tons, gross weight	1,000	4,931	641	2,858	569	2,917	W	W
Lead (recoverable content of ores, etc.)____short tons	3,581	1,083	1,500	420	863	228	1,420	423
Mercury____76-pound flasks	3,355	1,482	4,703	2,301	4,780	2,560	8,165	4,124
Perlite____short tons	W	W	10,712	94	9,315	79	8,998	77
Petroleum (crude)____thousand 42-gallon barrels	307	W	279	W	271	W	223	W
Pumice____thousand short tons	55	190	105	236	62	144	83	188
Sand and gravel____do	9,085	9,134	10,166	8,644	7,812	10,442	8,447	10,834
Silver (recoverable content of ores, etc.)____thousand troy ounces	867	1,122	566	877	645	1,384	884	1,583
Stone____thousand short tons	2,002	2,519	1,375	2,145	1,325	2,041	1,494	2,433
Talc and soapstone____short tons	4,715	24	2,096	17	3,029	38	6,434	81
Tungsten ore and concentrate____short tons, 60 percent WO_3 basis	W	W	W	W	25	58	34	69
Zinc (recoverable content of ores, etc.)____short tons	5,827	1,690	3,035	840	2,104	568	941	275
Value of items that cannot be disclosed: Brucite, cement, clays, diatomite, fluorspar, lime, lithium minerals, magnesite, molybdenum, peat (1966–67), pyrites (1969), salt, uranium (1966), and values indicated by symbol W	XX	17,555	XX	15,941	XX	19,354	XX	25,593
Total	XX	112,637	XX	90,883	XX	120,041	XX	168,295
NEW HAMPSHIRE								
Clays____thousand short tons	51	$51	42	$42	41	$41	44	$40
Mica, sheet____pounds	----	----	16,000	W	----	----	----	----
Peat____short tons	175	2	50	(6)	----	----	----	----
Sand and gravel____thousand short tons	7,626	4,807	8,449	5,137	7,742	5,698	6,310	5,149
Stone____do	206	2,091	473	2,887	383	3,377	320	2,888
Value of items that cannot be disclosed: Feldspar, gem stones, mica (scrap 1969), and values indicated by symbol W	XX	49	XX	51	XX	50	XX	43
Total	XX	7,000	XX	8,117	XX	9,166	XX	8,120
NEW JERSEY								
Clays____thousand short tons	488	$1,319	437	$1,189	373	$1,008	327	$1,123
Gem stones	NA	10	NA	10	NA	10	NA	10

See footnotes at end of table.

Table 5.—Mineral production[1] in the United States, by States—Continued

Mineral	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)
NEW JERSEY—Continued								
Peat ... short tons	36,312	$489	43,045	$542	55,786	$621	46,367	$551
Sand and gravel ... thousand short tons	17,782	29,322	18,626	29,975	20,306	33,570	20,325	33,977
Stone ... do	12,453	28,056	12,611	28,253	13,151	30,343	15,162	34,034
Zinc (recoverable content of ores, etc.) [9] ... short tons	25,237	7,319	26,041	7,031	25,668	6,930	25,076	7,322
Value of items that cannot be disclosed: Iron ore (1966–67), lime, magnesium compounds, manganiferous residuum, greensand marl, and titanium concentrate	XX	9,080	XX	5,747	XX	4,984	XX	6,090
Total	XX	75,595	XX	72,747	XX	77,466	XX	83,107
NEW MEXICO								
Carbon dioxide, natural ... thousand cubic feet	795,885	$58	771,516	$57	749,364	$52	902,186	$69
Clays ... thousand short tons	W	W	46	74	66	89	70	89
Coal (bituminous) ... do	2,755	9,110	3,463	12,641	3,429	13,507	4,471	16,376
Copper (recoverable content of ores, etc.) ... short tons	108,614	78,571	75,008	57,345	90,769	75,968	119,956	114,040
Feldspar ... long tons	---	---	---	---	98	W	W	W
Gem stones	NA	45	NA	60	NA	59	NA	60
Gold (recoverable content of ores, etc.) ... troy ounces	9,295	325	5,188	182	6,630	[5] 260	8,952	[5] 372
Gypsum ... thousand short tons	146	545	155	588	146	549	141	526
Helium, grade A ... thousand cubic feet	95,900	3,357	71,200	2,492	39,100	1,355	13,000	260
Iron ore (usable) ... thousand long tons, gross weight	W	W	W	W	17	113	W	W
Lead (recoverable content of ores, etc.) ... short tons	1,596	482	1,827	512	1,363	360	2,368	705
Lime ... thousand short tons	34	472	17	243	27	377	37	W
Manganese ore (35 percent or more Mn) ... short tons, gross weight	W	W	W	W	6,729	W	4,855	131
Manganiferous ore (5 to 35 percent Mn) ... do	47,590	324	49,323	348	50,681	379	49,146	340
Natural gas ... million cubic feet	998,076	124,760	1,067,510	138,776	1,164,182	156,000	1,138,133	155,924
Natural gas liquids:								
Natural gasoline and cycle products ... thousand 42-gallon barrels	8,065	19,736	8,050	20,730	8,868	23,104	9,053	24,388
LP gases ... do	19,433	31,832	21,647	40,003	23,802	34,989	24,920	30,402
Peat ... short tons	---	---	---	---	446	4	446	4
Perlite ... do	343,334	3,423	346,586	3,424	365,481	3,706	397,987	4,493
Petroleum (crude) ... thousand 42-gallon barrels	124,154	352,101	126,144	368,340	128,550	378,708	129,227	404,441
Potassium salts ... thousand short tons, K_2O equivalent	2,953	108,653	2,883	91,098	2,289	63,406	2,327	62,034
Pumice ... thousand short tons	245	787	220	639	243	527	226	415
Salt ... do	66	716	82	1,036	W	W	W	W
Sand and gravel ... do	15,503	13,029	14,672	14,336	12,262	12,396	8,574	10,422
Silver (recoverable content of ores, etc.) ... thousand troy ounces	243	314	157	244	225	482	466	834
Stone ... thousand short tons	2,652	4,056	1,391	2,403	2,226	3,527	2,826	3,286
Uranium (recoverable content U_3O_8) ... thousand pounds	9,340	74,721	11,202	89,615	12,282	95,144	11,811	69,887
Vanadium (recoverable in ore and concentrate) ... short tons	W	53	W	W	W	W	W	W
Zinc (recoverable content of ores, etc.) ... do	29,296	8,496	21,380	5,919	18,686	5,045	24,308	7,098
Value of items that cannot be disclosed: Beryllium (1968–69), cement, fluorspar (1967–69), mica (scrap), molybdenum, tin (1966, 1969) and values indicated by symbol W	XX	20,328	XX	23,001	XX	23,669	XX	29,150
Total	XX	856,294	XX	874,106	XX	893,775	XX	935.746

NEW YORK								
Clays ---- thousand short tons	1,464	$1,726	1,506	$1,814	1,675	$1,790	1,623	$1,783
Emery ---- short tons	11,102	210	W	W	W	W	W	W
Gem stones	NA	10	NA	10	NA	10	NA	10
Gypsum ---- thousand short tons	559	2,998	570	3,118	570	2,925	492	2,945
Lead (recoverable content of ores, etc.) ---- short tons	1,097	332	1,653	463	1,396	369	1,686	502
Lime ---- thousand short tons	1,096	9,870	1,139	10,570	1,086	10,154	1,055	10,224
Natural gas ---- million cubic feet	2,699	837	3,837	1,201	4,632	1,390	4,861	1,458
Peat ---- short tons	27,211	250	23,053	232	14,888	153	14,352	178
Petroleum (crude) ---- thousand 42-gallon barrels	1,735	7,925	1,972	9,026	1,532	7,093	1,256	5,683
Salt ---- thousand short tons	4,980	36,203	5,320	41,568	5,218	42,488	5,582	45,561
Sand and gravel ---- do	41,903	43,091	43,500	44,499	43,439	45,812	39,806	42,518
Silver (recoverable content of ores, etc.) ---- thousand troy ounces	22	28	31	48	28	59	32	57
Stone ---- thousand short tons	34,130	54,543	33,389	56,615	35,441	63,510	37,561	66,839
Zinc (recoverable content of ores, etc.) ---- short tons	73,454	21,302	70,555	19,534	66,194	17,872	58,728	17,149
Value of items that cannot be disclosed: Cement, abrasive garnet, iron ore, talc, titanium concentrate, wollastonite, and values indicated by symbol W	XX	121,482	XX	110,620	XX	106,011	XX	107,432
Total	XX	300,807	XX	299,318	XX	299,636	XX	302,339
NORTH CAROLINA								
Barite ---- thousand short tons	----	----	1	$6	W	W	----	----
Clays [3] ---- do	3,381	$2,241	2,977	2,012	3,310	$2,148	3,342	$2,610
Feldspar ---- long tons	301,610	3,157	265,690	3,113	316,862	4,340	338,149	4,615
Gem stones	NA	15	NA	25	NA	20	NA	20
Mica:								
Scrap ---- short tons	63,480	2,348	69,639	1,751	69,054	1,640	67,214	1,513
Sheet ---- pounds	4,500	1	4,500	W	15,000	W	W	3
Sand and gravel ---- thousand short tons	11,601	11,132	10,014	9,962	10,771	11,178	10,562	11,437
Stone ---- do	[4] 22,377	[4] 36,136	24,507	41,488	24,543	42,429	26,812	47,829
Talc and pyrophyllite ---- short tons	113,366	576	109,393	513	100,030	520	105,728	586
Value of items that cannot be disclosed: Asbestos, cement, clay (kaolin), iron ore (1969), lithium minerals, olivine, phosphate rock (1966–68), stone (crushed and dimension marble 1966, and dimension slate 1966), and values indicated by symbol W	XX	16,272	XX	18,224	XX	20,544	XX	21,844
Total	XX	71,878	XX	77,094	XX	82,819	XX	90,455
NORTH DAKOTA								
Clays ---- thousand short tons	76	$100	W	W	W	W	W	W
Coal (lignite) ---- do	3,543	6,976	4,156	$7,967	4,487	$7,986	4,704	$8,696
Gem stones	NA	1	NA	1	NA	1	NA	1
Natural gas ---- million cubic feet	46,585	7,547	40,462	6,636	41,023	6,769	33,587	5,441
Natural gas liquids:								
Natural gasoline ---- thousand 42-gallon barrels	552	1,415	554	1,443	558	1,479	508	1,346
LP gases ---- do	2,188	3,859	2,111	3,901	2,156	3,622	1,951	2,868
Petroleum (crude) ---- do	27,126	69,170	25,315	65,818	25,040	66,106	22,703	63,568
Sand and gravel ---- thousand short tons	10,145	10,568	8,822	9,118	10,839	10,159	7,039	7,274

See footnotes at end of table.

Table 5.—Mineral production [1] in the United States, by States—Continued

Mineral	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)
NORTH DAKOTA—Continued								
Stone ---- thousand short tons	170	$305	596	$1,092	165	$326	72	$99
Value of items that cannot be disclosed: Lime, molybdenum (1966–67), peat (1966–68), salt, uranium (1966–68), and values indicated by symbol W	XX	2,327	XX	1,562	XX	1,588	XX	1,755
Total	XX	102,268	XX	97,538	XX	98,036	XX	91,048
OHIO								
Cement:								
Portland ---- thousand 376-pound barrels	15,181	$48,740	14,726	$46,860	15,222	$49,814	15,100	$50,071
Masonry ---- thousand 280-pound barrels	976	2,785	946	2,730	1,063	3,155	1,123	3,527
Clays ---- thousand short tons	5,089	14,522	4,670	15,185	4,750	15,216	4,587	11,693
Coal (bituminous) ---- do	43,341	164,444	46,014	176,921	48,323	191,427	51,242	210,082
Gem stones	NA	3	NA	3	NA	3	NA	3
Lime ---- thousand short tons	3,858	50,997	3,636	48,817	3,701	49,367	4,159	60,975
Natural gas ---- million cubic feet	43,133	10,223	41,315	9,957	42,673	10,540	49,793	12,837
Peat ---- short tons	5,214	84	7,301	100	6,506	94	10,848	116
Petroleum (crude) ---- thousand 42-gallon barrels	10,899	32,700	9,924	31,427	11,204	35,722	10,972	36,098
Salt ---- thousand short tons	5,138	35,735	5,407	39,549	5,713	43,172	5,844	43,519
Sand and gravel ---- do	43,851	52,909	43,196	52,888	46,734	57,671	49,160	63,361
Stone ---- do	45,002	72,900	45,458	72,534	r 4 48,054	r 4 78,772	51,792	86,570
Value of items that cannot be disclosed: Abrasive stone, gypsum, stone (dimension limestone and dolomite, 1968)	XX	1,998	XX	1,917	XX	r 1,945	XX	1,815
Total	XX	488,040	XX	498,888	XX	536,898	XX	580,667
OKLAHOMA								
Clays [3] ---- thousand short tons	745	$754	744	$869	726	$967	802	$1,182
Coal (bituminous) ---- do	843	4,935	823	4,703	1,089	6,401	1,838	10,662
Gypsum ---- do	785	2,212	804	2,266	931	2,565	7 980	7 3,912
Helium: Grade A ---- thousand cubic feet	352,400	12,333	309,100	9,835	308,600	8,700	220,500	7,717
Crude ---- do	---------	---------	---------	---------	---------	---------	132,900	1,123
Lead (recoverable content of ores, etc.) ---- short tons	2,999	907	2,727	764	2,387	631	605	180
Natural gas ---- million cubic feet	1,351,225	189,172	1,412,952	202,052	1,390,884	197,506	1,523,715	233,128
Natural gas liquids:								
Natural gasoline and cycle products ---- thousand 42-gallon barrels	13,717	35,715	13,545	35,846	13,905	38,829	14,621	38,931
LP gases ---- do	23,482	44,381	23,944	49,276	25,497	39,520	27,304	34,403
Petroleum (crude) ---- thousand 42-gallon barrels	224,839	654,281	230,749	676,095	223,623	668,202	224,729	701,155
Salt ---- thousand short tons	W	W	10	76	7	44	9	51
Sand and gravel ---- do	6,040	7,565	4,540	5,280	5,041	6,288	5,262	7,156
Stone ---- do	15,334	17,393	16,355	18,932	17,290	21,950	18,799	23,650

Zinc (recoverable content of ores, etc.) .... short tons	11,237	3,259	10,670	2,954	6,921	1,869	2,744	801
Value of items that cannot be disclosed: Cement, clay (bentonite), copper, lime, pumice, silver, tripoli, and values indicated by symbol W	XX	24,484	XX	23,178	XX	23,360	XX	26,758
Total	XX	997,391	XX	1,032,126	XX	1,016,832	XX	1,090,809
OREGON								
Clays .... thousand short tons	361	$362	[3] 295	[3] $295	[3] 213	[3] $284	215	$321
Diatomite .... short tons	W	W	108	2	120	W	85	W
Gem stones	NA	750	NA	750	NA	750	NA	750
Gold (recoverable content of ores, etc.) .... troy ounces	281	10	186	7	23	[5] 1	875	[5] 36
Lead .... short tons	------	------	------	------	------	------	(6)	(6)
Lime .... thousand short tons	116	2,283	99	2,059	120	2,407	115	2,337
Mercury .... 76-pound flasks	700	309	943	461	938	502	43	22
Nickel (content of ore and concentrate) .... short tons	15,036	W	15,287	W	17,294	W	17,056	W
Peat .... do	900	17	W	W	360	11	------	------
Perlite .... do	W	W	8	(6)	------	------	------	------
Pumice .... thousand short tons	714	1,256	834	1,195	725	977	875	1,139
Sand and gravel .... do	35,327	34,986	19,630	25,250	18,260	21,457	15,740	20,491
Silver (recoverable content of ores, etc.) .... thousand troy ounces	(6)	(6)	(6)	(6)	(6)	1	5	9
Stone .... thousand short tons	33,288	48,335	13,201	20,256	14,312	21,168	11,662	18,897
Talc and soapstone .... short tons	------	------	W	W	3	1	W	W
Value of items that cannot be disclosed: Cement, clay (fire clay 1967–69), copper (1966, 1968–69), iron ore (pigment material 1966), and values indicated by symbol W	XX	19,176	XX	16,285	XX	16,890	XX	16,162
Total	XX	107,484	XX	66,560	XX	64,449	XX	60,164
PENNSYLVANIA								
Cement:								
Portland .... thousand 376-pound barrels	40,004	$114,357	40,197	$114,592	43,018	$123,176	44,893	$126,941
Masonry .... thousand 280-pound barrels	2,960	7,860	2,929	7,948	3,151	8,706	3,085	8,504
Clays [3] .... thousand short tons	3,293	17,033	2,994	16,703	3,034	17,679	2,727	19,637
Coal:								
Anthracite .... do	12,941	100,663	12,256	96,160	11,461	97,245	10,473	100,769
Bituminous .... do	81,443	425,168	79,412	419,345	76,200	408,982	78,631	461,579
Copper (recoverable content of ores, etc.) .... short tons	3,178	2,299	4,401	3,365	4,850	4,059	3,382	3,215
Gem stones	NA	4	NA	4	NA	4	NA	4
Lime .... thousand short tons	1,585	22,816	1,719	24,715	1,702	24,272	2,008	28,952
Natural gas .... million cubic feet	90,914	25,820	89,966	25,280	87,987	24,460	79,134	21,841
Natural gas liquids:								
Natural gasoline .... thousand 42-gallon barrels	76	186	28	77	27	73	22	61
LP gases .... do	44	121	42	114	37	95	35	78
Peat .... short tons	52,912	562	39,505	437	35,806	385	34,613	407
Petroleum (crude) .... thousand 42-gallon barrels	4,337	19,300	4,387	19,701	4,160	18,698	4,448	20,086
Sand and gravel .... thousand short tons	17,567	29,562	17,479	29,614	18,101	31,076	18,105	31,451
Stone .... do	59,088	99,233	60,155	103,157	62,812	108,151	66,992	117,726
Zinc (recoverable content of ores, etc.) [9] .... short tons	28,080	8,143	35,067	9,468	30,382	8,203	33,035	9,646
Value of items that cannot be disclosed: Clays (kaolin), cobalt, gold, iron ore, scrap mica, pyrites, pyrophyllite, silver, and tripoli	XX	30,281	XX	27,718	XX	28,780	XX	25,470
Total	XX	903,408	XX	898,398	XX	904,044	XX	976,367

See footnotes at end of table.

Table 5.—Mineral production [1] in the United States, by States—Continued

Mineral	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)
RHODE ISLAND								
Sand and gravel .... thousand short tons	2,276	$2,212	2,334	$2,416	2,291	$2,546	2,480	$3,015
Stone .... do	535	1,734	481	1,618	W	W	W	1,417
Value of items that cannot be disclosed: Other nonmetals and values indicated by symbol W	XX	1	XX	1	XX	1,676	XX	1
Total	XX	3,947	XX	4,035	XX	4,222	XX	4,433
SOUTH CAROLINA								
Clays .... thousand short tons	2,139	$8,830	1,733	$8,048	1,936	$8,923	2,444	$10,911
Sand and gravel .... do	6,016	7,668	5,248	7,178	5,662	8,074	5,692	8,229
Stone .... do	8,129	12,510	[4] 8,310	[4] 12,366	8,942	13,717	8,846	13,506
Value of items that cannot be disclosed: Barite (1966), cement, feldspar, kyanite, scrap mica, peat, pyrites, stone (dimension granite 1967), and vermiculite	XX	16,585	XX	20,682	XX	21,144	XX	23,217
Total	XX	45,593	XX	48,274	XX	51,858	XX	55,864
SOUTH DAKOTA								
Beryllium concentrate .... short tons, gross weight	124	$40	W	W	75	$35	46	$23
Cement:								
Portland .... thousand 376-pound barrels	1,974	6,367	1,406	$4,815	1,826	6,228	1,556	5,715
Masonry .... thousand 280-pound barrels	51	170	54	178	54	180	49	181
Clays .... thousand short tons	231	870	199	799	226	1,119	187	1,171
Coal (lignite) .... do	10	45	5	27	----	----	----	----
Feldspar .... long tons	53,810	369	61,411	420	39,077	264	29,434	194
Gem stones	NA	20	NA	30	NA	34	NA	36
Gold (recoverable content of ores, etc.) .... troy ounces	606,467	21,226	601,785	21,062	593,052	[5] 23,283	593,146	[5] 24,621
Gypsum .... thousand short tons	17	68	12	49	16	65	11	46
Lead (recoverable content of ores, etc.) .... short tons	----	----	----	----	----	----	1	(6)
Mica, scrap .... do	W	W	W	W	W	W	423	20
Petroleum (crude) .... thousand 42-gallon barrels	239	479	211	502	187	401	158	362
Sand and gravel .... thousand short tons	13,630	13,585	13,463	13,737	11,558	11,578	11,158	10,807
Silver (recoverable content of ores, etc.) .... thousand troy ounces	110	142	121	188	138	295	124	223
Stone .... thousand short tons	2,186	7,995	1,866	9,694	1,860	9,687	2,092	10,839
Value of items that cannot be disclosed: Columbium-tantalum concentrates (1967, 1969), lime, molybdenum (1966–67), tin (1966, 1969), uranium, vanadium (1966–67), and values indicated by symbol W	XX	1,796	XX	1,117	XX	917	XX	683
Total	XX	53,172	XX	52,618	XX	54,086	XX	54,921

TENNESSEE								
Barite, thousand short tons	29	$412	15	$235	21	$362	16	$295
Cement:								
Portland, thousand 376-pound barrels	8,177	25,718	8,062	25,548	8,488	27,691	9,159	29,403
Masonry, thousand 280-pound barrels	1,095	2,822	1,092	2,992	1,370	3,836	1,331	3,587
Clays, thousand short tons	[3] 1,359	[3] 4,909	1,574	5,152	[3] 1,562	[3] 5,772	[3] 1,719	[3] 7,064
Coal (bituminous), do	6,309	23,763	6,832	26,974	8,148	29,647	8,082	30,682
Copper (recoverable content of ores, etc.), short tons	15,410	11,148	14,600	11,162	14,196	11,881	15,353	14,596
Gold (recoverable content of ores, etc.), troy ounces	141	5	181	6	140	[5] 5	126	[5] 5
Lead (recoverable content of ores, etc.), short tons	181	55	---	---	---	---	---	---
Natural gas, million cubic feet	---	---	58	11	48	9	57	11
Petroleum (crude), thousand 42-gallon barrels	7	W	7	W	6	W	32	W
Phosphate rock, thousand short tons	3,125	23,886	2,992	22,571	3,149	23,628	W	W
Sand and gravel, do	8,628	11,142	7,975	10,679	7,344	11,140	6,175	9,709
Silver (recoverable content of ores, etc.), thousand troy ounces	101	130	130	202	90	192	79	141
Stone [4], thousand short tons	31,260	41,432	31,463	41,958	32,083	43,854	33,265	46,192
Zinc (recoverable content of ores, etc.), short tons	103,117	29,904	113,065	31,303	124,039	33,491	124,532	36,363
Value of items that cannot be disclosed: Clay (fuller's earth), lime, pyrites, stone (crushed sandstone (1966–68), dimension sandstone 1967), and values indicated by symbol W	XX	7,258	XX	10,779	XX	9,826	XX	27,402
Total	XX	182,584	XX	189,572	XX	201,334	XX	205,451
TEXAS								
Cement:								
Portland, thousand 376-pound barrels	30,827	$97,188	31,944	$99,329	34,499	$107,532	36,037	$117,989
Masonry, thousand 280-pound barrels	884	2,872	888	2,847	1,059	3,371	1,110	3,873
Clays, thousand short tons	4,516	7,187	4,497	8,081	4,687	8,860	4,407	8,664
Gem stones	NA	150	NA	150	NA	150	NA	150
Gypsum, thousand short tons	899	3,258	984	3,419	1,039	3,616	1,314	4,398
Helium: Crude, thousand cubic feet	1,030,500	10,605	977,600	10,246	1,038,700	11,100	1,190,300	13,053
Grade A, do	364,100	12,744	335,900	9,900	362,100	9,400	140,500	4,917
Lime, thousand short tons	1,473	18,696	1,564	20,713	1,564	21,154	1,633	22,107
Natural gas, million cubic feet	6,953,790	903,993	7,188,900	948,935	7,495,414	1,011,881	7,853,199	1,075,888
Natural gas liquids:								
Natural gasoline and cycle products, thousand 42-gallon barrels	92,625	269,332	95,991	277,105	97,075	269,182	96,628	289,042
LP gases, do	151,425	260,755	177,367	320,326	189,162	278,068	194,599	237,411
Petroleum (crude), do	1,057,706	3,141,387	1,119,962	3,375,565	1,133,380	3,450,707	1,151,775	3,696,328
Salt, thousand short tons	7,724	33,797	8,344	36,435	8,534	42,663	9,261	43,012
Sand and gravel, do	26,222	31,313	31,398	39,170	31,843	41,546	29,972	39,756
Stone, do	43,578	56,659	49,424	61,577	48,480	58,006	46,638	64,986
Sulfur (Frasch process), thousand long tons	3,703	96,820	3,448	111,931	2,571	105,482	2,552	68,360
Talc and soapstone, short tons	102,399	367	90,836	356	125,880	517	163,812	668
Value of items that cannot be disclosed: Native asphalt, barite (1966), bromine, coal (lignite), graphite, iron ore, magnesium chloride (for metal), magnesium compounds (except for metal), mercury, perlite (1966–67), pumice, sodium sulfate, uranium, and vermiculite (1967–68)	XX	74,918	XX	80,286	XX	82,596	XX	79,368
Total	XX	5,022,041	XX	5,406,371	XX	5,505,831	XX	5,769,970

See footnotes at end of table.

Table 5.—Mineral production [1] in the United States, by States—Continued

Mineral	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)
UTAH								
Carbon dioxide, natural ... thousand cubic feet	94,006	$7	65,664	$5	57,747	$4	64,839	$5
Clays [3] ... thousand short tons	89	240	114	288	160	476	179	1,286
Coal (bituminous) ... do	4,635	26,763	4,175	24,281	4,316	24,893	4,657	29,396
Copper (recoverable content of ores, etc.) ... short tons	265,383	191,978	168,609	128,905	228,245	191,027	296,699	282,066
Fluorspar ... do	W	W	W	W	8,762	213	6,667	207
Gem stones	NA	75	NA	80	NA	83	NA	85
Gold (recoverable content of ores, etc.) ... troy ounces	438,736	15,356	288,350	10,092	334,419	[5] 13,129	433,385	[5] 17,990
Iron ore (usable) ... thousand long tons, gross weight	1,956	13,478	1,708	11,916	1,764	11,281	1,921	12,552
Lead (recoverable content of ores, etc.) ... short tons	64,124	19,385	53,813	15,068	45,205	11,945	41,332	12,313
Lime ... thousand short tons	200	3,640	169	3,182	174	3,439	191	3,947
Natural gas ... million cubic feet	69,366	8,809	48,965	6,463	46,151	7,292	46,733	7,197
Petroleum (crude) ... thousand 42-gallon barrels	24,112	63,760	24,048	63,221	23,504	62,826	23,295	65,320
Pumice ... thousand short tons	W	W	W	W	8	19	10	21
Salt ... do	427	3,770	403	3,525	405	3,756	481	4,439
Sand and gravel ... do	12,368	12,937	9,412	8,631	10,293	9,364	19,151	16,835
Silver (recoverable content of ores, etc.) ... thousand troy ounces	7,755	10,028	4,875	7,556	5,121	10,982	5,954	10,661
Stone ... thousand short tons	2,246	4,269	1,831	4,108	1,953	4,312	2,582	4,434
Tungsten concentrates ... short tons, 60 percent WO_3 basis	---	---	W	W	W	W	3	6
Uranium (recoverable content U_3O_8) ... thousand pounds	1,225	9,797	1,287	10,300	1,712	13,175	1,140	6,824
Vanadium (recoverable in ore and concentrate) ... short tons	353	1,519	471	2,024	563	2,010	W	W
Zinc (recoverable content of ores, etc.) ... do	37,323	10,824	34,251	9,483	33,153	8,951	34,902	10,191
Value of items that cannot be disclosed: Asphalt (gilsonite), cement, clays (fire clay 1966–67, kaolin, 1966–68), gypsum, magnesium compounds molybdenum, natural gas liquids, perlite (1966–67, 1969), phosphate rock, potassium salts, pyrites (1966–68), and values indicated by symbol W	XX	52,243	XX	45,349	XX	44,774	XX	57,507
Total	XX	448,878	XX	354,477	XX	423,951	XX	543,282
VERMONT								
Lime ... thousand short tons	W	W	W	W	W	W	2	$25
Peat ... short tons	333	$5	280	$4	W	W	180	4
Sand and gravel ... thousand short tons	2,323	1,744	3,718	2,178	3,587	$2,806	3,336	3,028
Stone ... do	2,650	19,926	2,761	20,520	2,536	21,401	2,151	19,810
Value of items that cannot be disclosed: Asbestos, clays, gem stones, talc, and values indicated by symbol W	XX	4,235	XX	4,566	XX	4,508	XX	4,892
Total	XX	25,910	XX	27,268	XX	28,715	XX	27,759
VIRGINIA								
Clays ... thousand short tons	1,486	$1,813	1,382	$1,623	1,462	$1,714	1,677	$1,504
Coal (bituminous) ... do	35,565	153,341	36,721	171,183	36,966	178,946	35,555	192,802
Gem stones	NA	7	NA	7	NA	7	NA	7

Lead (recoverable content of ores, etc.) short tons	3,078	930	3,430	960	3,573	944	3,358	1,000
Lime thousand short tons	840	10,486	829	10,345	919	11,138	1,072	13,653
Natural gas million cubic feet	4,249	1,275	3,818	1,149	3,389	1,013	2,846	845
Petroleum (crude) thousand 42-gallon barrels	1	W	3	W	3	W	1	W
Sand and gravel thousand short tons	17,191	16,635	9,863	12,494	10,859	13,644	12,140	15,954
Soapstone short tons	3,989	10	W	W	3,928	10	4,600	12
Stone thousand short tons	34,151	55,550	31,324	52,470	31,217	53,533	33,461	58,713
Zinc (recoverable content of ores, etc.) [9] short tons	17,666	5,123	18,846	5,088	19,257	5,199	18,704	5,462
Value of items that cannot be disclosed: Aplite, cement, feldspar, gypsum, iron ore (pigment materials), kyanite, salt, titanium concentrate, and values indicated by symbol W	XX	29,127	XX	28,366	XX	29,515	XX	27,575
Total	XX	274,297	XX	283,685	XX	295,663	XX	317,527
WASHINGTON								
Barite thousand short tons	---------	---------	([6])	$1	---------	---------	---------	---------
Cement:								
Portland thousand 376-pound barrels	6,820	$24,340	5,614	20,581	6,328	$23,030	6,356	$22,724
Masonry thousand 280-pound barrels	60	187	65	200	56	175	58	204
Clays [3] thousand short tons	185	249	139	203	r 255	r 253	230	434
Coal (bituminous) do	59	514	59	517	178	823	58	480
Copper (recoverable content of ores, etc.) short tons	34	25	21	16	22	18	18	17
Gem stones	NA	75	NA	75	NA	100	NA	150
Lead (recoverable content of ores, etc.) short tons	5,859	1,771	2,762	773	5,655	1,494	8,649	2,577
Peat do	25,599	136	40,608	181	40,440	159	32,684	134
Sand and gravel thousand short tons	29,002	26,806	28,164	27,520	31,432	27,839	34,245	31,046
Stone do	13,250	20,273	14,454	19,099	14,331	16,690	15,742	21,069
Talc and soapstone short tons	3,880	22	4,916	26	W	W	4,228	W
Zinc (recoverable content of ores, etc.) do	24,772	7,184	21,540	5,964	13,884	3,749	9,738	2,843
Value of items that cannot be disclosed: Carbon dioxide (1966–67), clays (fire clay), diatomite, gold, gypsum, lime, magnesite (1966–68), mercury (1968), olivine, pumice, silver, tungsten (1967), uranium (1966), vanadium (1966), and values indicated by symbol W	XX	7,514	XX	6,911	XX	7,095	XX	6,948
Total	XX	89,096	XX	82,067	XX	r 81,425	XX	88,626
WEST VIRGINIA								
Clays [3] thousand short tons	300	$334	245	$254	193	$219	247	$348
Coal (bituminous) do	149,681	753,851	153,749	800,683	145,921	775,720	141,011	807,811
Lime do	240	3,492	217	3,099	207	2,848	269	3,648
Natural gas million cubic feet	211,610	49,940	211,460	50,962	236,971	62,086	231,759	62,575
Petroleum (crude) thousand 42-gallon barrels	3,674	14,623	3,561	14,244	3,312	13,149	3,104	11,888
Salt thousand short tons	1,147	5,446	1,127	5,137	1,308	4,971	1,309	4,978
Sand and gravel do	5,448	11,569	5,827	12,167	5,657	11,900	5,890	12,666
Stone [4] do	9,738	16,354	9,445	16,447	9,011	16,789	9,031	15,801
Value of items that cannot be disclosed: Calcium-magnesium chloride (1966–67), cement, clay (fire clay), gem stones, natural gas liquids, and stone (dimension sandstone)	XX	36,191	XX	34,865	XX	30,026	XX	28,715
Total	XX	891,800	XX	937,858	XX	917,708	XX	948,430

See footnotes at end of table.

Table 5.—Mineral production [1] in the United States, by States—Continued

Mineral	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)
WISCONSIN								
Clays .... thousand short tons	123	$148	89	$112	17	$34	12	$24
Iron ore (usable) .... thousand long tons, gross weight	---	---	---	---	---	---	36	W
Lead (recoverable content of ores, etc.) .... short tons	1,694	512	1,596	447	1,126	298	1,102	328
Lime .... thousand short tons	204	3,186	212	3,414	224	3,620	244	4,080
Peat .... short tons	2,379	164	1,823	W	1,902	153	1,761	155
Sand and gravel .... thousand short tons	41,523	30,713	42,542	32,955	39,807	30,903	42,815	35,414
Stone .... do	16,150	23,735	17,122	24,863	17,000	25,223	18,954	27,571
Zinc (recoverable content of ores, etc.) .... short tons	24,775	7,185	28,953	8,016	25,711	6,942	22,901	6,687
Value of items that cannot be disclosed: Abrasive stones, cement, gem stones, and values indicated by symbol W	XX	10,367	XX	9,805	XX	4,522	XX	5,533
Total	XX	76,010	XX	79,612	XX	71,695	XX	79,792
WYOMING								
Clays .... thousand short tons	1,559	$15,874	1,495	$14,313	1,828	$17,275	1,992	$18,970
Coal (bituminous) .... do	3,670	11,840	3,588	11,876	3,829	12,117	4,602	15,443
Gem stones	NA	120	NA	125	NA	127	NA	129
Iron ore (usable) .... thousand long tons, gross weight	1,978	19,700	1,854	19,186	1,967	19,452	2,048	20,751
Lime .... thousand short tons	W	W	W	W	28	W	27	W
Natural gas .... million cubic feet	243,381	35,290	240,074	35,051	248,481	36,278	303,517	44,617
Natural gas liquids:								
Natural gasoline .... thousand 42-gallon barrels	2,295	6,281	2,361	6,447	2,331	6,501	2,523	7,051
LP gases .... do	3,954	7,308	4,139	7,648	3,917	7,090	4,428	7,085
Petroleum (crude) .... do	134,470	344,243	136,312	351,685	144,250	380,589	154,945	433,846
Sand and gravel .... thousand short tons	7,187	7,496	8,181	8,253	9,350	8,973	7,568	7,288
Stone .... do	1,393	2,560	1,246	2,375	1,434	2,754	1,584	3,012
Uranium (recoverable content U_3O_8) .... thousand pounds	4,593	36,741	4,655	37,243	5,928	44,343	6,716	40,318
Vanadium (recoverable in ore and concentrate) .... short tons	W	555	W	W	---	---	---	---
Value of items that cannot be disclosed: Cement, copper (1969), feldspar (1966–68), gold (1969), gypsum, phosphate rock, pumice (1967, 1969), silver (1969), sodium carbonates and sulfates, vermiculite (1967), and values indicated by symbol W	XX	36,379	XX	36,494	XX	40,691	XX	48,932
Total	XX	524,387	XX	530,696	XX	576,190	XX	647,442

[r] Revised. NA Not available. W Withheld to avoid disclosing individual company confidential data. XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2] Excludes certain cement, included with "Value of items that cannot be disclosed."
[3] Excludes certain clays, included with "Value of items that cannot be disclosed."
[4] Excludes certain stone, included with "Value of items that cannot be disclosed."
[5] Based on average U.S. Treasury price ($35.00) Jan. 1, 1968 through Mar. 15, 1968; and Engelhard selling quotations Mar. 20, 1968 through 1969.
[6] Less than ½ unit.
[7] Final figure, supersedes figure given in commodity section volume I-II.
[8] Excludes salt in brine, included with "Value of items that cannot be disclosed."
[9] Recoverable zinc valued at the yearly average price of Prime Western slab zinc, East St. Louis market. Represents value established after transportation, smelting and manufacturing charges have been added to the value of ore at mine.

Table 6.—Mineral production[1] in the Canal Zone and islands administered by the United States[2]

Mineral	1966		1967		1968		1969	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
American Samoa:								
Pumice .... thousand short tons	17	$22	28	$24	21	$51	2	$5
Sand and gravel .... do	20	18	7	7	20	19	7	7
Stone .... do	12	12	28	50	53	79	54	108
Total	XX	52	XX	81	XX	149	XX	120
Canal Zone:								
Sand and gravel .... thousand short tons	72	91	56	94	55	77	60	97
Stone (crushed) .... do	114	267	100	245	106	290	74	231
Total	XX	358	XX	339	XX	367	XX	328
Guam: Stone .... thousand short tons	900	1,396	511	820	560	998	654	1,399
Virgin Islands: Stone (crushed) .... do	88	303	183	851	366	1,555	411	1,682
Wake: Stone (crushed) .... do	11	66	31	150	41	132	9	45

XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2] Production data for Wake furnished by U.S. Department of Transportation, Federal Aviation Administration; Guam, by the Government of Guam: American Samoa, by the Government of American Samoa.

Table 7.—Mineral production[1] in the Commonwealth of Puerto Rico

Mineral	1966		1967		1968		1969	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement .... thousand 376-pound barrels	7,603	$24,277	8,447	$27,397	8,923	$27,577	8,943	$27,920
Clays .... thousand short tons	350	271	291	244	512	481	438	454
Lime .... do	30	960	35	1,106	39	1,187	41	1,505
Salt .... do	11	183	12	195	32	395	32	395
Sand and gravel .... do	9,879	14,554	14,101	21,633	16,146	24,723	9,432	23,296
Stone .... do	5,732	10,541	7,269	12,795	7,367	13,580	6,985	13,550
Total	XX	50,786	XX	63,370	XX	67,943	XX	67,120

XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

Table 8.—U.S. exports of principal minerals and products

Mineral	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)
Metals:				
Aluminum:				
Ingots, slabs, crude .... short tons..	180,279	$85,855	344,414	$172,137
Scrap .... do....	49,427	16,017	86,255	33,827
Plates, sheets, bars, etc .... do....	114,062	77,418	135,707	99,596
Castings and forgings .... do....	3,527	10,104	4,360	10,473
Antimony: Metals and alloys, crude short tons..	109	54	207	216
Bauxite, including bauxite concentrates thousand long tons..	7	360	6	456
Aluminum sulfate .... short tons..	18,252	571	12,274	367
Other aluminum compounds .... do....	r 931,104	r 80,828	1,038,680	85,850
Beryllium .... pounds..	93,475	622	28,951	630
Bismuth: Metals and alloys .... do....	120,466	r 292	447,931	1,515
Cadmium .... thousand pounds..	530	1,400	1,085	3,254
Chrome:				
Ore and concentrates:				
Exports .... thousand short tons..	13	517	49	1,915
Reexports .... do....	126	5,351	150	5,806
Ferrochrome .... do....	27	5,735	25	5,679
Cobalt .... thousand pounds..	2,539	4,348	3,257	5,951
Columbium metals, alloys and other forms thousand pounds..	8	291	41	601
Copper:				
Ore, concentrate, composition metal and unrefined (copper content) short tons..	80,739	58,481	5,517	5,113
Refined copper and semimanufactures short tons..	297,992	308,098	236,914	303,386
Other copper manufactures .... do....	4,669	5,681	4,602	6,160
Copper sulfate or blue vitriol .... do....	927	718	3,127	2,385
Copper base alloys .... do....	98,534	98,322	94,803	111,048
Ferroalloys:				
Ferrosilicon .... do....	18,372	4,481	6,487	1,666
Ferrophosphorous .... do....	36,708	930	37,351	912
Gold:				
Ore and base bullion .... troy ounces..	181,385	6,765	58,867	2,434
Bullion, refined .... do....	23,781,006	832,394	279,434	9,853
Iron ore .... thousand long tons..	5,884	70,835	5,160	62,310
Iron and steel:				
Pig iron .... short tons..	10,941	657	43,961	2,647
Iron and steel products (major):				
Semimanufactures .... short tons..	1,759,527	307,885	4,806,722	641,214
Manufactured steel mill products short tons..	700,215	293,775	705,579	322,826
Iron and steel scrap: Ferrous scrap, including rerolling materials short tons..	6,692,058	202,849	9,289,608	305,026
Lead:				
Pigs, bars, anodes .... short tons..	8,281	4,740	4,968	3,913
Scrap .... do....	937	219	2,340	505
Magnesium:				
Metal and alloys and semimanufactured forms, n.e.c .... short tons..	19,457	13,049	27,372	17,961
Manganese:				
Ore and concentrate .... do....	18,500	2,042	19,231	1,627
Ferromanganese .... do....	3,710	645	1,759	483
Mercury:				
Exports .... 76-pound flasks..	7,496	3,951	507	294
Reexports .... do....	103	54	108	57
Molybdenum:				
Ore and concentrates (molybdenum content) .... thousand pounds..	29,006	48,070	57,584	99,055
Metal and alloys, crude and scrap thousand pounds..	293	217	21	70
Wire .... do....	26	551	61	1,083
Semifabricated forms, n.e.c. thousand pounds..	118	487	229	682
Powder .... do....	53	170	782	469
Ferromolybdenum .... do....	863	1,194	1,455	2,381
Nickel:				
Alloys and scrap (including monel metal), ingots, bars, sheets, etc ... short tons..	28,555	56,386	29,240	64,420
Catalysts .... do....	3,340	7,299	3,592	7,531
Nickel-chrome electric resistance wire do....	624	2,652	746	3,630
Semifabricated forms, n.e.c .... do....	1,162	5,336	1,180	6,487

See footnotes at end of table.

Table 8.—U.S. exports of principal minerals and products—Continued

Mineral	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)
Metals—Continued				
Platinum:				
Ore, concentrate, metal and alloys in ingots, bars, sheets, anodes, and other forms, including scrap---troy ounces--	222,998	$30,997	223,569	$30,356
Palladium, rhodium, iridium, osmiridium, ruthenium, and osmium (metal) and alloys including scrap---troy ounces--	172,159	18,522	277,495	16,355
Platinum group manufactures, except jewelry	NA	2,493	NA	4,310
Rare earths:				
Cerium ore, metal, alloys and lighter flints---pounds--	89,858	303	103,169	351
Silver:				
Ore and base bullion thousand troy ounces--	23,129	47,549	30,952	53,334
Bullion, refined---do----	102,632	199,551	57,957	103,386
Tantalum:				
Ore, metal, and other forms thousand pounds--	171	1,899	209	2,652
Powder---do----	84	2,668	100	2,952
Tin:				
Ingots, pigs, bars, etc.:				
Exports---long tons--	3,813	12,734	2,362	8,459
Reexports---do----	682	2,267	541	1,927
Tin scrap and other tin-bearing material except tinplate scrap---do----	5,128	2,676	5,369	4,825
Titanium:				
Ore and concentrate---short tons--	4,238	276	1,424	183
Sponge (including iodide titanium and scrap---short tons--	2,756	1,748	2,802	1,936
Intermediate mill shapes and mill products, n.e.c---short tons--	1,228	7,575	1,773	9,206
Dioxide and pigments---do----	30,188	8,227	24,507	7,510
Tungsten: Ore and concentrates:				
Exports---do----	604	1,705	6,930	19,829
Reexports---do----	56	117	---------	---------
Vanadium ore and concentrate, pentoxide, etc. (vanadium content)---thousand pounds--	925	1,972	516	1,300
Zinc:				
Slabs, pigs, or blocks---short tons--	33,011	9,797	9,298	2,612
Sheets, plates, strips, or other forms, n.e.c. short tons--	3,048	2,228	2,714	1,746
Scrap (zinc content)---do----	2,293	886	1,989	716
Semifabricated forms, n.e.c---do----	15,000	3,840	28,810	6,321
Zirconium:				
Ore and concentrate---do----	2,026	361	2,698	295
Metals and alloys and other forms pounds--	693,927	8,709	443,462	5,911
Nonmetals:				
Abrasives:				
Dust and powder of precious or semiprecious stones, including diamond dust and powder---thousand carats--	6,015	16,616	8,122	21,599
Crushing bort---do----	26	168	45	265
Industrial diamonds---do----	300	1,153	345	1,634
Diamond grinding wheels---do----	594	3,010	699	3,561
Other natural and artificial, metallic abrasives and products	NA	39,319	NA	43,628
Asbestos: Unmanufactured:				
Exports---short tons--	41,217	4,677	34,522	4,626
Reexports---do----	19	2	1,651	353
Boron: Boric acid, borates, crude and refined short tons--	r 206,732	20,347	233,650	24,004
Cement---376-pound barrels--	942	3,884	589	3,189
Clays:				
Kaolin or china clay---short tons--	r 389,882	12,995	477,674	14,789
Fire clay---do----	151,940	2,672	162,557	2,621
Other clays---do----	r 977,569	r 28,466	934,237	28,358
Fluorspar---do----	12,614	496	3,605	213
Graphite---do----	4,169	509	5,655	682
Gypsum:				
Crude, crushed or calcined thousand short tons--	39	1,688	40	2,003
Manufactures, n.e.c	NA	1,868	NA	1,443
Kyanite and allied minerals---short tons--	20,477	1,311	19,696	1,353
Lime---do----	68,915	1,437	51,006	1,153

See footnotes at end of table.

Table 8.—U.S. exports of principal minerals and products—Continued

Mineral	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)
Nonmetals—Continued				
Mica sheet, waste and scrap and ground pounds	27,014,321	$1,408	11,810,008	$1,274
Manufactured do	474,509	1,358	638,830	1,834
Mineral-earth pigments: Iron oxide, natural and manufactured short tons	3,321	1,257	3,992	1,439
Nitrogen compounds (major) thousand short tons	4,042	186,472	3,614	160,039
Phosphate rock do	12,083	104,559	11,369	87,418
Phosphatic fertilizers (superphosphates) thousand short tons	1,289	56,359	847	33,922
Pigments and compounds (lead and zinc):				
Lead pigments short tons	1,877	770	1,688	686
Zinc pigments do	4,940	1,483	4,865	1,641
Potash:				
Fertilizer do	1,302,875	38,353	1,232,636	33,061
Chemical do	33,397	5,114	26,620	4,712
Quartz, natural, quartzite, cryolite and chiolite do	751	168	794	165
Salt:				
Crude and refined thousand short tons	728	4,650	716	4,486
Shipments to noncontiguous Territories thousand short tons	18	1,772	14	1,200
Sodium and sodium compounds:				
Sodium sulfate thousand short tons	56	1,844	91	2,644
Sodium carbonate do	288	9,131	324	10,326
Stone:				
Dolomite, block do	102	1,518	93	1,809
Limestone, crushed, ground, broken thousand short tons	1,297	3,294	1,382	3,189
Marble and other building and monumental thousand cubic feet	NA	849	NA	863
Stone, crushed, ground, broken thousand short tons	292	3,278	284	3,569
Manufactures of stone	NA	1,030	NA	793
Sulfur:				
Crude thousand long tons	1,549	65,650	1,536	56,186
Crushed, ground, flowers of thousand long tons	53	3,855	11	1,495
Talc, crude and ground short tons	65,648	3,521	69,022	3,713
Fuels:				
Carbon black thousand pounds	263,122	28,626	196,203	22,915
Coal:				
Anthracite thousand short tons	518	6,553	627	8,420
Bituminous do	50,637	495,980	56,234	585,452
Briquets do	65	2,698	73	3,952
Coke do	792	18,613	1,629	38,510
Petroleum:				
Crude thousand barrels	1,803	4,452	1,436	3,694
Gasoline do	r 2,083	r 12,519	2,516	10,262
Jet do	r 2,092	r 6,339	1,853	10,525
Naphtha do	r 2,427	r 25,144	2,016	15,402
Kerosine do	r 613	r 5,180	154	1,334
Distillate oil do	r 1,547	r 6,884	1,753	6,626
Residual oil do	20,013	40,746	16,770	34,004
Lubricating oil do	r 18,001	r 207,732	16,397	184,205
Asphalt do	r 429	r 4,571	472	5,003
Liquefied petroleum gases do	r 10,608	r 32,514	12,798	34,292
Wax do	1,588	31,934	1,632	32,724
Coke do	r 19,497	r 68,025	23,061	74,176
Petrochemical feedstocks do	r 2,795	r 15,415	3,848	18,170
Miscellaneous do	r 1,049	r 21,756	921	18,651
Total	XX	4,671,788	XX	4,382,628

r Revised. NA Not available. XX Not applicable.

Table 9.—U.S. imports for consumption of principal minerals and products

Mineral	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)
Metals:				
Aluminum:				
Metal short tons	685,699	$298,759	468,236	$214,845
Scrap do	37,521	12,134	28,850	11,003
Plates, sheets, bars, etc do	62,135	41,816	57,209	38,554
Antimony:				
Ore (antimony content) do	10,614	4,145	12,098	5,248
Needle or liquated do	60	42	62	51
Metal do	2,693	2,037	980	888
Oxide do	4,801	3,540	4,715	3,852
Arsenic: White (As_2O_3 content) do	25,195	2,626	18,171	2,064
Bauxite: Crude thousand long tons	10,976	140,228	12,180	165,802
Beryllium ore short tons	3,822	1,413	6,422	2,648
Bismuth pounds	1,265,671	4,718	891,499	3,699
Boron carbide do	227,486	575	422,133	883
Cadmium:				
Metal thousand pounds	1,927	4,602	1,078	3,166
Flue dust (cadmium content) do	1,605	1,796	1,115	1,495
Calcium:				
Metal pounds	137,251	120	354,370	307
Chloride short tons	14,069	523	9,226	350
Chromate:				
Ore and concentrates (Cr_2O_3 content) thousand short tons	499	18,189	506	20,030
Ferrochrome do	41	14,197	42	12,958
Metal do	1	2,053	1	2,133
Cobalt:				
Metal thousand pounds	9,219	16,285	12,037	21,725
Oxide (gross weight) do	1,186	2,113	1,175	2,023
Salts and compounds (gross weight) thousand pounds	107	90	131	67
Columbium ore do	3,657	2,848	4,161	2,681
Copper: (copper content)				
Ore and concentrates short tons	71,884	66,291	3,588	3,274
Regulus, black, coarse do	8	4	6	17
Unrefined, black, blister do	274,180	224,013	241,712	233,265
Refined in ingots, etc do	403,630	438,608	131,171	132,573
Old and scrap do	11,571	12,117	5,889	5,355
Old and clippings do	2,131	2,042	2,035	2,109
Ferroalloys: Ferrosilicon (silicon content) short tons	10,612	3,207	16,944	4,577
Gold:				
Ore and base bullion troy ounces	213,662	7,855	236,738	9,064
Bullion do	5,730,853	218,408	5,624,649	227,842
Iron ore thousand long tons	43,941	453,753	40,758	402,529
Iron and steel:				
Pig iron short tons	785,899	r 30,481	406,568	18,513
Iron and steel products (major):				
Iron products short tons	39,542	9,606	35,012	9,604
Steel products do	r 17,853,087	r 1,989,377	13,983,804	1,758,171
Scrap do	276,498	10,784	311,350	12,280
Tinplate do	17,727	541	23,849	917
Lead:				
Ore, flue dust, matte (lead content) short tons	96,863	18,990	115,286	22,697
Base bullion (lead content) do	8	4	1,993	699
Pigs and bars (lead content) do	337,620	81,264	278,873	72,104
Reclaimed, scrap, etc (lead content) short tons	4,249	748	6,682	1,513
Sheets, pipe, and shot do	893	256	518	174
Babbitt metal and solder (lead content) short tons	566	2,244	667	3,822
Manufactures do	r 2,138	r 528	1,981	543
Magnesium:				
Metallic and scrap do	r 4,077	r 2,203	3,515	1,913
Alloys (magnesium content) do	r 656	r 1,228	467	1,175
Sheets, tubing, ribbons, wire and other forms (magnesium content) short tons	r 40	r 428	14	66
Manganese:				
Ore (35 percent or more manganese) (manganese content) short tons	870,390	45,264	980,961	39,178
Ferromanganese (manganese content) short tons	r 158,304	r 21,178	234,563	31,708
Mercury:				
Compounds pounds	33,473	47	46,944	15,499
Metal 76-pound flasks	23,246	11,164	31,924	15,207
Minor metals: Selenium and salts pounds	582,535	3,076	563,475	3,363

See footnotes at end of table.

Table 9.—U.S. imports for consumption of principal minerals and products—Continued

Mineral	1968		1969	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Metals—Continued				
Nickel:				
Pigs, ingots, shot, cathodes..short tons..	108,158	$201,312	99,652	$209,468
Scrap..do....	[r]1,974	[r]2,575	3,188	8,084
Oxide..do....	6,388	8,911	4,013	6,524
Platinum group:				
Unwrought:				
Grains and nuggets (platinum) troy ounces..	[r]64,972	[r]10,223	67,560	9,741
Sponge (platinum)..do....	[r]303,562	[r]36,991	272,794	33,665
Sweepings, waste and scrap..do....	[r]54,695	3,861	127,053	5,422
Iridium..do....	5,503	1,018	5,938	1,027
Palladium..do....	[r]1,068,400	[r]46,547	249,389	10,704
Rhodium..do....	41,026	8,868	38,077	8,615
Ruthenium..do....	[r]13,162	454	7,566	391
Other platinum group metals..do....	21,722	3,593	11,602	1,696
Semimanufactured:				
Platinum..do....	68,677	8,172	58,249	8,018
Palladium..do....	96,916	4,244	382,583	14,280
Rhodium..do....	29,990	1,492	3,387	444
Other platinum group metals..do....	5,359	229	1,453	190
Radium: Radioactive substitutes..........	NA	3,241	NA	4,697
Rare earths: Ferrocerium and other cerium alloys..pounds..	23,003	77	17,328	91
Silver:				
Ore and base bullion thousand troy ounces..	28,786	49,587	32,332	48,115
Bullion..do....	41,923	88,213	39,544	71,247
Tantalum ore..thousand pounds..	1,230	4,164	975	3,196
Tin:				
Ore (tin content)..long tons..	2,282	5,287	-------	---------
Blocks, pigs, grains, etc..do....	57,358	181,940	54,950	185,037
Dross, skimmings, scrap, residues and tin alloys, n.s.p.f..long tons..	487	532	948	1,052
Tin foil, powder, flitters, etc..........	NA	2,742	NA	3,458
Titanium:				
Ilmenite..short tons..	246,109	5,167	316,574	3,907
Rutile..do....	174,366	12,653	204,907	16,207
Metal..pounds..	7,610,236	8,148	13,211,214	11,712
Ferrotitanium..do....	398,923	143	1,103,148	259
Compounds and mixtures..do....	111,080,989	19,618	111,219,610	19,220
Tungsten: (tungsten content)				
Ore and concentrate..thousand pounds..	1,743	3,272	1,503	3,445
Metal..do....	33	356	36	466
Other alloys..do....	22,951	120	20,436	139
Zinc:				
Ore (zinc content)..short tons..	[r]484,803	[r]68,971	565,234	79,242
Blocks, pigs, and slabs..do....	306,651	76,035	327,849	85,097
Sheets..do....	754	290	966	418
Old, dross, and skimmings..do....	1,459	182	2,486	322
Dust..do....	8,100	2,443	8,251	2,652
Manufactures..........	NA	447	NA	511
Zirconium: Ore, including zirconium sand short tons..	59,900	2,014	95,414	3,858
Nonmetals:				
Abrasives: Diamonds (industrial) thousand carats..	[r]13,686	[r]60,302	14,076	52,821
Asbestos..short tons..	737,909	72,930	694,558	76,422
Barite:				
Crude and ground..do....	662,705	5,666	616,573	5,783
Witherite..do....	[r]2,054	[r]76	459	22
Chemicals..do....	5,977	843	6,661	1,113
Cement..thousand 376-pound barrels..	[r]7,289	[r]17,378	9,687	24,376
Clays:				
Raw..short tons..	91,205	1,709	76,698	1,541
Manufactured..do....	6,177	242	5,190	209
Cryolite..do....	33,772	5,455	20,406	4,251
Feldspar: Crude..long tons..	---------	---------	46	7
Fluorspar..short tons..	1,050,107	28,699	1,149,546	32,818
Gem stones:				
Diamonds..thousand carats..	4,348	475,131	4,690	504,647
Emeralds..do....	365	10,644	309	9,175
Other..........	NA	51,418	NA	52,871
Graphite..short tons..	67,922	2,494	58,479	2,419
Gypsum:				
Crude, ground, calcined thousand short tons..	5,476	11,473	5,860	12,481
Manufactures..........	NA	1,585	NA	2,041
Iodine, crude..thousand pounds..	5,883	5,594	5,705	5,753
Kyanite..short tons..	1,450	51	2,088	88

See footnotes at end of table.

Table 9.—U.S. imports for consumption of principal minerals and products—Continued

Mineral	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)
Nonmetals—Continued				
Lime:				
Hydrated short tons	873	$21	39,270	$542
Other do	71,632	877	144,471	1,911
Dead-burned dolomite [1] do	33,498	1,552	10,780	568
Magnesium:				
Magnesite do	131,640	8,489	113,369	7,464
Compounds do	49,344	1,326	48,719	1,251
Mica:				
Uncut sheet and punch thousand pounds	1,491	1,539	1,601	1,695
Scrap do	r 3,157	77	3,078	74
Manufactures do	5,293	3,373	5,520	3,060
Mineral-earth pigments: Iron oxide pigments:				
Natural short tons	4,442	253	2,736	225
Synthetic do	18,596	3,455	22,555	4,390
Ocher, crude and refined do	126	8	87	6
Siennas, crude and refined do	1,464	173	1,341	146
Umber, crude and refined do	4,671	178	6,240	235
Vandyke do	589	50	472	42
Nitrogen compounds (major), including urea thousand short tons	1,652	82,221	1,779	87,913
Phosphate, crude do	116	2,679	140	3,554
Phosphatic fertilizers do	44	2,222	83	3,976
Pigments and salts:				
Lead pigments and compounds short tons	32,004	6,950	32,473	7,984
Zinc pigments and compounds do	20,838	4,152	23,518	4,476
Potash do	r 3,658,158	r 78,077	3,978,363	67,034
Pumice:				
Crude or unmanufactured do	9,436	69	8,424	81
Wholly or partly manufactured do	302,240	736	375,861	819
Manufactures, n.s.p.f.	NA	17	NA	61
Quartz crystal (Brazillian pebble) pounds	1,180,153	607	1,291,003	477
Salt thousand short tons	3,456	11,487	3,302	11,990
Sand and gravel:				
Glass sand do	25	144	43	194
Other sand and gravel do	729	984	854	1,253
Sodium sulfate do	305	5,108	286	4,808
Stone and whiting	NA	r 24,629	NA	29,306
Strontium: Mineral short tons	12,896	290	27,803	595
Sulfur and pyrites:				
Sulfur, ores and other forms, n.e.s. thousand long tons	1,572	64,277	1,674	57,222
Pyrites do	13	68	99	322
Talc: Unmanufactured short tons	24,313	973	20,358	749
Fuels:				
Carbon black:				
Acetylene pounds	5,343,923	915	7,097,186	1,220
Gas black and carbon black do	2,351,312	173	1,129,280	165
Coal:				
Bituminous, slack, culm and lignite short tons	224,394	1,900	108,914	1,081
Briquets do	2,891	44	1,351	18
Coke do	94,085	1,904	173,052	3,354
Peat:				
Fertilizer grade do	285,875	12,716	297,364	13,631
Poultry and stable grade do	1,725	100	2,633	121
Petroleum:				
Crude oil thousand barrels	472,323	1,067,450	513,849	1,120,191
Gasoline do	21,591	81,614	22,709	87,203
Special naphtha do	1,399	3,442	3,191	8,233
Kerosine do	190	568	965	2,567
Distillate fuel oil do	r 67,234	r 199,600	78,275	223,867
Residual fuel oil do	r 409,928	r 807,578	461,611	987,848
Military jet fuel do	7,117	21,066	5,134	15,813
Commercial jet fuel do	r 31,390	r 95,112	40,405	124,447
Liquefied gases do	11,647	19,916	12,651	20,373
Asphalt do	6,236	13,096	4,761	10,284
Unfinished oil do	29,350	71,321	38,008	87,798
Lubricants do	33	533	163	1,535
Wax do	17	74	158	799
Petrochemical feed stocks do	---------	---------	40	106
Total	XX	r 8,562,563	XX	8,212,755

r Revised. NA Not available. XX Not applicable.
[1] Dead-burned basic refractory material consisting chiefly of magnesia and lime.

Table 10.—Comparison of world and United States production of principal metals and minerals

Mineral	1968 World r [1]	1968 United States		1969 p World [1]	1969 United States	
	Thousand short tons (unless otherwise stated)	Thousand short tons (unless otherwise stated)	Percent of world	Thousand short tons (unless otherwise stated)	Thousand short tons (unless otherwise stated)	Percent of world
Fuels:						
Carbon black ... thousand pounds	5,144,207	2,811,806	55	5,585,639	2,963,261	53
Coal:						
Bituminous	2,078,608	540,428	26	2,139,111	555,493	26
Lignite	811,037	4,817	1	832,677	5,012	1
Pennsylvania anthracite	202,032	11,461	6	199,602	10,473	5
Coke (excluding breeze):						
Gashouse [3]	17,975	174	1	16,755	NA	NA
Oven and beehive	346,832	63,653	18	333,747	64,757	19
Natural gas (marketable) ... million cubic feet	31,071,657	19,322,400	62	33,999,154	20,698,240	61
Peat	208,423	619	(2)	218,584	572	(2)
Petroleum (crude) ... thousand barrels	14,104,250	3,329,042	24	15,220,221	3,371,751	22
Nonmetals:						
Asbestos	3,290	121	4	NA	126	NA
Barite	4,017	[4] 927	23	4,188	1,077	26
Cement ... thousand 376-pound barrels	3,009,950	[5] 412,273	14	3,168,951	[5] 416,889	13
China clay	12,836	[6] 4,201	33	NA	[6] 4,739	NA
Corundum	7	------	------	7	------	------
Diamonds ... thousand carats	10,481	------	------	11,156	------	------
Diatomite	1,650	[7] 627	38	1,554	598	38
Feldspar ... thousand long tons	2,170	668	31	2,267	674	30
Fluorspar	3,906	252	6	4,174	183	4
Graphite	481	W	NA	341	W	NA
Gypsum	53,443	10,018	19	55,195	9,881	18
Lime (sold or used by producers)	93,259	18,637	20	97,591	20,209	21
Magnesite	11,656	W	NA	12,027	W	NA
Mica (including scrap) ... thousand pounds	343,468	250,661	73	363,358	266,115	73
Nitrogen, agricultural [8]	27,872	6,872	25	30,582	6,985	23
Phosphate rock	92,500	41,251	45	NA	37,725	NA
Potash (K_2O equivalent)	17,856	2,722	15	18,311	2,804	15
Pumice [9]	14,957	3,530	24	14,613	3,609	25
Pyrites ... thousand long tons	22,114	872	4	21,748	W	NA
Salt	139,248	[5] 28,813	21	147,571	[5] 30,848	21
Strontium [9]	14	------	------	30	------	------
Sulfur, elemental ... thousand long tons	18,619	8,814	47	19,655	8,560	44
Talc, pyrophyllite, and soapstone	4,866	958	20	5,015	1,029	21
Vermiculite [9]	419	290	69	463	310	67
Metals, mine basis:						
Antimony (content of ore and concentrate) ... short tons	67,737	856	1	72,059	938	1
Arsenic, white [9]	66	W	NA	57	W	NA
Bauxite ... thousand long tons	45,221	[10] 1,665	4	51,113	[10] 1,843	4
Beryllium concentrate ... short tons	7,219	168	2	7,926	W	NA
Bismuth ... thousand pounds	8,076	W	NA	8,465	W	NA
Cadmium ... do	32,354	[11] 10,651	33	37,587	[11] 12,646	34
Chromite	5,336	------	------	5,635	------	------

Cobalt (contained)	r 23	W	NA	22	W	NA
Columbium-tantalum concentrates [9] thousand pounds	19,844	W	NA	29,192	W	NA
Copper (content of ore and concentrate)	6,024	[12] 1,205	20	6,645	[12] 1,545	23
Gold thousand troy ounces	46,154	1,478	3	46,418	1,733	4
Iron ore thousand long tons	674,440	[13] 85,865	13	712,406	[13] 88,260	12
Lead (content of ore and concentrate)	3,299	[12] 359	10	3,523	[12] 509	14
Manganese ore (35 percent or more Mn)	18,727	11	(2)	19,864	6	(2)
Mercury thousand 76-pound flasks	258	29	11	285	29	10
Molybdenum (content of ore and concentrate) thousand pounds	125,735	93,447	74	142,802	99,807	70
Nickel (content of ore and concentrate)	546	15	3	530	16	3
Platinum groups (Pt., Pd., etc.) thousand troy ounces	3,394	15	(2)	3,387	22	(2)
Silver do	275,075	32,729	12	288,601	41,906	15
Tin (content of ore and concentrate) long tons	227,935	W	NA	223,609	W	NA
Titanium concentrates:						
Ilmenite [9]	3,261	979	30	3,531	931	26
Rutile [9]	339	W	NA	414	----------	NA
Tungsten concentrate (contained tungsten) short tons	35,212	5,094	14	36,030	4,702	13
Vanadium (content of ore and concentrate) [9] do	11,799	6,483	55	11,349	5,577	49
Zinc (content of ore and concentrate)	5,499	529	10	5,827	553	9
Metals, smelter basis:						
Aluminum	8,875	3,255	37	10,019	3,793	38
Copper	6,804	[14] 1,351	20	7,304	[14] 1,585	21
Iron, pig (including ferroalloys)	425,424	91,388	21	459,697	97,593	21
Lead	3,331	[15] 467	14	3,671	[15] 639	17
Magnesium short tons	212,663	98,375	46	212,649	99,886	45
Selenium [9] thousand pounds	2,012	633	31	2,759	1,229	45
Steel ingots and castings	583,626	[16] 131,462	23	633,431	[16] 141,262	22
Tellurium [9] thousand pounds	258	121	47	427	234	55
Tin [17] long tons	230,768	[18] 3,453	1	224,458	345	(2)
Uranium oxide (U_3O_8) [9] short tons	22,772	12,338	54	21,632	10,934	51
Zinc	5,125	1,021	20	5,586	1,041	19

p Preliminary. r Revised. NA Not available. W Withheld to avoid disclosing individual company confidential data.

[1] Total is not strictly comparable with previous years as it does not represent total world production. Confidential U.S. data are excluded. The data includes reported figures and reasonable estimates in some instances where data were not available, no reasonable estimate could be made and none has been included except for gold, silver, and pyrites.

[2] Less than ½ unit.

[3] Includes low- and medium-temperature and gashouse coke.

[4] Sold or used by producers.

[5] Includes Puerto Rico.

[6] Kaolin sold or used by producers.

[7] Average annual production from the appropriate 3-year totals, 1966–68.

[8] Year ended June 30 of year stated (United Nations).

[9] World total exclusive of U.S.S.R.

[10] Dry bauxite equivalent of crude ore.

[11] Includes secondary.

[12] Recoverable.

[13] Iron-nickel ore.

[14] Smelter output from domestic and foreign ores, exclusive of scrap. Production from domestic ores only, exclusive of scrap, was as follow: 1968, 1,233,951; 1969, 1,547,494.

[15] Lead refined from domestic and foreign ores, excludes lead refined from imported base bullion.

[16] Data from American Iron and Steel Institute. Excludes production of castings by companies that do not produce steel ingots.

[17] Includes tin content of alloys made directly from ores.

[18] U.S. imports of tin concentrates (tin content).

Injury Experience and Worktime in the Mineral Industries

By Forrest T. Moyer [1]

The safety record for all mineral mining and processing industries in 1969 showed an improvement in fatality experience but a worsening in nonfatal injury experience. The overall injury-severity rate of 2,427 days lost per million man-hours of worktime was sharply better than that of 2,741 in 1968. However, the frequency rate of 17.32 injuries per million man-hours was higher than the corresponding rate of 16.76 in the preceding year.

The totals of 510 fatal and 32,125 nonfatal injuries in 1969 occurred at respective frequency rates of 0.27 and 17.05 per million man-hours. The comparable data for 1968 were 607 fatal and 31,254 nonfatal injuries at respective frequencies of 0.32 and 16.44 per million man-hours. This indicated improvement in fatality experience resulted primarily from the absence of major disasters (a single accident which results in the death of five men or more) throughout 1969. There were three major disasters in 1968 with a total of 108 work fatalities: A shaft fire at a Louisiana salt mine resulted in 21 deaths: a dust explosion at a Kentucky coal mine caused nine fatalities; and a gas and dust explosion resulted in 78 deaths in a West Virginia coal mine.

The safety records of the separate mineral industries varied as summarized in the later text and detailed in the tables of this chapter.

Mine Safety Legislation.—The first Federal legislation specifically directed towards coal mine safety, "An act relating to certain inspections and investigations in coal mines for the purpose of obtaining information relating to health and safety conditions, accidents, and occupational diseases therein, and for other purposes" (Public Law 49—77th Congress), was approved May 7, 1941. This act provided right-of-entry to coal mines for Federal inspectors but, since no enforcement authority was provided, only recommendations for safety and health improvements could be made. This legislation was strengthened by the Federal Coal Mine Safety Act (Public Law 552—82nd Congress) approved July 16, 1952, which through amendments placed emphasis on prevention of major disasters and gave specified authorities to the Bureau of Mines concerning dangers that could lead to a mine explosion, mine fire, mine inundation, or man-trip or man-hoist accidents. However, these powers did not apply to any mines in which less than 15 persons were regularly employed in underground workings. The Federal Coal Mine Safety Act Amendments of 1965 (Public Law 89–376), approved March 26, 1966, removed the mine-size limitations and extended the provisions of the 1952 act to all underground mines regardless of the number of men working underground.

Subsequent to the gas and dust explosion in the Consol No. 9 mine, Farmington, West Virginia, in November 1968, legislative hearings on a new coal mine health and safety bill culminated in the "Federal Coal Mine Health and Safety Act of 1969" (Public Law 91–173), which was approved December 30, 1969. This measure repealed the former legislation, established comprehensive, interim, mandatory, health and safety standards, and directed the Secretary of Health, Education, and Welfare and the Secretary of the Interior to develop and promulgate improved mandatory standards covering all factors for the protection of the health and safety of coal

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miners. Operators of coal mines, regardless of size or kind of mine, and coal miners are required to comply with the standards. Regulations for the protection of the health of miners became prominent for the first time, particularly those relating to dust and noise levels. The act also provides for payment of compensation by the Federal Government to coal miners disabled due to coal-workers' pneumoconiosis arising out of employment in an underground coal mine.

The first Federal legislation on health and safety in metal and nonmetal mines, the Federal Metal and Nonmetallic Mine Safety Act (Public Law 89-577), was approved September 16, 1966. It covers all mines extracting minerals, except coal and lignite, in nonliquid form, or, if in liquid form, with workers underground, and the milling of such minerals. The Secretary of the Interior was directed to develop, after consultation with advisory committees, and promulgate health and safety standards for the protection of life, the promotion of health and safety, and the prevention of accidents in mines and mills subject to the act. Enforcement authority was provided. The first health and safety standards promulgated under the act were published in the Federal Register, v. 34, No. 145, July 31, 1969, pp. 12503-12527. These standards became fully effective, in accordance with the law, 1 year later, on July 31, 1970.

Scope of Report.—The statistics in this chapter comprise the injury and work experience of all personnel engaged in production, exploration, development, maintenance, repair, and force-account construction work, including supervisory and technical personnel, and working partners at mineral-producing and mineral-processing establishments in the United States. Data concerning officeworkers are excluded except for the oil and gas industry for which such data are not separable.

The coverage of all industries is complete except for oil and gas, in which coverage varies from year to year, particularly with respect to small companies. The 1969 data were collected and compiled by the Division of Statistics with continued modification of procedures. These modifications affect only the figures on men working, days active, and man-days. All injury rates were calculated from unrounded data and in some instances cannot be reproduced from the rounded data shown in the tables.

Most of the information was reported by the producer or operator, but to obtain complete coverage it was necessary to estimate some worktime data for nonreporting plants with information from other sources. Injury experience for these nonreporters was not estimated, but was projected from the aggregate injury experience of reporters in the same industry.

MINERALS

METAL MINES AND MILLS

All general measures of injury experience at both metal mines and mills worsened in 1969. Fatalities at mines and mills totaled 68 and occurred at a frequency of 0.43, compared with corresponding data of 59 deaths at a rate of occurrence of 0.40 in 1968. The total of 3,730 nonfatal injuries, 355 more than in the preceding year, had a rate of occurrence of 23.50 per million man-hours compared with 22.67 in 1968.

At all metal mines in 1969 there were 62 fatal and 3,110 nonfatal injuries, both well above the corresponding totals in the preceding year. Although there was a substantial gain in man-hours of exposure, the injury frequency rate increased to 30.52 and the severity rate to 5,124 days lost per million man-hours in 1969 (table 1).

The safety record at metal mills showed a similar regression from that of 1968. The six fatal and 620 nonfatal injuries had frequency and severity rates of 11.42 and 1,173 in 1969, and each of these general measures was higher than in 1968.

At copper mines in 1969 the fatality record was improved but nonfatal injury experience was worse. The 15 deaths were three less than in 1968, and, largely as a result of this reduction, the injury-severity rate was lowered appreciably to 3,404 in 1969. However, the total of 755 nonfatal injuries was 154 higher than in 1968, and the rate of occurrence for all injuries at copper mines increased slightly to 18.59 despite the large gain in man-hours of work. Most general measures of injury experience at copper mills increased in 1969. There was one fatality in both 1969 and 1968, but nonfatal injuries increased to 170 in the current year. As a result, the frequency and severity rates of injuries, respectively 10.53 and 946, were higher than in 1968. Operating activity, as measured by man-hours worked, was substantially higher in 1969 at both mines and mills.

All general measures of injury experience for gold-silver lode and placer mines were improved in 1969, but this betterment was offset by a regression in experience for the associated mills. At the mines, there were seven fatal and 315 nonfatal injuries compared with corresponding figures of 10 and 320 in 1968. The resulting injury rates of 47.55 for frequency and 9,759 for severity in 1969 were moderately below those for the preceding year. At gold-silver mills the one fatal and 15 nonfatal injuries in 1969 were well above similar data of no fatalities and four nonfatal injuries during the preceding year. Hence, both the frequency and severity rates, respectively 21.98 and 9,021, were markedly worse than in 1968.

The safety record at iron mines in 1969 was better than in 1968 in all aspects except the injury-frequency rate, which at 17.54 was slightly higher. Totals of six fatal and 435 nonfatal injuries and the severity rate of 2,182 were each lower than the corresponding data for 1968. However, at iron mills all measures of safety performance were worse in 1969. Two fatal and 150 nonfatal injuries compared unfavorably with no fatalities and 135 nonfatal injuries in 1968. As a result, the injury-frequency rate of 8.72 was higher and the severity rate of 962 in 1969 was more than double that of 1968. The rate of operations, gaged by worktime, was appreciably lower in 1969 at the mines, whereas at the mills it was slightly higher.

At lead-zinc mines each of the general measures of injury experience retrogressed in 1969. The 15 fatal and 1,050 nonfatal injuries were respectively two and 153 higher than in 1968. The resulting rate of occurrence, 66.57, and the severity rate, 8,458, both were markedly worse than in the preceding year. At lead-zinc mills, there was one fatality compared with none in 1968, but the total of 70 nonfatal injuries was 22 less than in the preceding year. The frequency rate of injuries in 1969 was improved to 24.33, but the severity rate of 3,155 was markedly higher than in 1968. Man-hours of worktime in 1969 were slightly higher at both mines and mills.

The 12 fatalities at uranium mines in 1969 were double the total for 1968, and as a result of this increase, the injury-severity rate worsened to 10,805, also double that for 1968. Nonfatal injury experience was better than in 1968, and the total for 1969 decreased to 245. Hence, the frequency rate for fatal and nonfatal injuries was lowered to 33.06 per million man-hours. At uranium mills, no fatalities occurred in 1969, whereas there was one in 1968. However, nonfatal injuries increased by 22 to a total of 60 in 1969. The resulting injury-frequency rate of 17.30 was nearly double that of 1968. Owing to the absence of fatal injuries, the severity rate of 481 was only one-fourth that in the preceding year.

In 1969, all general measures of safety performance at both mines and mills working miscellaneous metals (bauxite, mercury, titanium, tungsten, etc.) regressed appreciably. At the mines, the occurrences of seven fatal and 310 nonfatal injuries compared, respectively, with three and 243 in 1968. The resulting frequency rate of 46.84 and the severity rate of 7,555 were sharply worse than in 1968. At miscellaneous metal mills, there were one fatal and 155 nonfatal injuries, whereas in 1968 there were no fatal and 135 nonfatal injuries. The injury rates of 11.21 for frequency and 1,092 for severity both were markedly higher than in 1968.

NONFERROUS REDUCTION AND REFINING PLANTS

Injury experience measures at nonferrous metal smelting, reducing, and refining plants worsened appreciably in 1969. The numbers of both fatal and nonfatal injuries increased markedly, and there were substantial increases in both injury-frequency and injury-severity rates. There were 15 fatal and 1,565 nonfatal injuries compared with four and 1,155, respectively, in 1968. The injury-frequency rate of 12.61 in 1969 was 19 percent higher than in 1968, and the injury-severity rate of 1,293 days lost per million man-hours was 78 percent above that of last year.

The safety record was worse during 1969 in all aspects at copper, lead, zinc, and aluminum smelting and refining plants in 1969 (table 3). At plants reducing and refining miscellaneous nonferrous metal, there were no fatalities in either 1969 or 1968, but nonfatal injuries increased to 45 in 1969. As a result, the frequency rate of injuries increased sharply to 7.64 per million man-hours. However, the injury-severity rate of 254 at these plants was well below that for 1968. This was the sole general measure of injury experience in which there was improvement throughout the nonferrous metal reducing and refining industries during 1969.

Operating activity, as measured by man-hours worked, was higher in 1969 than in 1968 in each of the industry groupings of smelting and refining plants. Aggregate worktime at all plants in 1969 was slightly more than 125 million man-hours compared with 109 million in 1968.

NONMETAL (EXCEPT STONE) MINES AND MILLS

The combined safety record of nonmetal mines and mills was improved in all respects in 1969. The 27 fatal and 2,360 nonfatal injuries were, respectively, 12 and 112 fewer than in 1968. The resulting frequency rates of 0.28 for fatal and 24.16 for nonfatal injuries in 1969 were well below the corresponding respective rates of 0.39 and 24.87 in the preceding year (tables 4–5).

At clay-shale mines all measures of injury experience worsened in 1969. There were four fatal and 200 nonfatal injuries compared with one fatal and 175 nonfatal injuries in 1968. The frequency rate of 25.68 for all injuries in 1969 was sharply higher, and the severity rate of 3,881 was nearly double that of the preceding year. At clay mills, the six fatalities were four more than in 1968, and as a result, the severity rate for all injuries increased to 2,427 in 1969. Although the total of 860 nonfatal injuries was 94 less than in 1968, the frequency rate for all disabilities increased slightly to 30.41 in 1969 owing to lessened man-hours of exposure.

There were no fatalities at gypsum mines, compared with one in 1968, and as a result the severity rate of all injuries was improved sharply to 517 in 1969. Nonfatal injuries increased by one to a total of 20 in 1969, and the resulting frequency of all injuries, 11.06, was slightly higher than in 1968. The safety record at gypsum mills worsened in all measures of safety performance. There were one fatal and 30 nonfatal injuries compared with corresponding figures of none and 21 in 1968. The injury-frequency rate of 7.84 was higher and the severity rate, 2,021, was nearly 8 times higher than in 1968.

Fatality experience worsened in 1969 at both mines and mills in the phosphate rock industry. The three fatalities in the mines and one in the mills were more than in 1968 and were responsible for the sharply increased injury-severity rates of, respectively, 3,708 and 1,726 for 1969. However, nonfatal injury experience was improved markedly, and the totals of 70 nonfatal injuries at mines and 30 at mills were, respectively, 93 and 21 below 1968 data. Owing to these reductions, the injury-frequency rates of 11.90 for the mines and 7.28 for the mills were markedly better than in 1968.

At potash mines the total of four fatalities was double the number in 1968, and this increase was primarily responsible for the sharply worsened injury-severity rate of 7,328 in 1969. There were no fatalities in either year at potash mills. The nonfatal injury record was better in 1969 at both mines and mills. The reduced totals of nonfatal injuries, 130 at mines and 25 at mills, resulted in improved injury-frequency rates of 33.84 and 13.98, respectively, for 1969.

All measures of safety performance were improved in 1969 at salt mines. The reduced totals of two fatal and 170 nonfatal injuries resulted in decreased frequency and severity rates of 42.23 and 5,688, respectively. There was a major disaster in 1968 from a shaft fire at a Louisiana salt mine in which 21 men died. No work fatalities occurred at salt mills in either 1969 or 1968. However, the number of nonfatal injuries increased to 215 in 1969, and the frequency rate worsened to 27.71. The injury-severity rate was improved to 466, compared with 535 in 1968.

Virtually all native sulfur is produced by the Frasch process through wells by solution mining. Any processing after mining by this process is not separable from the mining activity. There were no fatalities in either 1969 or 1968 at sulfur mines. However, nonfatal injuries increased to 95 and the resulting injury-frequency and injury-severity rates increased to 18.37 and 976, respectively, in 1969. There was no reported work activity at sulfur mills during 1969.

At miscellaneous nonmetal (barite, boron minerals, feldspar, fluorite, mica, talc, etc.) mines fatalities decreased to four, but nonfatal injuries increased to 200 in 1969. The resulting frequency rate of 34.36 was higher than in 1968, and the severity rate improved to 4,963. At mills, the totals of two fatal and 315 nonfatal injuries were higher than in 1968, and both the frequency and severity rates, 18.92 and 1,584, respectively, worsened in 1969.

STONE QUARRIES AND MILLS

The overall safety record of all stone operations in 1969 was an improvement in fatality experience but a slight worsening in the nonfatal injury record. Fatalities were lowered to 53, and this reduction was primarily responsible for the improved injury-severity rate of 2,635 in 1969. Nonfatal injuries increased to 3,390, and, as a result, the frequency rate worsened slightly to 18.41 in 1969 (table 6).

All general measures of safety performance were improved at cement operations during 1969. The totals of eight fatal and 350 nonfatal injuries were both lower than in 1968. The resulting injury rates of 6.45 for frequency and 1,429 for severity were lower than in the preceding year.

Injury experience worsened at granite operations in 1969. Five fatal and 395 nonfatal injuries resulted in frequency and severity rates of 25.78 and 3,287, respectively. Each of these measures was worse than in 1968.

The fatality record at lime operations was improved but nonfatal injury experience worsened in 1969. Work deaths were reduced to three, and this reduction was principally responsible for the improved severity rate of 1,962. However, nonfatal injuries increased sharply to 355, and the resulting frequency rate of 19.60 was well above that of 1968.

At limestone quarries and plants fatalities increased to 31 in 1969, and this increase was largely responsible for the worsening of the injury-severity rate to 3,800, compared with 3,533 in 1968. Although nonfatal injuries increased to 1,490 in 1969, the injury-frequency rate of 22.58 was virtually unchanged from that of 1968, owing to the increased man-hours of work in the current year.

The fatality record at marble operations worsened and the two fatalities, compared with none in 1968, were primarily responsible for the sharp worsening of the severity rate of 4,418 for the current year. Nonfatal injuries decreased to 160 but, owing to the reduced worktime, the injury-frequency rate increased to 31.42.

At sandstone operations, fatalities were reduced to two, four less than in 1968, and this reduction was responsible for the sharp improvement in the injury-severity rate of 2,250 in 1969. However, nonfatal injuries increased to a total of 245 and caused the injury-frequency rate to increase to 25.31 in 1969.

Safety performance was improved at slate plants in 1969. There were no fatalities in either 1969 or 1968. Nonfatal injuries were decreased to 75, and the injury-frequency and injury-severity rates were lowered to 30.83 and 480, respectively, in 1969.

There were two fatal and 230 nonfatal injuries at traprock quarries, compared with two and 218, respectively, in 1968. The resulting injury-frequency rate for 1969 worsened to 25.07. The injury-severity rate was improved to 2,120 owing to an apparent reduction in the overall seriousness of the nonfatal injuries.

At miscellaneous (gneiss, schist, quartz, etc.) stone operations, fatality experience was improved, but the nonfatal injury record worsened in 1969. There were no fatalities, compared with two in 1968, and this reduction was primarily responsible for the sharply improved severity rate of 1,224 in 1969. However, the increase to 85 nonfatal injuries resulted in a worsened frequency rate of 25.69 in 1969.

SAND AND GRAVEL OPERATIONS

The fatality record worsened, but the nonfatal injury experience was improved at sand and gravel operations in 1969 (table 7). Fatalities increased to 31, or five more than in 1968, and this increase was primarily responsible for the worsening of the injury-severity rate to 3,025 in 1969. The total of 1,930 nonfatal injuries, 62 less than in 1968, coupled with the increased man-hours of work, resulted in an improved frequency rate of 20.82 in 1969.

SLAG (IRON-BLAST-FURNACE) OPERATIONS

The fatality record at slag plants worsened to three deaths, two more than in

1968, and the injury-severity rate increased to 6,061, owing principally to the larger number of deaths (table 8). Nonfatal injuries were reduced to 49, or eight fewer than in 1968, and the injury-frequency rate was reduced to 14.55 for 1969.

MINERAL FUELS

The overall safety record of the mineral fuels industries was less favorable in 1969 than in 1968 owing to a regression in nonfatal injury experience which more than offset the better fatality experience. The total of 19,411 fatal and nonfatal injuries occurred at a frequency of 15.94 per million man-hours, 4 percent higher than the 1968 rate of 15.36. The 313 work fatalities with a frequency of occurrence of 0.26 in 1969 were respectively 107 less and 21 percent lower than the comparable figures of 420 deaths at a rate of 0.33 in 1968. Nonfatal injuries totaled 19,098 in 1969, 155 more than in 1968, and occurred at a frequency of 15.69 per million man-hours, 4 percent above that of 15.03 in the preceding year. Of the major industry groups (tables 9–13) the coal mining and peat industries had better injury-frequency and injury-severity rates in 1969, whereas, the coke and native-asphalt industries had worse injury rates than in 1968. The oil and natural gas industries had an increased rate of occurrence of injuries and the injury-severity rate was virtually unchanged.

COAL MINES

Overall injury experience (fatal and nonfatal) of the coal mining industry was improved in 1969. The injury-frequency rate of 42.07 work injuries per million man-hours of exposure was 1 percent lower than in 1968, and the injury-severity rate, 7,309 days lost per million man-hours, declined 30 percent owing to a 35-percent decrease in the number of fatalities reported (table 9).

Work fatalities in 1969 totaled 203 and occurred at a frequency rate of 0.85 per million man-hours of worktime. These data established new record annual lows for the total number and for the frequency rate of fatal injuries. The previous low records were 222 fatalities in 1967 and 0.90 fatal injuries per million man-hours in 1950 and in 1953. In 1968, the 311 work deaths included 87 lives lost in two major disasters, nine in one and 78 in the second disaster. The year 1969 was the seventh in statistical history in which no major disasters (a single accident which results in the death of five men or more) occurred in coal mines. The 6 preceding years were 1949, 1950, 1955, 1956, 1964, and 1967. The improved fatality record in 1969 resulted entirely from the better experience at bituminous coal mines, which more than offset the sharply worsened fatality record at anthracite mines.

Nonfatal injuries increased to 9,800 in 1969, 161 more than in 1968, and the frequency rate of these injuries increased slightly to 41.21 per million man-hours from 41.12 in 1968.

Bituminous Coal and Lignite Mines.— Fatality experience of 190 fatalities at an occurrence rate of 0.83 per million man-hours worked set new record low points for the bituminous coal and lignite mining industries. The previous low annual records were 213 fatalities in 1967 and 0.89 fatal injuries per million man-hours in 1953. In 1968, when there were two major disasters, the total of 307 fatalities resulted in a frequency rate of 1.37 per million man-hours worked.

By general work locations, the fatalities in 1969 were distributed as follows: Underground workings, 141; associated surface of underground mines, 15; strip mines, 25; auger mines, three; and mechanical cleaning plants, six. In underground workings, work-deaths from falls of roof, face, and rib dropped 21 percent to 77 in 1969 from 98 in 1968. However, fatalities from the next ranking causes of fatal accidents, haulage and machinery, increased in 1969. Haulage accidents at all work locations resulted in 45 deaths compared with 37 in 1968. There were 39 deaths from machinery accidents compared with 25 in 1968.

An estimated 9,360 nonfatal injuries during 1969 resulted in a frequency rate of 41.12 per million man-hours worked. This total was 225 more than in 1968, and the frequency rate was slightly higher than the 1968 rate of 40.89.

Owing primarily to the better fatality experience, the injury-severity rate for bituminous coal and lignite mines was lowered sharply to 7,207 days lost per million man-hours in 1969.

Anthracite Mines.—Fatality experience for Pennsylvania anthracite mines retrogressed in 1969. The 13 work deaths reported for the year occurred at the rate of 1.28 per million man-hours worked. Comparable data for 1968 were four fatalities at a frequency rate of 0.36 per million man-hours. Of the fatalities reported for 1969, seven occurred in underground workings, one was in the associated surface works of an underground mine, three were at strip mines, and two were at mechanical cleaning plants.

The total of 440 nonfatal work injuries at anthracite mines was 13 percent lower than the 1968 total of 504, and the frequency rate declined 5 percent to 43.32 in 1969 from 45.77 per million man-hours in 1968.

At anthracite mines, the injury-severity rate of 9,586 days lost per million man-hours in 1969 was more than double that of 1968 as a result of the worsened fatality record.

COKE OPERATIONS

Injury experience in the coking industry worsened appreciably in 1969. There were 15 fatal and 231 nonfatal injuries, respectively, eight and 27 more than in 1968. As a result, the frequency rate of all injuries increased to 6.39 per million man-hours, and the severity rate to 2,533 days lost per million man-hours (table 11).

Slot Ovens.—Fifteen fatalities, eight more than in the preceding year, and 216 nonfatal injuries, 32 more than in 1968, occurred at slot-oven plants in 1969. The resulting frequency rate of all injuries, 6.05 per million man-hours, was 18 percent higher than in 1968. Likewise, the severity rate retrogressed to 2,542 days lost per million man-hours, 36 percent higher than the 1968 rate.

Beehive Ovens.—Injury experience at beehive-oven plants was better than in 1968. There were no fatalities in either 1969 or 1968, and the total of 15 nonfatal injuries was five less than in 1968. Consequently, the injury-frequency rate declined 19 percent to 42.74, and the injury-severity rate declined 14 percent to 1,598.

OIL AND GAS OPERATIONS

The totals of 95 fatal and 9,023 nonfatal injuries in the oil and gas industries during 1969 were, respectively, seven and 46 less than in 1968 (table 10). However, there was a larger proportional decline in worktime to a total of 939 million man-hours in 1969. Consequently, the injury-frequency rate of 9.71 for all injuries was 5 percent higher than the 1968 rate of 9.29. The injury-severity rate, 983 days lost per million man-hours worked, was changed only slightly from the 1968 rate of 985.

PEAT

The safety record of the peat industry was better in 1969. There were no fatalities in either 1969 or 1968, and the eight nonfatal injuries matched the corresponding figure for 1968 (table 12). However, there was a moderate increase in worktime to a total of 831,000 man-hours in 1969. As a result, both the injury-frequency and injury-severity rates, respectively 9.62 and 184, was improved over similar rates for 1968.

NATIVE ASPHALT

Injury experience in the native asphalt industry (bituminous limestone, bituminous sandstone, and gilsonite operations) worsened in 1969. There were no fatalities in either 1969 or 1968, but the total of 36 nonfatal injuries was 13 more than in 1968 (table 13). Consequently, the injury-frequency rate increased 38 percent to 37.93 per million man-hours of exposure. The injury-severity rate, 733 days lost per million man-hours, was 9 percent higher than in 1968.

Table 1.—Worktime and injury experience at metal mines in the United States, by industry groups

Industry and year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rates per million man-hours	
					Fatal	Non-fatal	Frequency	Severity
Copper:								
1965	16,880	298	5,033	40,285	19	896	22.71	4,348
1966	16,278	317	5,164	41,323	23	976	24.18	4,856
1967	17,258	218	3,760	30,064	19	654	22.39	5,520
1968	15,492	267	4,168	33,461	18	601	18.50	4,146
1969 p	16,600	309	5,184	41,465	15	755	18.59	3,404
Gold-silver (lode-placer):								
1965	4,074	241	982	7,896	4	264	33.94	5,970
1966	3,847	236	907	7,254	10	305	43.42	9,846
1967	3,611	237	855	6,844	8	263	39.60	10,022
1968	3,681	221	824	6,610	10	320	49.93	12,433
1969 p	3,600	234	845	6,770	7	315	47.55	9,759
Iron:								
1965	14,439	273	3,942	31,752	5	510	16.22	1,727
1966	14,056	277	3,898	31,360	13	553	18.05	3,526
1967	12,772	282	3,600	28,859	11	478	16.94	2,846
1968	11,890	285	3,415	27,388	7	463	17.16	2,368
1969 p	11,500	271	3,141	25,195	6	435	17.54	2,182
Lead-zinc:								
1965	8,805	259	2,279	18,240	17	1,089	60.64	8,128
1966	8,692	261	2,273	18,212	15	1,096	61.00	8,108
1967	7,781	252	1,962	15,727	15	913	59.01	8,563
1968	7,518	258	1,973	15,749	13	897	57.78	7,459
1969 p	7,500	262	1,993	15,970	15	1,050	66.57	8,458
Uranium:								
1965	3,654	211	771	6,205	10	282	47.06	12,144
1966	3,604	204	735	5,945	7	210	36.50	8,845
1967	3,745	223	834	6,751	5	312	46.95	7,139
1968	4,552	219	1,024	8,564	6	312	37.13	5,426
1969 p	4,400	218	957	7,805	12	245	33.06	10,805
Miscellaneous:								
1965	3,568	277	987	7,898	3	251	32.16	3,467
1966	3,443	281	967	7,762	7	295	38.91	7,555
1967	3,329	283	943	7,549	8	261	35.64	8,455
1968	3,047	284	867	6,920	3	243	35.55	5,045
1969 p	2,900	292	842	6,765	7	310	46.84	7,555
Total: [1]								
1965	51,420	272	13,994	112,277	58	3,292	29.84	4,704
1966	49,920	279	13,944	111,857	75	3,435	31.38	5,736
1967	48,496	246	11,953	95,794	66	2,881	30.76	5,881
1968	46,180	263	12,271	98,693	57	2,836	29.31	4,910
1969 p	46,500	277	12,963	103,975	62	3,110	30.52	5,124

p Preliminary.
[1] Data may not add to totals shown because of rounding.

Table 2.—Worktime and injury experience at metal mills in the United States, by industry groups

Industry and year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries: Fatal	Number of injuries: Nonfatal	Injury rates per million man-hours: Frequency	Injury rates per million man-hours: Severity
Copper:								
1965	5,190	335	1,737	13,897	--	90	6.48	364
1966	5,369	344	1,847	14,765	--	75	5.08	394
1967	5,953	228	1,358	10,863	3	112	10.59	2,106
1968	5,612	286	1,621	12,969	1	135	10.49	894
1969 p	6,200	329	2,045	16,335	1	170	10.53	946
Gold-silver (lode-placer):								
1965	388	257	100	798	--	24	30.09	563
1966	406	287	117	934	1	31	34.26	8,479
1967	347	283	98	786	--	23	29.26	4,877
1968	225	304	68	547	--	4	7.31	6,633
1969 p	300	313	85	680	1	15	21.98	9,021
Iron:								
1965	6,334	288	1,823	14,651	1	121	8.33	718
1966	6,293	299	1,881	15,090	3	117	7.95	1,615
1967	6,137	305	1,875	15,032	1	149	9.98	1,049
1968	6,579	321	2,129	17,071	--	135	7.91	426
1969 p	7,200	304	2,177	17,440	2	150	8.72	962
Lead-zinc:								
1965	1,271	278	353	2,825	2	76	27.61	5,061
1966	1,449	268	389	3,104	--	77	24.81	2,290
1967	1,410	251	354	2,835	1	78	27.86	3,430
1968	1,230	265	340	2,725	--	92	33.77	2,316
1969 p	1,300	267	353	2,835	1	70	24.33	3,155
Uranium:								
1965	1,248	313	391	3,112	--	71	22.81	1,713
1966	1,420	297	422	3,398	--	69	20.31	1,291
1967	1,518	281	427	3,419	--	56	16.38	342
1968	1,626	302	491	3,977	1	38	9.81	1,627
1969 p	1,500	302	442	3,585	--	60	17.30	481
Miscellaneous:								
1965	5,053	331	1,671	13,373	--	90	6.73	221
1966	5,238	325	1,701	13,760	3	206	15.19	2,192
1967	5,563	315	1,752	14,015	2	169	12.20	1,176
1968	5,026	321	1,612	12,893	--	135	10.47	720
1969 p	5,900	298	1,757	13,920	1	155	11.21	1,092
Total: [1]								
1965	19,484	312	6,074	48,657	3	472	9.76	793
1966	20,175	315	6,357	51,050	7	575	11.40	1,563
1967	20,928	280	5,863	46,951	7	587	12.65	1,488
1968	20,298	306	6,262	50,182	2	539	10.78	888
1969 p	22,300	307	6,861	54,800	6	620	11.42	1,173

p Preliminary.
[1] Data may not add to totals shown because of rounding.

Table 3.—Worktime and injury experience at primary nonferrous reduction and refinery plants in the United States, by industry groups

Industry and year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries: Fatal	Number of injuries: Nonfatal	Injury rates per million man-hours: Frequency	Injury rates per million man-hours: Severity
Copper:								
1965	10,875	334	3,635	29,060	3	314	10.91	1,257
1966	10,411	335	3,486	27,779	5	362	13.21	1,673
1967	10,750	226	2,434	19,471	2	260	13.46	1,219
1968	10,293	291	2,993	23,909	1	338	14.18	991
1969 p	11,700	332	3,892	31,030	4	470	15.28	1,627
Lead:								
1965	2,326	301	701	5,608	1	74	13.37	2,897
1966	2,508	317	795	6,360	3	105	16.98	3,392
1967	2,031	289	587	4,679	--	110	23.51	1,546
1968	2,366	293	693	5,543	1	126	22.91	2,434
1969 p	2,600	343	894	7,150	2	195	27.68	2,668
Zinc:								
1965	7,128	340	2,426	18,971	4	284	15.18	1,897
1966	7,086	330	2,337	18,432	1	338	18.39	895
1967	7,280	316	2,304	18,426	5	289	15.96	2,493
1968	6,715	334	2,246	17,972	--	335	18.64	742
1969 p	6,500	357	2,319	18,555	6	385	21.13	2,675
Aluminum:								
1965	19,582	343	6,712	52,048	3	278	5.40	629
1966	18,372	348	6,393	50,986	--	228	4.47	368
1967	20,508	347	7,107	56,854	1	245	4.33	439
1968	20,059	346	6,937	55,805	2	324	5.84	468
1969 p	22,200	352	7,805	62,455	3	465	7.53	660
Miscellaneous:								
1965	1,716	283	485	3,880	1	21	5.67	1,795
1966	2,024	351	711	5,699	--	34	5.97	763
1967	2,477	307	761	6,081	1	33	5.59	1,093
1968	2,096	344	720	5,783	--	32	5.53	421
1969 p	2,200	346	773	6,155	--	45	7.64	254
Total: [1]								
1965	41,627	335	13,959	109,567	12	971	8.97	1,173
1966	40,401	340	13,722	109,257	9	1,067	9.85	985
1967	43,046	307	13,194	105,511	9	937	8.97	1,029
1968	41,529	327	13,590	109,012	4	1,155	10.63	725
1969 p	45,200	347	15,683	125,350	15	1,565	12.61	1,293

p Preliminary.
[1] Data may not add to totals shown because of rounding.

Table 4.—Worktime and injury experience at nonmetal (except stone) mines in the United States, by industry groups

Industry and year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries: Fatal	Number of injuries: Nonfatal	Injury rates per million man-hours: Frequency	Injury rates per million man-hours: Severity
Clay-shale:								
1965	5,544	220	1,217	9,877	4	291	29.87	4,034
1966	5,776	219	1,266	10,316	2	281	27.43	2,147
1967	5,213	227	1,182	9,607	2	247	25.92	1,967
1968	4,785	218	1,044	8,496	1	175	20.72	1,956
1969 p	4,600	210	978	7,985	4	200	25.68	3,881
Gypsum:								
1965	970	255	247	2,001	2	19	10.49	6,439
1966	935	244	228	1,848	--	23	12.45	3,743
1967	891	249	222	1,799	1	12	7.23	3,628
1968	898	254	228	1,839	1	19	10.88	3,518
1969 p	900	259	235	1,900	--	20	11.06	517
Phosphate rock:								
1965	2,507	294	738	5,962	2	122	20.80	2,460
1966	3,183	302	960	7,791	5	161	21.31	4,329
1967	3,181	272	865	6,991	3	160	23.32	3,554
1968	2,822	273	771	6,249	2	163	26.40	2,654
1969 p	2,600	283	734	5,965	3	70	11.90	3,708
Potash:								
1965	1,753	357	625	5,004	1	192	38.57	4,334
1966	1,934	357	690	5,516	4	209	38.61	5,663
1967	1,913	328	627	5,017	3	163	33.09	4,713
1968	1,630	326	531	4,245	2	157	37.45	3,495
1969 p	1,400	346	495	3,960	4	130	33.84	7,328
Salt:								
1965	1,638	279	457	3,745	3	97	26.70	7,103
1966	1,809	279	504	4,104	2	90	22.42	4,371
1967	1,768	266	470	3,892	2	168	43.68	4,318
1968	1,762	276	486	3,961	24	175	50.23	39,168
1969 p	1,700	280	496	4,070	2	170	42.23	5,688
Sulfur:								
1965	1,371	363	497	4,466	2	55	12.76	3,073
1966	1,491	360	537	4,632	--	54	11.66	1,985
1967	1,640	365	598	4,783	2	54	11.71	2,873
1968	1,672	347	581	5,117	--	86	16.81	904
1969 p	2,000	322	642	5,170	--	95	18.37	976
Miscellaneous:								
1965	3,431	242	831	6,706	7	213	32.81	9,127
1966	3,599	234	841	6,796	3	240	35.76	3,810
1967	3,414	235	801	6,461	4	222	34.98	4,709
1968	3,061	232	711	5,725	6	178	32.14	7,268
1969 p	3,200	232	738	5,965	4	200	34.36	4,963
Total: [1]								
1965	17,214	268	4,612	37,760	21	989	26.75	5,048
1966	18,727	268	5,027	41,003	16	1,058	26.19	3,586
1967	18,020	264	4,765	38,550	17	1,026	27.06	3,499
1968	16,630	262	4,352	35,633	36	953	27.76	7,182
1969 p	16,400	261	4,318	35,020	17	885	25.79	4,024

p Preliminary.
[1] Data may not add to totals shown because of rounding.

Table 5.—Worktime and injury experience at nonmetal (except stone) mills in the United States, by industry groups

Industry and year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rates per million man-hours	
					Fatal	Non-fatal	Frequency	Severity
Clay-shale:								
1965	14,136	264	3,738	30,116	5	890	29.72	2,047
1966	15,603	270	4,214	34,028	3	1,020	30.06	2,101
1967	15,874	256	4,068	32,742	6	1,007	30.94	2,172
1968	14,764	265	3,929	31,576	2	954	30.28	1,506
1969 p	13,200	268	3,555	28,545	6	860	30.41	2,427
Gypsum: [1]								
1965	2,890	283	817	6,557	--	25	3.81	588
1966	2,589	269	696	5,557	1	21	3.96	1,721
1967	2,094	265	555	4,473	--	15	3.35	163
1968	1,638	269	441	3,613	--	21	5.81	275
1969 p	1,700	268	464	3,825	1	30	7.84	2,021
Phosphate rock:								
1965	2,476	312	773	6,198	4	54	9.36	5,194
1966	1,948	335	653	5,237	3	60	12.03	3,821
1967	2,042	297	607	4,854	1	55	11.54	3,420
1968	1,632	303	495	3,964	--	51	12.87	600
1969 p	1,600	306	495	3,985	1	30	7.28	1,726
Potash:								
1965	1,126	357	402	3,214	--	72	22.40	1,959
1966	1,030	360	371	2,967	--	47	15.84	2,028
1967	992	347	344	2,751	2	49	18.54	4,921
1968	647	309	203	1,625	--	42	25.85	702
1969 p	600	351	224	1,790	--	25	13.98	322
Salt:								
1965	3,909	284	1,109	8,967	--	154	17.17	867
1966	3,814	292	1,112	8,898	2	162	18.43	1,787
1967	3,704	283	1,047	8,393	--	156	18.59	448
1968	3,396	279	947	7,619	--	170	22.31	535
1969 p	3,500	276	970	7,795	--	215	27.71	466
Sulfur:								
1965	10	305	3	24	--	2	81.97	82
1966	2	300	1	5	--	-----	-----	------
1967	1	250	(2)	2	--	1	500.00	12,500
1968	-----	---	-----	-----	--	-----	-----	------
1969 p	-----	---	-----	-----	--	-----	-----	------
Miscellaneous:								
1965	6,668	296	1,976	15,898	1	286	18.05	1,840
1966	7,015	286	2,006	16,118	2	254	15.88	1,541
1967	6,720	289	1,944	15,635	4	242	15.73	2,232
1968	6,869	279	1,915	15,385	1	281	18.33	1,259
1969 p	7,200	290	2,091	16,805	2	315	18.92	1,584
Total: [3]								
1965	31,215	283	8,819	70,975	10	1,483	21.04	1,987
1966	32,001	283	9,052	72,810	11	1,564	21.63	2,030
1967	31,427	273	8,565	68,850	13	1,525	22.34	2,043
1968	28,946	273	7,930	63,781	3	1,519	23.86	1,184
1969 p	27,900	279	7,800	62,745	10	1,475	23.68	1,828

p Preliminary.
[1] Beginning with 1965, includes data on certain mills not reported in prior years.
[2] Less than ½ unit.
[3] Data may not add to totals shown because of rounding.

Table 6.—Worktime and injury experience at stone quarries and mills in the United States, by industry groups

Industry and year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Frequency	Severity
Cement: [1]								
1965	22,947	319	7,322	58,563	10	331	5.82	1,399
1966	22,611	326	7,381	59,044	6	359	6.18	1,245
1967	22,073	317	7,008	56,119	4	347	6.25	1,140
1968	21,942	320	7,025	56,218	10	380	6.94	1,568
1969 p	22,300	318	7,088	55,840	8	350	6.45	1,429
Granite:								
1965	8,956	243	2,176	18,284	6	409	22.70	2,966
1966	8,141	246	2,005	16,756	2	412	24.71	3,069
1967	7,853	249	1,958	16,351	3	401	24.71	2,296
1968	7,980	246	1,962	16,514	4	384	23.50	3,155
1969 p	7,200	253	1,828	15,595	5	395	25.78	3,287
Lime: [1]								
1965	7,671	291	2,234	17,958	4	282	15.93	1,808
1966	7,467	299	2,236	18,039	6	345	19.46	3,269
1967	7,764	282	2,190	17,583	5	285	16.49	2,417
1968	7,527	283	2,134	17,210	5	258	15.28	2,108
1969 p	7,800	292	2,281	18,215	3	355	19.60	1,962
Limestone:								
1965	32,872	240	7,904	67,038	21	1,448	21.91	3,182
1966	30,380	245	7,434	63,422	30	1,542	24.79	4,385
1967	31,145	245	7,619	64,907	26	1,429	22.42	3,327
1968	30,726	248	7,621	65,130	29	1,442	22.59	3,533
1969 p	31,100	251	7,804	67,445	31	1,490	22.58	3,800
Marble:								
1965	2,534	249	631	5,165	2	181	35.43	3,303
1966	2,953	255	753	6,178	1	213	34.64	2,523
1967	2,894	251	725	6,080	--	189	31.09	1,115
1968	2,806	246	691	5,782	--	174	30.09	2,134
1969 p	2,400	250	602	5,125	2	160	31.42	4,418
Sandstone:								
1965	5,745	227	1,305	10,696	4	278	26.36	3,192
1966	5,447	240	1,308	10,895	3	314	29.10	2,739
1967	5,012	241	1,209	10,047	--	242	24.09	622
1968	5,147	232	1,194	9,858	6	237	24.65	4,403
1969 p	4,800	247	1,177	9,760	2	245	25.31	2,250
Slate:								
1965	1,232	262	322	2,630	--	84	31.93	723
1966	1,376	266	366	2,975	1	79	26.89	2,762
1967	1,423	260	371	3,024	3	100	34.06	6,611
1968	1,380	261	360	2,907	--	91	31.30	573
1969 p	1,200	250	291	2,400	--	75	30.83	480
Traprock:								
1965	5,530	213	1,180	9,855	1	215	21.92	1,166
1966	5,562	221	1,231	10,263	1	241	23.58	1,975
1967	4,794	224	1,075	8,940	4	210	23.94	3,281
1968	4,535	242	1,096	9,083	2	218	24.22	2,735
1969 p	4,600	243	1,106	9,255	2	230	25.07	2,120
Miscellaneous:								
1965	2,093	220	460	3,811	--	77	20.21	1,416
1966	1,889	211	398	3,216	1	78	24.56	2,528
1967	1,807	217	393	3,176	1	64	20.47	2,333
1968	2,041	227	462	3,918	2	76	19.91	3,794
1969 p	1,800	223	406	3,350	--	85	25.69	1,224
Total: [2]								
1965	89,580	263	23,535	194,000	48	3,305	17.28	2,330
1966	85,826	269	23,113	190,787	51	3,583	19.05	2,852
1967	84,765	266	22,548	186,227	46	3,267	17.79	2,308
1968	84,084	268	22,543	186,620	58	3,260	17.78	2,700
1969 p	83,100	272	22,583	186,980	53	3,390	18.41	2,635

p Preliminary.
[1] Includes burning or calcining and other mill operations.
[2] Data may not add to totals shown because of rounding.

Table 7.—Worktime and injury experience at sand and gravel plants in the United States

Year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries: Fatal	Number of injuries: Nonfatal	Injury rates per million man-hours: Frequency	Injury rates per million man-hours: Severity
1965	54,159	221	11,947	100,083	40	1,870	19.08	3,214
1966	55,344	225	12,459	104,971	35	2,098	20.32	2,901
1967	52,363	216	11,296	96,645	32	1,919	20.19	2,933
1968	49,901	219	10,930	93,156	26	1,992	21.66	2,688
1969 p	50,100	219	10,961	94,195	31	1,930	20.82	3,025

p Preliminary.

Table 8.—Worktime and injury experience at slag (iron-blast-furnace) plants in the United States

Year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries: Fatal	Number of injuries: Nonfatal	Injury rates per million man-hours: Frequency	Injury rates per million man-hours: Severity
1965	1,537	277	425	3,415	1	50	14.93	3,173
1966	1,472	277	407	3,332	--	44	13.20	709
1967	1,721	255	439	3,539	3	53	15.82	5,762
1968	1,724	263	454	3,697	1	57	15.69	2,454
1969	1,610	271	442	3,573	3	49	14.55	6,061

Table 9.—Worktime and injury experience at coal mines in the United States, by industry groups

Industry and year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries: Fatal	Number of injuries: Nonfatal	Injury rates per million man-hours: Frequency	Injury rates per million man-hours: Severity
Bituminous coal and lignite mines:								
1965	137,602	213	29,242	232,613	251	10,071	44.37	9,243
1966	135,952	213	28,928	230,087	227	9,617	42.78	7,900
1967	131,562	220	28,910	229,415	213	9,506	42.36	7,817
1968	127,535	221	28,144	223,406	307	9,135	42.26	10,825
1969 p	128,300	224	28,754	227,625	190	9,360	41.95	7,207
Anthracite mines:								
1965	11,132	204	2,271	16,375	8	1,067	65.65	4,936
1966	9,292	203	1,883	13,672	6	829	61.07	4,477
1967	7,750	219	1,701	12,359	9	609	50.00	5,511
1968	6,932	217	1,508	11,011	4	504	46.13	4,182
1969 p	6,300	221	1,399	10,156	13	440	44.60	9,586
Total: [1]								
1965	148,734	212	31,513	248,988	259	11,138	45.77	8,960
1966	145,244	212	30,811	243,759	233	10,446	43.81	7,708
1967	139,312	220	30,611	241,774	222	10,115	42.75	7,699
1968	134,467	221	29,651	234,417	311	9,639	42.45	10,513
1969 p	134,700	224	30,153	237,781	203	9,800	42.07	7,309

p Preliminary.
[1] Data may not add to totals shown because of rounding.

Table 10.—Worktime and injury experience of the oil industry (all activities) and the natural gas industry (excluding distribution activities) in the United States

Year	Average men working daily	Man-hours worked (thousands)	Number of injuries: Fatal	Number of injuries: Nonfatal	Injury rates per million man-hours: Frequency	Injury rates per million man-hours: Severity
1965	436,935	931,645	78	8,963	9.70	934
1966	451,747	954,527	103	8,724	9.25	1,050
1967	445,562	938,946	88	8,776	9.44	981
1968	466,652	986,952	102	9,069	9.29	985
1969	449,606	939,385	95	9,023	9.71	983

Table 11.—Worktime and injury experience at coke ovens in the United States, by industry groups

Industry and year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries: Fatal	Number of injuries: Nonfatal	Injury rates per million man-hours: Frequency	Injury rates per million man-hours: Severity
Slot ovens:								
1965	14,003	357	4,998	39,984	7	192	4.98	1,816
1966	13,745	363	4,983	39,909	3	155	3.96	658
1967	13,409	360	4,821	38,583	5	201	5.34	963
1968	12,877	361	4,645	37,167	7	184	5.14	1,876
1969	13,418	356	4,779	38,169	15	216	6.05	2,542
Beehive ovens:								
1965	518	222	115	885	--	36	40.68	1,318
1966	471	236	111	821	--	36	43.82	1,048
1967	292	179	52	374	4	25	77.61	67,561
1968	216	233	50	378	--	20	52.85	1,855
1969	199	226	45	351	--	15	42.74	1,598
Total: [1]								
1965	14,521	352	5,113	40,869	7	228	5.75	1,805
1966	14,216	358	5,094	40,730	3	191	4.76	666
1967	13,701	356	4,873	38,956	9	226	6.03	1,602
1968	13,093	359	4,696	37,546	7	204	5.62	1,875
1969	13,617	354	4,824	38,520	15	231	6.39	2,533

[1] Data may not add to totals shown because of rounding.

Table 12.—Worktime and injury experience in the peat industry in the United States

Year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries: Fatal	Number of injuries: Nonfatal	Injury rates per million man-hours: Frequency	Injury rates per million man-hours: Severity
1965	623	150	94	784	--	13	16.57	593
1966	523	184	96	804	--	10	12.44	373
1967	506	187	95	785	--	15	19.11	733
1968	533	186	99	798	--	8	10.02	244
1969	567	172	98	831	--	8	9.62	184

Table 13.—Worktime and injury experience in the native-asphalt industry (bituminous limestone, bituminous sandstone, and gilsonite mines and mills) in the United States

Year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries: Fatal	Number of injuries: Nonfatal	Injury rates per million man-hours: Frequency	Injury rates per million man-hours: Severity
1965	427	253	108	874	1	26	30.90	8,335
1966	368	270	99	806	1	28	35.98	7,872
1967	393	255	100	821	--	33	40.21	2,985
1968	399	259	103	837	--	23	27.49	672
1969	445	262	117	949	--	36	37.93	733

Abrasive Materials

By J. Robert Wells [1]

Domestic production of natural abrasive materials in 1969, as indicated by the quantities of these commodities sold or used by producers, was slightly lower than the record output of 1968. Total tonnage was less by about 2 percent, and total value was down 4 percent. Although tripoli and abrasive garnet output declined, tripoli accounted for almost three-fourths of the total tonnage of the natural abrasives sold or used, and garnet provided more than half of the reported total value.

The 1969 output of abrasive-grade artificial alumina in the United States and Canada was substantially greater than that of 1968, but there was almost no change in the figure for crude silicon carbide. Tonnage of shipments of metallic abrasives from U.S. plants, after increasing in all but two of the last 10 years, reached the highest total yet recorded. For all three of these artificial abrasives taken together, both the total tonnage and the total value were greater than the comparable figures in any previous year.

Table 1.—Salient abrasive statistics in the United States

Kind	1965	1966	1967	1968	1969
Natural abrasives (domestic) sold or used by producers:					
Tripoli____short tons__	71,138	66,163	70,984	85,534	84,673
Value____thousands__	$381	$328	$377	$796	$734
Special silica-stone products [1] short tons__	3,603	3,806	2,701	3,141	3,311
Value____thousands__	$432	$515	$574	$629	$600
Garnet____short tons__	19,330	21,952	20,494	22,136	20,458
Value____thousands__	$1,717	$2,092	$1,849	$1,922	$1,874
Emery____short tons__	10,720	11,102	W	W	W
Value____thousands__	$204	$210	W	W	W
Artificial abrasives [2]____short tons__	524,305	607,508	552,812	567,814	608,622
Value____thousands__	$73,102	$82,794	$80,405	$86,316	$92,589
Foreign trade (natural and artificial abrasives):					
Exports (value)____thousands__	$50,418	$51,753	$50,896	$60,266	$70,687
Reexports (value)____do____	$13,750	$13,143	$17,239	$19,807	$20,373
Imports for consumption (value) do____	$89,332	$110,650	$100,427	$103,150	$100,748

W Withheld to avoid disclosing individual company confidential data.
[1] Includes grinding pebbles, grindstones, oilstones, tube-mill liners, and whetstones.
[2] Production of silicon carbide and aluminum oxide (United States and Canada); shipments of metallic abrasives (United States).

Foreign Trade.—The United States has long been substantially a net importer of abrasive materials, and it is worthy of mention that, even though that pattern persisted in 1969, the totals for exports and imports of those substances came much nearer to a balance than at any time in the last two decades. In the case of industrial diamond—in terms of dollars the largest single item of abrasives foreign trade—the total value of imports was 12 percent less than that in 1968 and only about 20 percent more than the combined values of 1969 exports and reexports. The corresponding disparity in 1968 was 60 percent, while as recently as 1967, the figure for imports was well over twice that for exports plus reexports.

[1] Physical scientist, Bureau of Mines, Knoxville, Tenn.

Table 2.—U.S. exports of abrasive materials, by kinds

(Thousands)

Kind	1968		1969	
	Quantity	Value	Quantity	Value
NATURAL ABRASIVES				
Dust and powder of precious or semiprecious stones, including diamond dust and powder.......carats..	6,015	$16,616	8,122	$21,599
Crushing bort............do....	26	168	45	265
Industrial diamond............do....	300	1,153	345	1,634
Emery, natural corundum, and other natural abrasives, n.e.c............pounds..	40,431	2,569	31,792	2,832
MANUFACTURED ABRASIVES				
Artificial corundum (fused aluminum oxide)...do....	r 31,431	6,311	34,004	6,775
Silicon carbide, crude or in grains............do....	14,166	2,706	12,556	2,487
Carbide abrasives, n.e.c............do....	4,933	2,802	3,026	5,434
Grinding and polishing wheels and stones:				
Diamond............carats..	594	3,010	699	3,561
Pulpstones............pounds..	2,199	682	2,460	692
Hand polishing stones, whetstones, oilstones, hones, and similar stones............do....	737	850	915	1,227
Wheels and stones, n.e.c............do....	5,131	7,404	4,774	7,633
Abrasive paper and cloth, coated with natural or artificial abrasive materials............reams..	301	8,973	300	8,521
Coated abrasives, n.e.c............	NA	1,719	NA	2,307
Metallic abrasives............pounds..	53,402	5,303	62,146	5,720
Total............	XX	60,266	XX	70,687

r Revised. NA Not available. XX Not applicable.

Table 3.—U.S. reexports of abrasive materials, by kinds

(Thousands)

Kind	1968		1969	
	Quantity	Value	Quantity	Value
NATURAL ABRASIVES				
Dust and powder of precious or semiprecious stones, including diamond dust and powder.......carats..	198	$497	148	$391
Crushing bort............do....	316	2,008	350	2,238
Industrial diamond............do....	3,018	17,242	2,704	17,503
Emery, natural corundum, and other natural abrasives, n.e.c............pounds..	24	5	200	42
MANUFACTURED ABRASIVES				
Carbide abrasives, n.e.c............do....	------	------	20	79
Grinding and polishing wheels and stones:				
Diamond............carats..	1	9	1	3
Wheels and stones, n.e.c............pounds..	2	3	6	11
Hand polishing stones, whetstones, oilstones, hones and similar stones............do....	2	1	------	------
Abrasive paper and cloth, coated with natural or artificial abrasive materials............reams..	(1)	7	(1)	2
Coated abrasives, n.e.c............	NA	31	NA	72
Metallic abrasives............pounds..	5	4	91	32
Total............	XX	19,807	XX	20,373

NA Not available. XX Not applicable.

[1] Less than ½ unit.

Table 4.—U.S. imports for consumption of abrasive materials (natural and artificial), by kinds

(Thousands)

Kind	1968 Quantity	1968 Value	1969 Quantity	1969 Value
Corundum, crude or crushed short tons	6	$113	------	------
Emery, flint, rottenstone, and tripoli, crude or crushed short tons	32	707	21	$766
Silicon carbide, crude do	106	14,249	109	14,648
Aluminum oxide, crude do	149	17,085	169	21,086
Other crude artificial abrasives do	4	322	(1)	7
Abrasives, ground, grains, pulverized or refined:				
Silicon carbide short tons	2	717	2	711
Aluminum oxide do	8	1,966	5	1,200
Emery, corundum, flint, garnet, and other, including artificial abrasives short tons	1	133	2	685
Papers, cloths, and other materials wholly or partly coated with natural or artificial abrasives	(2)	5,764	(2)	6,255
Hones, whetstones, oilstones, and polishing stones number	376	73	285	67
Abrasive wheels and millstones:				
Burrstones, manufactured or bound up into millstones short tons	(1)	4	(1)	6
Solid natural stone wheels number	1	9	4	16
Diamond do	58	308	72	488
Other	(2)	789	(2)	1,105
Articles not especially provided for:				
Emery or garnet	(2)	26	(2)	13
Natural corundum or artificial abrasive materials	(2)	176	(2)	206
Other	(2)	47	(2)	88
Grit, shot, and sand of iron and steel short tons	1	121	3	380
Diamonds:				
Diamond dies number	9	239	10	200
Crushing bort carats	r 697	r 1,568	357	918
Other industrial diamond do	r 4,264	r 36,957	4,731	29,797
Miners' diamond do	r 900	r 4,907	783	4,363
Dust and powder do	r 7,825	r 16,870	8,205	17,743
Total	XX	r 103,150	XX	100,748

r Revised. XX Not applicable.
1 Less than ½ unit.
2 Quantity not reported.

TRIPOLI

Tripoli from Arkansas and Oklahoma, amorphous or soft silica from Illinois, rottenstone from Pennsylvania are all fine-grained, porous silica materials that are so essentially similar in composition and uses that it is customary to discuss them, without distinction, as a group. The quantity of processed tripoli and related materials used in 1969 for abrasive purposes amounted to about 70 percent of the total production, while filler uses accounted for 20 percent.

Tripoli producers in 1969 were Malvern Minerals Co., Industrial Minerals, Inc., and Hercules Minerals Co., operating in Garland, Polk, and Pike Counties, Ark., respectively; Tammco, Inc., and Illinois Minerals Co., both in Alexander County, Ill.; The Carborundum Co. in Newton County, Mo., and Ottawa County, Okla.; Keystone Filler & Manufacturing Co. and Penn Paint & Filler Co., both in Lycoming, Pa. In the four States producing tripoli in 1969, output increased in Illinois and Pennsylvania and declined in Arkansas and Oklahoma.

Prices quoted in Engineering and Mining Journal, December 1969, for tripoli and amorphous silica were as follows:

Tripoli, paper bags, 40-ton carloads, f.o.b. Elco, Ill., air-floated, through 200 mesh, cents per pound	11/4
Silica, amorphous, 50-lb paper bags, carloads, dollars per short ton:	
90–95 percent through 200 mesh	25
96–99 percent through 200 mesh	27
90–95 percent through 325 mesh	29
96–98 percent through 325 mesh	29
98–99.4 percent through 325 mesh	30
99.5 percent through 325 mesh	42
99.9 percent through 400 mesh	63
99 percent below 15 microns	69
99 percent below 10 microns	89

Table 5.—Processed tripoli [1] sold or used by producers in the United States, by uses [2]

Kind		1965	1966	1967	1968	1969
Abrasives	short tons	48,935	45,785	44,961	52,837	50,337
Value	thousands	$2,025	$1,880	$1,916	$2,201	$2,013
Filler	short tons	11,011	10,581	11,240	13,418	14,352
Value	thousands	$296	$285	$354	$388	$413
Other	short tons	4,830	4,491	4,797	5,203	5,487
Value	thousands	$142	$133	$143	$149	$157
Total	short tons	64,776	60,857	60,998	71,458	70,176
Value [3]	thousands	$2,463	$2,298	$2,413	$2,737	$2,584

[1] Includes amorphous silica and Pennsylvania rottenstone.
[2] Partly estimated.
[3] Data may not add to total shown because of independent rounding.

SPECIAL SILICA STONE PRODUCTS

Special silica-stone products sold or used by producers in 1969 included oilstones from Arkansas, whetstones from Indiana, grinding pebbles from Minnesota and Wisconsin, grindstones from Ohio, and tube-mill liners from Minnesota. No domestic production of millstones has been reported since 1963. The total tonnage of silica-stone products sold or used increased by 5 percent in 1969, but chiefly because of lower per-ton values for Arkansas oilstones and for Minnesota grinding pebbles, there was a net decrease of 5 percent in the corresponding total value.

Novaculite for oilstones was produced in 1969 by Arkansas Oilstones Co., Inc., John O. Glassford, Cleve Milroy, M. V. Smith, Norton Pike Division of Norton Co., and Hiram A. Smith Whetstone Co., all from operations in Garland County, Ark.; whetstones by Hindostan Whetstone Co., Orange County, Ind., grinding pebbles and tube-mill liners by The Jasper Stone Co., Rock County, Minn.; grinding pebbles by Baraboo Quartizite Co., Inc., Sauk County, Wis.; and grindstones by Cleveland Quarries Co., operating the Amherst quarry in Lorain County, Ohio.

Table 6.—Special silica-stone products sold or used by producers in the United States [1]

Year	Short tons	Value (thousands)
1965	3,603	$432
1966	3,806	515
1967	2,701	574
1968	3,141	629
1969	3,311	600

[1] Includes grinding pebbles, grindstones, oilstones, tube-mill liners, and whetstones.

A journal article provided an illustrated account of the operations of a leading producer of grinding media and mill liners. The author described some of the handcraft stone-cutting procedures that are still required in an automated age to prepare these speciality products to serve the needs of industry.[2]

NATURAL SILICATE ABRASIVES

Garnet.—The quantity and value of abrasive-grade garnet sold or used in 1969 by domestic producers was less than in 1968. Abrasive garnet was produced in 1969 in two States, New York and Idaho, each with two active producers. Barton Mines Corp., the largest producer, extracted garnet from extensive deposits in Warren County, N.Y. The material was crushed and sized for use in coated abrasives for metal lapping and for grinding and polishing glass. Interpace Corp., taking over operations of Cabot Corp. in Essex County, N.Y., recovered garnet as a byproduct from the treatment of wollastonite ore. The Idaho Garnet Abrasive Co. and the Emerald Creek Garnet Milling Co., both working on placer deposits in Benewah County, Idaho, extracted abrasive-grade garnet. Both the Idaho and the Essex County, N.Y., materials were mostly used as sand-blast abrasive. An informative article was published describing the installations and operations of the larger of the two Idaho producers of the mineral.[3]

[2] Herod, Buren C. Jasper Stone Company. Pit and Quarry, v. 62, No. 1, July 1969, pp. 74–79.
[3] Trauffer, Walter E. Idaho Garnet Abrasive Co. is Leading Producer of Rare Material. Pit and Quarry, v. 61, No. 8, February 1969, pp. 132–136.

Table 7.—Abrasive garnet sold or used by producers in the United States

Year	Short tons	Value (thousands)
1965	19,330	$1,717
1966	21,952	2,092
1967	20,494	1,849
1968	22,136	1,922
1969	20,458	1,874

Staurolite.—Commercial production of staurolite, a complex iron and aluminum silicate used mostly as a sand-blast abrasive, was reported by E. I. du Pont de Nemours in Clay County, Fla. The "Minor Nonmetals" chapter of the Minerals Yearbook contains additional information concerning this material, but actual production figures are withheld to avoid disclosure of individual company confidential data.

NATURAL ALUMINA ABRASIVES

Corundum.—There has been no substantial production of abrasive-grade corundum from domestic mines since the early 1900's, and the imposition of economic sanctions by the United Nations in 1968 put a stop to imports from Southern Rhodesia, the customary source of supply. A small quantity of corundum of unspecified origin was imported in 1969 from France, but U.S. consumers mostly depended upon accumulated stocks or switched to alternate abrasives.

Table 8.—World production of corundum, by countries

(Short tons)

Country	1967	1968	1969 p
India	337	359	e 360
Rhodesia, Southern	e 4,600	NA	NA
South Africa, Republic of	351	282	e 240
U.S.S.R. e	5,500	6,600	6,600
Total [1]	10,788	7,241	7,200

e Estimate. p Preliminary. NA Not available.
[1] Totals are of listed figures only.

The December 1969 issue of Engineering and Mining Journal quoted the following prices for crude corundum in carload lots, c.i.f., U.S. ports, per short ton: crystal $120–$130; boulder $70–$75. These prices were unchanged from the quotations of December 1968.

In 1969, the Office of Emergency Preparedness (OEP) dropped corundum from the list of strategic and critical materials for stockpiling. As of June 30, 1969, corundum in the amount of 1,964 short tons remained on Government inventory, pending Congressional approval of a plan for its sale that had been submitted in the closing days of December 1968 by the Stockpile Disposal Division of the General Services Administration (GSA).

Emery.—Domestic production of emery in 1969 was confined, as it has been for many years, to mines in Westchester County, N.Y., where for the second consecutive year only two firms were active. De Luca Emery Mine, Inc., operating its No. 2 mine near Peekskill, produced material to be processed into aggregate for heavy-duty, nonslip floors and pavements. The Di Rubbo American Emery Co. produced emery from the Kingston mine at Croton-on-Hudson for general abrasive purposes. The combined output of the two firms, compared with the total in 1968, was less in quantity and total value.

Table 9.—Emery sold or used by producers in the United States

Year	Short tons	Value (thousands)
1963	6,732	$119
1964	9,214	172
1965	10,720	204
1966	11,102	210
1967–69	W	W

W Withheld to avoid disclosing individual company confidential data.

An article by three Bureau of Mines authors described the occurrence of emery in Oregon—a mineral hitherto unreported in that State.[4]

[4] White, Jack C., Jerry J. Gray, and Joseph W. Town. Emery and Emerylike Rocks of the West-Central Cascade Range, Oregon. The Ore Bin (State of Oregon Department of Geology and Mineral Industries, Portland, Oreg.), v. 30, No. 11, November 1968, pp. 213–223.

INDUSTRIAL DIAMOND

There is no source of natural industrial diamond in the United States, but domestic production of synthetic industrial diamond material in 1969 amounted to approximately 13 million carats. Secondary production (salvage from used diamond tools and diamond-containing wastes) provided an additional 3 million carats. Industrial diamond imports declined in value for the third consecutive year.

As a followup to the designation by OEP of approximately 17.9 million carats of crushing bort as surplus, a conference was held in Washington, D.C., on February 12, 1969. The stated purpose was to obtain the views of representatives of interested Governmental agencies and private industrial organizations concerning the plan that had been proposed by the Property Management and Disposal Service of GSA for the eventual sale of this material. The stockpile objective for industrial diamond stones, established at 16.5 million carats on April 17, 1964, was revised upward on December 3, 1969, to 20.0 million carats.

Table 10.—U.S. imports for consumption of industrial diamond (excluding diamond dies)
(Thousand carats and thousand dollars)

Year	Quantity	Value
1967	17,112	$63,576
1968 r	13,686	60,302
1969	14,076	52,821

r Revised.

WORLD REVIEW

Interest in the subject of industrial diamond was increasingly an object of attention among both governmental agencies and private industrial organizations around the world. In addition to the growing volume of production of natural industrial diamond from a large number of mining operations on four continents, there was also a notable expansion of the output of synthetic diamond from facilities in the United States, Ireland, Sweden, Republic of South Africa, Japan, and the U.S.S.R.

Angola.—In a move to further the national economy the Portuguese Government awarded a dimond mining concession for two tracts totaling about 26,000 square kilometers to Diversa-International de Exploração de Diamantes, S.A.R.L. It was stated that the company has the financial and technical support of the U.S. company Diversa, Inc. The granting of mining rights on an additional 50,000 square kilometers, comprising both onshore and offshore areas, was expected to follow shortly.

Australia.—Many geologists and mining men believe that this nation may possibly develop a dimond industry comparable to that of the Republic of South Africa. Diamonds have been found in every State, especially in New South Wales, but the diamonds are alluvial, and their ultimate sources have not been discovered. The search is currently centered in the Kimberley Mountains of Western Australia, a region of abundant and potentially diamond-bearing volcanic pipes strikingly similar to those of the classical diamond-rich areas of Africa.

Botswana.—Officials of De Beers Consolidated Mines Ltd. announced that 12 years of intensive exploration has enabled the firm's geologists to close in on at least two diamondiferous kimberlite formations in the Lethlakane area of central Botswana. Preliminary drilling revealed the presence of diamonds in paying quantities and predominantly of industrial grade to a depth of at least 20 feet. Eventual expenditure of up to $20 million in additional exploration and in mine development is considered likely.

Brazil.—Total diamond production in 1969, all from alluvial gravels, was rumored to be as high as 600,000 carats, of which 60 percent probably was gem-grade crystal. The remainder consisted predominantly of first-quality industrial stones. Bort-grade material is found only as the exception in Brazil.

Canada.—A thesis presented at the University of Western Ontario summarized the results of a number of years of effort—unsuccessful thus far in regard to the principal object—to determine the sources that have produced sporadic discoveries of glacially transported diamonds in the Great Lakes area. The author suggested factors that may have thwarted this search in the past and proposed possible lines of attack on the problem that may be useful in the future.[5]

[5] Canadian Mining Journal. Provenance of Diamonds in the Glacial Drift of the Great Lakes Region, North America. V. 90, No. 5, May 1969, p. 101 (book review).

Table 11.—U.S. imports for consumption of industrial diamond, by countries

(Thousand carats and thousand dollars)

Country	Crushing bort (including all types of bort suitable for crushing)				Other industrial diamond (including glazers' and engravers' diamond, unset)				Miners' diamond				Powder and dust			
	1968		1969		1968		1969		1968		1969		1968		1969	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Belgium-Luxembourg	76	$157	43	$89	517	r $2,950	571	$2,941	5	r $22	18	$76	109	$241	52	$110
Brazil	------	------	------	------	3	55	11	153	4	55	(1)	10	------	------	------	------
Canada	r 11	r 29	12	51	r 102	r 543	94	562	r 20	r 77	31	171	450	334	425	330
Central African Republic	10	20	11	30	67	1,038	43	951	25	46	8	15	------	------	------	------
Congo	104	237	25	52	81	441	91	225	------	------	------	------	9	20	23	56
France	(1)	(1)	------	------	4	73	2	33	2	3	(1)	(1)	3	4	(1)	9
Germany, West	------	------	------	------	24	217	11	246	1	(1)	5	246	13	25	37	63
Ghana	4	11	------	------	r 423	r 1,739	259	1,015	5	12	3	21	r 20	r 53	------	------
Ireland	105	253	19	55	r (1)	r 2	18	53	582	3,137	536	2,786	r 5,815	r 13,065	6,169	14,089
Israel	(1)	4	2	8	26	437	42	460	------	------	2	8	4	9	4	9
Japan	1	(1)	(1)	(1)	96	1,160	109	1,321	30	66	2	10	366	804	498	1,099
Netherlands	113	233	138	307	323	4,229	747	3,652	7	145	2	6	108	259	63	129
Sierre Leone	------	------	(1)	(1)	120	2,395	5	18	------	------	------	------	(1)	(1)	------	------
South Africa, Republic of	r 188	r 433	45	200	r 1,442	r 10,546	1,385	9,252	r 178	r 1,098	124	636	r 173	r 459	211	434
Switzerland	2	5	------	------	8	84	24	197	------	------	------	------	92	196	56	107
United Kingdom	21	49	36	70	650	7,108	802	3,758	15	107	16	225	r 573	r 1,143	615	1,192
Venezuela	1	3	------	------	7	63	21	293	1	3	------	------	------	------	------	------
Western Africa, n.e.c.	r 61	r 134	26	53	358	3,210	442	4,393	r 17	r 104	5	27	87	251	44	105
Other	------	------	(1)	3	13	667	54	274	8	32	31	126	3	7	8	11
Total	r 697	r 1,568	357	918	r 4,264	r 36,957	4,731	29,797	r 900	r 4,907	783	4,363	r 7,825	r 16,870	8,205	17,743

r Revised.
[1] Less than ½ unit.

Table 12.—World production of industrial diamond, by countries
(Thousand carats)

Country	1967	1968	1969 p
Africa:			
Angola	306	351	e 425
Central African Republic	260	e 304	e 316
Congo (Kinshasa)	12,891	11,353	e 15,000
Congo (Brazzaville) [1] [2]	r 4,154	4,343	NA
Ghana	2,283	e 2,202	e 2,520
Guinea e	r 51	NA	NA
Ivory Coast	e 70	e 77	e 120
Liberia [1]	181	213	e 220
Sierra Leone	r 873	r 962	1,337
South-West Africa e [3]	r 90	r 86	90
Tanzania	494	346	397
South Africa, Republic of: e			
Premier	1,783	1,915	NA
De Beers Group [4]	1,742	1,983	NA
Other [5]	222	340	NA
Total, Republic of South Africa	3,747	4,238	4,482
Other areas:			
Brazil e	160	160	160
Guyana	e 56	e 38	21
India	2	r 2	e 2
Indonesia e	r 6	r 6	6
U.S.S.R. e	5,600	5,600	6,000
Venezuela	31	54	58
Total [6]	31,255	30,335	31,154

e Estimate. p Preliminary. r Revised. NA Not available.
[1] Exports, data for Liberia are for fiscal year ending August 31 of year stated.
[2] Probable origin, Republic of the Congo (Kinshasa).
[3] Output of Consolidated Diamond Mines of South-West Africa Ltd.
[4] Includes some alluvial diamond from De Beers properties.
[5] Includes alluvial.
[6] Total is of listed figures only.

Central African Republic.—Total diamond production in 1968, the last year for which complete data have been released, was 609,000 carats, of which 35 to 50 percent may have been of industrial grade. Under the terms of the Government's development plan (1967–70), diamond will continue to be emphasized as the nation's most valuable mineral commodity. One of the provisions of the plan calls for an 18-percent expansion of diamond production during the stated term—from 540,000 carats in 1966 to 640,000 carats in 1970.

Congo (Kinshasa).—Announcement by the U.S. General Services Administration of a tentative plan for the disposal of approximately 18 million carats of crushing bort industrial diamond from stockpile holdings evoked an unfavorable response from Congolese officials. The Congo has long been the world's foremost source of industrial diamond, and Finance Minister Nendaka stated that the proposed sales would inevitably exert a depressing influence on his nation's economy.

An agreement signed on May 2, 1969, by SIBEKA (Société des Investisseurs de Beceka) formally ceded to the Government of The Democratic Republic of the Congo a controlling 50-percent share of the ownership of that firm's subsidiary Société Minière de Bakwanga (MIB), the Congo's largest diamond producer. In effect, this accord places in the hands of the Congolese Government direct financial and administrative control over perhaps 40 percent of the free world's present output of natural industrial diamond.

Ghana.—The Government granted to the Consolidated African Selection Trust approval for the exploratory dredging of the bed of the River Birim. It is believed that the alluvial deposits of the Birim basin are rich enough in diamond content to support both dredging and surface mining operations.

India.—The National Mineral Development Corp. continued an intensive program of exploration in search of workable diamond deposits in the Golconda region of southern India, historically the world's principal source of diamonds prior to the mid-18th century discoveries in Africa and Brazil. The earlier mining operations in the Golconda area were conducted exclusively for the recovery of stones of gem quality, and it seems likely that waste accumulations there may contain important quantities of disregarded material of industrial-diamond grade.

Indonesia.—A report from Djakarta told of the discovery of an apparently rich diamond deposit at Guning Kaja ("Rich Mountain") in the Tjempaka district of South Borneo. Information was not included in the dispatch as to what proportion of the Borneo diamonds might be of industrial grade.

Ivory Coast.—Diamond mines at Tortiya, Sequela, and on the lower Bou, with three firms in active production and a fourth preparing to begin operations, yielded over 202,000 carats in 1969. About 60 percent of the output was considered to be industrial material, and practically the entire quantity was exported. The Directorate of Mines and Geology predicted that 1970 diamond production will be 5 to 10 percent greater than that in 1969.

Lesotho.—It was announced in April 1969 that Bethlehem Steel Corp. will acquire a 20-percent share in a company organized by the Rio Tinto Zinc Corp. to mine diamonds from the rich Letsang-La-Terai deposit in the Mekhotlung district. A one-quarter share in the new firm was reserved for the Lesotho Development Corp., an agency of the Lesothan Government. Lesotho was the source of the 600-carat, gem-quality Brown diamond that was sold in 1967 for about $700,000.

Liberia.—The entire 1969 production was, as usual, from alluvial deposits, and according to the latest statistics available, exports of diamond in fiscal year 1967–68 amounted to 750,000 carats, of which about one-third was of industrial quality. A new diamond discovery occurred in 1969 in the Kakata area north of Monrovia and excited sufficient interest to precipitate a rush and drain workers away from a large rubber plantation at nearby Harbel.

Sierra Leone.—Following the completion in 1968 of two new diamond separation plants at Yengema, the Sierra Leone Selection Trust, Ltd., contracted for the construction of still a third installation, which was to be put into operation in 1969. The new plant, housing two rotary washers, together with screening and concentrating equipment, and costing approximately $250,000, will treat diamondiferous gravel from the Kono district, one of the world's richest diamond-producing areas.

South Africa, Republic of.—Production of diamond, all grades, amounted to 2.3 million carats in the first quarter of 1969, equivalent to an annual rate of about 9 million carats. Approximately two-thirds of the total output may be rated as industrial material. Production by De Beers Consolidated Mines Ltd. from the rich deposit at Annex Kleinzee was expected to diminish with the approach of depletion, but a compensating increase was predicted from other properties in Namaqualand. Current exploration revealed an important deposit at Koingnass and substantial extensions of the reserve ground already blocked out north of Annex Kleinzee. An agreement by the Government to disclaim export duties on the diamond to be produced led to the decision to recommence operation of the Koffiefontein Mine in the Orange Free State, hereto considered to be no better than marginally profitable.[6] The Department of Mines granted permission to a subsidiary of International Ventures and Development Corp. to begin exploitation of the Barkley property 20 miles from Kimberley, a deposit worked superficially in the past but not yet fully delineated. Expenditure of more than $1 million was forecast to bring the mine into production.[7] Returns from the exploitation of marine deposits, especially those offshore, continued to be disappointingly meager.

Tanzania.—As an initial step toward achieving industrialization of the wealth in diamonds and other minerals known to exist in this east African republic, the Government arranged for a large party of engineers from the U.S.S.R. to undertake an intensive geological reconnaisance of the entire national area. Approximately half of Tanzania's present million-carat annual diamond production is classed as industrial diamond.

U.S.S.R.—According to Pravda, Soviet engineers have established a facility for the treatment of diamond-bearing kimberlite

[6] Muller, Dr. T. F. Bright Outlook for Mining. Min. J. (London), v. 272, No. 6984, June 27, 1969, pp. 580–583.

[7] Mining Journal (London). Mining Annual Review, 1969. Gem Stones and Abrasives. June 1969, pp. 111, 113–115, 117.

from a volcanic pipe at Udachanaya above the Arctic Circle, the most northerly plant of its kind on record. Russia's 1969 output of industrial diamond, principally from mines in Siberia, may have totaled 6 million carats.

Venezuela.—Output of diamond in 1969, largely from the alluvial gravels of the Paragua River south of Cerro Bolivar, reached a total of 194,000 carats, of which 58,000 carats was classified as industrial stones and 18,000 as crushing bort.

TECHNOLOGY

Diamond mining has been carried on without interruption for thousands of years and has involved the handling and patient sorting over of perhaps 3 billion tons of sand, gravel, and hard rock. It is estimated that the end product of all those ages of effort might tip the scales at no more than 130 tons. That is equivalent to a concentration ratio of about 23 million to 1, and the valuable portion of even a rich diamond ore may represent no more than 0.000004 percent of the total weight. The geological, historical, and technological aspects of diamond mining and concentration were sketched in a journal article, in which several color photographs provided an unusually vivid glimpse of the subject.[8] Diamond of industrial grade almost invariably accompanies the more sought-after crystals of gem quality, but only recently—for a limited number of decades—has there been a concerted effort to save this unattractive-looking material. The world's entire stock of industrial diamond, therefore, can amount to no more than a minor fraction of the estimated 130 tons of diamond that has been recovered in all time—perhaps only a few truck loads. Not many substances, pound for pound, are able to exert so pervasive an influence upon our industrial civilization.

The Industrial Diamond Association of America and the American Society of Tool and Manufacturing Engineers co-sponsored the International Industrial Diamond Conference held in Chicago in October 1969. The 11 sessions of the 3-day program featured the presentation of about 30 technical papers analyzing industrial diamond applications in the glass, ceramics, electronics, plastics, and the metalworking industries. The conference theme was "Diamond—Key to Industrial Progress."

Some of the ways in which industrial diamond serves in the varied steps of bringing a wide variety of English glass products into final form were portrayed in out-of-the-ordinary photographs reproduced in a magazine article. The applications illustrated ranged from the ultraprecise machine ruling of 200,000 lines to the inch on diffraction gratings, an operation in which weeks may pass in the completion of a single unit, to the highly skilled freehand engraving of fine crystalware.[9]

An illustrated journal article described the equipment and techniques used in forming miniature cubes of elemental silicon, thirteenth-thousandths of an inch (plus or minus five ten-thousandths) on a side, for semiconductor devices. The actual cuts are made, 44 at a pass, by a nest of circular saw blades, each electroplated with diamond and not much thicker than a sheet of kitchen foil.[10]

A major electronic components manufacturer found that almost every cutting or finishing operation involved in the close-tolerance mass production of sintered ferrite-ceramic magnets required the use of diamond grinding wheels.[11]

Specially designed vibration-free lathes made it possible for a British manufacturing firm to produce aluminum information-storage discs, 12 inches in diameter and mirror finished to less than three-millionths of an inch in surface relief, often to one-millionth. The sophisticated equipment and the industrial-diamond lathe tools employed in fabricating these precision parts for computers were described in a journal article.[12]

A recently devised ultrasonic method of impact grinding, has the capability of machining extremely hard and brittle materials with a high degree of precision. In a demonstration test a fragile wafer of alumina, about the size of a 25-cent piece and only 0.010 inch thick, was efficiently pierced with 59 evenly spaced square holes,

[8] Engineering and Mining Journal. Diamond Recovery Is Big Business. V. 170, No. 11, November 1969, pp. 67–80.

[9] Allen, Alfred C. England: Diamonds Fashion an Industry. Ceram. Ind., v. 93, No. 6, December 1969, pp. 53–55.

[10] Industrial Diamond Review. Slicing and Dicing Ultra-Pure Silicon Into Tiny Cubes for a Semiconductor Device. V. 29, No. 342, May 1969, pp. 208–209.

[11] Abrasive Engineering. Diamonds Essential to Machine Ferrites. V. 15, No. 5, May 1969, pp. 26–27.

[12] Hush, John S. From Discs to Tape and Back Again Ind. Diamond Rev., v. 29, No. 345, August 1969, pp. 310–313.

each 0.038 inch (plus or minus one-thousandth) on a side and with absolutely no measurable rounding of the edges. The new technique differs from all previous impact procedures in the innovative use of a single-crystal industrial diamond in the tip of the cutting tool.[13]

De Beers Industrial Diamond Division, London, announced the commercial availability of an entirely new type of metal-clad synthetic diamond grit especially suitable for resin bonding into abrasive wheels for the grinding of certain steels, cast iron, and other ductile materials. The blocky, cubo-octahedral structure of the new diamond material yields particles with distinct cutting edges that remove the metal in well-formed chips with no tendency to load the wheel. The metal cladding of the particles efficiently dissipates the heat evolved in high-speed grinding.[14] The use of grinding wheels containing the new De Beers abrasive reduced the time required to finish-grind the silicon carbide surface of a specialized motor component from three-quarters of an hour to just 6 minutes and thus lowered the cost per unit from $5 to $1.50.[15] A similarly important development in metalworking technology was realized by General Electric Co. in a new synthetic diamond abrasive especially designed for the dry-grinding of tungsten carbide. Under their "Man-Made" trademark, General Electric now markets eight distinct types of synthetic diamond grit. A folder was published detailing the descriptions of these materials and listing the specific end uses and appplications for which each of them is particularly recommended.[16]

An article related the findings of a mineralogical and crystallographic investigation of the cryptocrystalline or randomly oriented polycrystalline masses of diamond known by the Brazilian-Portuguese name "carbonados" and highly valued in industry for their hardness and unequaled omnidirectional toughness.[17]

Progress was reported in the exploration of heavy-media techniques for salvaging industrial diamond contained in grinding-refuse swarfs and sludges, one phase of a materials-recycling investigation under way at the Bureau of Mines Metallurgy Research Center in Rolla, Mo. Promising results were obtained in a sink-float application of thallous formate-malonate, an extraordinary liquid with a density four times that of water. Completion of this investigation, together with the preparation of a number of covering reports, is expected to take about 2 more years.

Titles of technical publications issued in 1969 by the Industrial Diamond Information Bureau (British) included "Diamond Research in 1969;" "Production and Quality Control of Fine Diamond Powders;" "Occurrence, Mining, and Recovery of Diamonds;" "Diamonds and Ceramics;" and the "Non-Cutting Uses of Industrial Diamonds."

Nine of 10 of the diamond-related 1969 United States, British, and Canadian patents that were reviewed dealt with procedures or materials for the production of synthetic diamond. There may be a significant clue to future trends in the synthetic diamond industry in the fact that just over one-half of those patents were issued to Japanese individuals or firms.

ARTIFICAL ABRASIVES

Crude fused aluminum oxide for abrasive purposes was produced in the United States and Canada in 1969 by six firms. The Carborundum Co.; Norton Co.; and General Abrasive Co. Inc. Division of U.S. Industries, Inc. (formerly Lionite Abrasives, Ltd.) each operated plants in both countries. Pyrominerals, Ltd.; Simonds Canada Abrasive Co., Ltd.; and The Exolon Company had operations only in Canada. The combined outputs of both countries, consisting of regular-grade material and white, high-purity material in a ratio of about 6 to 1 by weight, represented 61 percent of the

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[13] Industrial Diamond Review. Ultrasonic Machining With Whole Stone Diamonds. V. 29, No. 345, August 1969, pp. 314–316.

[14] Iron Age. Diamonds: Grinder's Best Friend. V. 204, No. 21, Nov. 20, 1969, p. 126.

[15] South African Mining and Engineering Journal. Synthetic Diamond Cuts Grinding Costs. V. 8, Pt. 1, No. 3980, May 16, 1969, p. 1077.

[16] Man-Made Diamond Abrasive Products. Specialty Materials Department, General Electric Co. Worthington, Ohio.

[17] Trueb, L. F., and W. C. Butterman. Carbonado: A Microstructural Study. Am. Miner., v. 54, No. 3–4, March–April 1969, pp. 412–425.

total rated capacity for all plants. It was estimated that about 12 percent of the total output of fused aluminum oxide, domestic and Canadian, served in nonabrasive applications, chiefly in the manufacture of refractories.

The GSA on January 1, 1969, offered for sealed-bid sale approximately 6,000 tons of surplus Government-owned, crude, fused aluminum oxide, and it was reported subsequently that 400 tons of this material was sold in the period January–June. About 129,000 tons of fused aluminum oxide in excess of the stockpile objective still remained on Government inventory as of June 30, 1969.

Crude silicon carbide was manufactured in the United States and Canada in 1969 by six firms. Norton Company and The Carborundum Company, operating plants in both countries, and The Exolon Company and General Abrasive Co. Division of U.S. Industries, Inc., only in Canada, turned out material for both abrasive and nonabrasive uses. The sixth company, Satellite Alloy Corp. with facilities only in the United States, produced silicon carbide exclusively for refactories and other nonabrasive applications. Consumption of the overall two-nation output of silicon carbide, equivalent to 89 percent of the industry's total rated capacity, was divided almost evenly between abrasive and nonabrasive purposes.

The Carborundum Co. disclosed plans for expanding its abrasives-manufacturing capacity by the construction of a new multimillion-dollar silicon carbide plant at Jacksboro, about 30 miles northwest of Knoxville, Tenn. Initial production at the new site—chosen to lie within the area served by the TVA power complex—is scheduled for late 1970.

Norton Co., one of the world's foremost makers of nonmetallic artificial abrasives, with plants in 17 countries, and already associated with Mitsubishi Metal Mining Co., Ltd., in the production of grinding wheels, signed licensing and technical-assistance agreements with two other Japanese firms for a joint abrasive-grain manufacturing enterprise.

Metallic abrasives, consisting principally of iron and steel grit, were produced in 1969 in eight States, among which Ohio continued securely in first place with respect to both tonnage and total value. Michigan was next in tonnage, but Indiana was a close second to Ohio in terms of dollars. Minnesota, for the second year in succession, reported no production of metallic abrasives.

Table 13.—Crude artificial abrasives produced in the United States and Canada

(Thousand short tons and thousand dollars)

Kind	1965	1966	1967	1968	1969
Silicon carbide [1]	138	159	142	159	161
Value	$19,963	$21,674	$19,612	$23,833	$23,945
Aluminum oxide (abrasive grade) [1]	195	244	207	192	217
Value	$24,909	$29,981	$28,183	$27,705	$31,276
Metallic abrasives [2]	191	205	204	216	230
Value	$28,230	$31,139	$32,610	$34,778	$37,369
Total [3]	524	608	553	568	609
Value [3]	$73,102	$82,794	$80,405	$86,316	$92,589

[1] Figures include material used for refractories and other nonabrasive purposes.
[2] Shipments for U.S. plants only.
[3] Data may not add to total shown because of independent rounding.

Table 14.—Production, shipments, and stocks of metallic abrasives in the United States, by products

Year and product	Manufactured		Sold or used		Stocks Dec. 31 (short tons)	Annual capacity (short tons)
	Short tons	Value (thousands)	Short tons	Value (thousands)		
1968:						
Chilled iron shot and grit	38,500	$3,714	37,776	$4,192	5,297	247,015
Annealed iron shot and grit	45,970	4,927	46,070	5,978	2,035	[1] 171,487
Steel shot and grit	130,698	18,363	130,668	24,203	10,113	148,163
Other [2]	1,728	348	1,688	405	162	11,250
Total	216,896	27,352	216,202	34,778	[3] 17,607	406,428
1969:						
Chilled iron shot and grit	34,407	$3,605	34,528	$3,825	5,176	244,625
Annealed iron shot and grit	45,865	4,895	47,281	6,042	619	[1] 158,343
Steel shot and grit	149,466	21,160	146,487	27,049	13,092	168,163
Other [2]	2,190	352	2,199	452	153	10,250
Total [4]	231,928	30,012	230,495	37,369	19,040	423,038

[1] Included in capacity of chilled iron shot and grit.
[2] Includes cut wire shot.
[3] Includes revisions in product detail.
[4] Data may not add to total shown because of independent rounding.

Table 15.—Stocks of crude artificial abrasives and capacity of manufacturing plants, as reported by producers in the United States and Canada

(Thousand short tons)

Year	Silicon carbide		Aluminum oxide		Metallic abrasives [1]	
	Stocks Dec. 31	Annual capacity	Stocks Dec. 31	Annual capacity	Stocks Dec. 31	Annual capacity
1965	9.1	155.9	10.9	304.8	17.9	376.8
1966	17.5	174.4	18.6	310.8	12.7	373.5
1967	12.9	176.1	30.2	330.2	15.6	400.1
1968	17.7	179.7	25.5	357.2	[r] 17.6	406.4
1969	9.1	181.7	33.2	358.2	19.0	423.0

[r] Revised.
[1] United States only.

TECHNOLOGY

The Bureau of Mines, at its Metallurgy Research Center in Rolla, Mo., continued to explore means of salvaging usable products from waste industrial materials, and a report was published covering an abrasive-related aspect of that investigation.[18]

Tests indicated that the incorporation in grinding wheels of cubic boron nitride abrasive grain—recently developed by General Electric Company—in place of the more conventional diamond or fused alumina can bring about important economics in the grinding of heat-treated, high-speed tool steel.[19]

A major advance toward the day of grinding wheels with characteristics precisely designed for particular applications was made by the introduction of artificial abrasive grain preshaped by extrusion and then sintered.[20]

[18] Barnard, Paul G., Aaron G. Starliper, and Heinie Kenworthy. Reclaiming Refractory Carbides and Cobalt From Cemented-Carbide Scrap. Secondary Raw Materials, v. 7, No. 9, September 1969, pp. 19–21.
[19] Iron and Steel (London). Boron Nitride Abrasive. V. 42, No. 6, December 1969, p. 398.
[20] Rue, Charles. Shape in Extruded Grain. Abrasive Eng., v. 15, No. 8, August 1969, pp. 22–23.

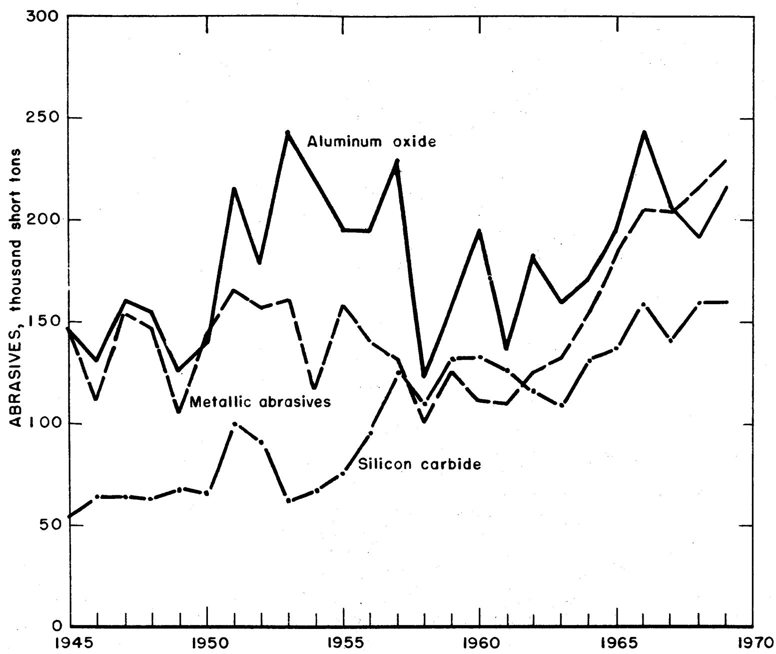

Figure 1.—Artifical abrasive production.

Aluminum

By John R. Lewis [1] and V. Anthony Cammarota, Jr. [1]

The aluminum industry of the United States did well in 1969. Domestic production of primary metal was at an alltime high of 3.8 million short [2] tons for the year, after a setback in 1968, which was caused by a midyear strike at plants of two principal producers. Apparent consumption also was at an alltime high, and prices for the metal rose from 26 cents per pound at the beginning of the year to a yearend price of 28 cents per pound. New primary production facility construction was moving toward completion in several areas, and for the first time in a decade, the United States in 1969 exported more basic aluminum products than were imported during the year.

Legislation and Government Programs.—Shipments of stockpile aluminum ingot by the General Services Administration during the year totaled 139,269 tons, more than twice the amounts shipped in either 1967 or 1968.

The Business and Defense Services Administration, (BDSA) U.S. Department of Commerce, established the aluminum set-aside for defense and related orders at 150,000 tons per quarter in 1969. At these levels, the quarterly set-asides represented 11 to 12 percent of total industry shipments anticipated in each quarter. The set-asides are established by BDSA under the defense materials system to meet estimated needs of the Department of Defense, Atomic Energy Commission, National Aeronautics and Space Administration, Federal Aviation Agency and related programs.

Table 1.—Salient aluminum statistics

(Thousand short tons and thousand dollars)

	1965	1966	1967	1968	1969 p
United States:					
Primary production	2,754	2,968	3,269	3,255	3,793
Value	$1,337,795	$1,446,011	$1,614,483	$1,639,621	$2,013,403
Price: Ingot, average cents per pound	24.5	24.5	25.0	25.6	27.2
Secondary recovery	641	693	698	817	856
Exports (crude and semicrude)	315	330	366	351	575
Imports for consumption (crude and semicrude)	620	679	539	793	558
Consumption, apparent	3,734	4,002	4,009	4,662	4,660
World: Production	6,951	7,583	8,343	8,875	10,019

p Preliminary.

DOMESTIC PRODUCTION

Primary.—The State of Washington, with its large supplies of electrical energy so necessary to aluminum reduction, continued at 953,000 tons, to be well ahead of the 13 other aluminum producing States in output. Second was Arkansas with 504,000 tons; Tennessee, with 334,000 tons, was third. Kentucky, the newcomer, produced 44,000 tons during 1969 from the new 180,000-ton-per-year plant of National-Southwire Aluminum Co., which is owned by National Steel Corp., and Southwire Co. After the smelter is completed a rolling mill will be erected by National Steel, so that its production and recently acquired

[1] Physical scientist, Division of Nonferrous Metals.

[2] The quantities used throughout this chapter are short tons unless otherwise specified.

end-product fabricating companies will comprise an integrated operation.

Again in 1969, reduction plant capacity was increased at a number of installations. The Aluminum Co. of America raised capacities at its plants as follows: 125,000 tons to 194,000 tons at Alcoa, Tenn.; and from 100,000 tons to 110,000 tons at Badin, N.C. Meanwhile, Reynolds Metals Co. raised capacities at several of its plants: From 55,000 tons to 63,000 tons at Arkadelphia, Ark.; from 109,000 tons at Jones Mills, Ark., to 122,000 tons; from 194,500 tons to 220,500 tons at Listerhill, Ala.; and from 115,000 tons to 128,000 tons at Massena, N.Y. Kaiser Aluminum & Chemical Corp. increased its Tacoma, Wash., plant capacity from 61,000 tons to 93,000 tons during the year.

Total production capacity in the United States at yearend 1968 was close to 3,627,700 tons; one year later it was 3,847,600 tons, an increase of about 6 percent in the year.

The Anaconda Aluminum Co. became a fully integrated producer in the fall when first shipments of alumina arrived at the Columbia Falls, Montana, reduction plant from a jointly owned bauxite mining and alumina operation in Jamaica.

Alcan Aluminum Corp., the United States fabricating subsidiary of Alcan Aluminium, Ltd., spent about $54 million improving its U.S. position during 1969. The Metal Goods Corp. of St. Louis, Mo., was acquired early in the year. The 100,000-ton-per-year cold-rolling mill at the company's Oswego, N.Y., plant was completed, and other plant improvements at Oswego were also finalized. Operation of the Oswego rolling mill was expected to result in a phaseout of this type of production at the company's Fairmont, West Va., plant.

Several thousand acres of land near the John Day Dam in Klickitat County, Wash., 25 miles southwest of Goldendale, were purchased by Harvey Aluminum Inc., and financing arrangements were completed for construction of Harvey's second reduction plant, which will increase output of the

Table 2.—Production and shipments of primary aluminum in the United States

(Short tons)

Quarter	1968		1969 p	
	Production	Shipments	Production	Shipments
First	840,723	898,459	916,925	933,201
Second	787,864	839,731	946,194	957,482
Third	741,431	756,857	952,204	952,750
Fourth	885,024	908,008	977,739	977,568
Total	3,255,042	3,403,055	3,793,062	3,821,001

p Preliminary.

Table 3.—Aluminum recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1968	1969 p	Form of recovery	1968	1969 p
New scrap:			As metal	72,132	47,641
Aluminum-base	[1] 661,570	[2] 715,046	Aluminum alloys	728,784	792,218
Copper-base	105	150	In brass and bronze	762	800
Zinc-base	88	85	In zinc-base alloys	7,067	7,000
Magnesium-base	434	500	In magnesium alloys	1,039	1,050
			In chemical compounds	7,124	7,467
Total	662,197	715,781	Total	816,908	856,176
Old scrap:					
Aluminum-base	153,959	139,645			
Copper-base	77	100			
Zinc-base	544	500			
Magnesium-base	131	150			
Total	154,711	140,395			
Grand total	816,908	856,176			

p Preliminary.

[1] Aluminum alloys recovered from aluminum-base scrap in 1968, including all constituents, were 699,147 tons from new scrap and 175,415 tons from old scrap and sweated pig, a total of 874,562 tons.

[2] Aluminum alloys recovered from aluminum-base scrap in 1969, including all constituents, were 771,790 tons from new scrap and 150,062 tons from old scrap and sweated pig, a total of 921,852 tons.

company by 100,000 tons, to 190,000 tons annually.

The new, from the ground up, $100 million plant of the Eastalco Aluminum Co. at Frederick, Md., approached completion by yearend 1969. Eastalco is owned 50 percent by Howmet Corp. and 50 percent by Péchiney Enterprises. It was expected by spring of 1970 that alumina, mainly from France, would begin to arrive at Baltimore, a 55-mile rail journey from the plant. Electric power was to be furnished by a local utility, and the reduction facility was to be equipped with an extensive antipollution system. Extrusion billet and ingot will both be produced at Frederick, and ultimate planned annual capacity was 155,000 tons. Initial output was expected to be about 85,000 tons per year. A new system for automatic control of individual pot voltages and anode effect will be employed to afford better control and to increase efficiency. Formerly these control adjustments were made manually. In fact, at Eastalco, a fully automatic method will be used to tend the pots, and a number of improved handling techniques are intended to increase operating efficiency and product quality.

The new, 35,000-ton-per-year plant of the Gulf Coast Aluminum Company at Lake Charles, La., owned 100 percent by Alusuisse, was under construction throughout 1969 and was scheduled to commence operation in the fall of 1970. Consolidated Aluminum Corp. was supervising construction and will oversee operation. Phelps Dodge has assisted in certain phases of the plant's development and is expected to share in its output. Electricity will be furnished by a gas fueled steam plant being built on the site. An electrode plant and a coke calcining plant also are part of the operation.

Entry of Noranda Aluminum, wholly owned subsidiary of Noranda Mines Ltd. of Canada, into primary aluminum production began to take solid form in 1969. Located in a 4,000-acre industrial park near New Madrid, on the Mississippi River in extreme southeastern Missouri, the $85 million reduction plant and adjacent $99 million, 600-megawatt thermal electric generating facility represented the largest single industrial investment in Missouri's history. Design and construction was contracted to Kaiser Engineers. Completion of an adjacent rod and cable plant in 1969 has created a ready market for part of the plant's output, once it is completed. Meanwhile, the facility was being supplied with ingot from other primary producers. Alumina supplies for the plant will be barged up the Mississippi River from the Gulf Coast area. Output in initial stages will be 70,000 tons of aluminum, with provision for ultimate production of 210,000 tons per year. The metal will mostly be consumed internally by the Noranda group of companies. First production was scheduled for the end of 1970, but construction was well ahead of the timetable throughout 1969.[3]

The aluminum complex of Revere Copper & Brass, Inc., situated on Goose Pond Island in the Tennessee River near Scottsboro, Ala., was rapidly taking shape during 1969. Completion is not scheduled until 1971. Initial capacity will be 112,000 tons per year of primary aluminum with provision for future expansion to 336,000 tons annually.

Northwest Aluminum, which was initiated by Bell Intercontinental Corp., was still proceeding with plans for a 130,000-ton-per-year primary aluminum smelter at Astoria, Oreg. Financing difficulties were blamed for additional postponements, and although the project had been started in 1966, at yearend it did not appear that a target date earlier than July 1972 for the highly computerized plant would be possible. Only site clearance and most of the engineering had been completed as 1969 drew to a close, but it was generally conceded that the project had sufficient promise to forestall abandonment. Alumina for the plant will probably come from Australia.

Secondary.—Each recent year has seen great strides in recovery and use of secondary aluminum, and its role in the aluminum metal market continued to expand in 1969. Recovery of secondary aluminum from scrap in the United States again set a new record, a trend which has become quite common. Slightly more than 856,000 tons were recovered in 1969, up 4.8 percent from the record of 1967, which in turn was 17 percent higher than in 1966, which was also a record year. Domestic recovery of aluminum alloys from aluminum-base scrap (including all constituents) was

[3] Noranda Mines Ltd., Toronto, Ontario, Canada. Annual Report for 1969, Feb. 10, 1970, 28 pp.

922,000 tons in 1969, an improvement of almost 5 percent over 1968 recoveries. Metallic recovery from new scrap held a strongly improved position in 1969 when there was a 10-percent increase in total volumes recovered. Recovery from old scrap and sweated pig, however, decreased about 14 percent from 175,415 tons in 1968 to 150,062 tons in 1969.

Copper-, zinc-, and magnesium-base scrap also yielded greater amounts of secondary aluminum in 1969. A total of 1,485

Table 4.—Stocks receipts and consumption of new and old aluminum scrap and sweated pig in the United States in 1969 [1] p

(Short tons)

Class of consumer and type of scrap	Stocks Jan. 1	Receipts	Consumption [2]	Stocks Dec. 31
Secondary smelters: [3]				
New scrap:				
Solids:				
Segregated low copper (Cu maximum, 0.4 percent)	4,415	104,987	105,470	3,932
Segregated high copper	835	18,775	19,101	509
Mixed low copper (Cu maximum, 0.4 percent)	2,055	74,249	74,075	2,229
High zinc (7000 series type)	422	9,863	9,491	794
Mixed clips	W	W	W	W
Borings and turnings:				
Low copper (Cu maximum, 0.4 percent)	W	W	W	W
Zinc, under 0.5 percent	W	W	W	W
Zinc, 0.5 to 1.0 percent	W	W	W	W
Other	1,214	62,780	62,525	1,469
Foil, dross, skimmings, and other	12,306	102,297	101,866	12,737
Total new scrap	27,396	545,219	545,618	26,997
Old scrap (solids)	6,745	109,041	110,061	5,725
Sweated pig (purchased for own use)	2,753	54,453	52,619	4,587
Total all classes	36,894	708,713	708,298	37,309
Primary producers, foundries, fabricators, and chemical plants:				
New scrap:				
Solids:				
Segregated low copper (Cu maximum, 0.4 percent)	2,957	177,567	177,407	3,117
Segregated high copper	165	14,670	14,726	109
Mixed low copper (Cu maximum, 0.4 percent)	5,031	53,515	56,105	2,441
High zinc (7000 series type)	277	2,479	2,357	399
Mixed clips	W	W	W	W
Borings and turnings:				
Low copper (Cu maximum, 0.4 percent)	W	W	W	W
Zinc, under 0.5 percent	W	W	W	W
Zinc, 0.5 to 1.0 percent	W	W	W	W
Other	169	18,487	18,645	11
Foil, dross, skimmings, and other	2,383	45,264	45,460	2,187
Total new scrap	11,407	320,322	323,385	8,344
Old scrap (solids)	329	8,804	8,901	232
Sweated pig (purchased for own use)	3,695	12,834	15,962	567
Total all classes	15,431	341,960	348,248	9,143
Total of all scrap consumed:				
New scrap:				
Solids:				
Segregated low copper (Cu maximum, 0.4 percent)	7,372	282,554	282,877	7,049
Segregated high copper	1,000	33,445	33,827	618
Mixed low copper (Cu maximum, 0.4 percent)	7,086	127,764	130,180	4,670
High zinc (7000 series type)	699	12,342	11,848	1,193
Mixed clips	2,558	77,332	77,387	2,503
Borings and turnings:				
Low copper (Cu maximum, 0.4 percent)	1,369	15,952	16,914	407
Zinc, under 0.5 percent	784	25,590	25,756	618
Zinc, 0.5 to 1.0 percent	1,863	61,734	61,718	1,879
Other	1,383	81,267	81,170	1,480
Foil, dross, skimmings, and other	14,689	147,561	147,326	14,924
Total new scrap	38,803	865,541	869,003	35,341
Old scrap (solids)	7,074	117,845	118,962	5,957
Sweated pig (purchased for own use)	6,448	67,287	68,581	5,154
Total all classes	52,325	1,050,673	1,056,546	46,452

p Preliminary. W Withheld to avoid disclosing individual company confidential data.
[1] Includes imported scrap.
[2] Calculated.
[3] Excludes secondary smelters owned by primary aluminum companies.

tons was recovered during the year, bettering the previous year by 7.7 percent. Using the average 1969 price of primary ingot (27.2 cents per pound) as a base, the value of the 854,691 tons of aluminum recovered from aluminum scrap was $465,000.

Based upon reports to the Bureau by consumers of aluminum-base scrap and sweated aluminum pig, calculated consumption was 1,056,546 tons—up 41,476 tons from the previous year. Independent secondary smelters used 67 percent of all aluminum base scrap, down from 69 percent in 1968. Primary producers took 196,857 tons or 18.5 percent (up from 15 percent the previous year and perhaps foretelling a trend), fabricators used 71,163 tons or 7 percent, and foundries used 80,228 tons, or 7.5 percent.

The Bureau of Mines estimates that full coverage of the industry would show a total scrap consumption of 1,229,000 tons (up 41,000 tons from estimate of 1968) and a secondary ingot production of 741,000 tons (down 2,000 tons). Calculated aluminum recovery, based upon full coverage, would total 978,000 tons (up 53,000 from 1968) and the metallic aluminum alloy recovery would total 1,030,000 tons (up 33,000 tons from 1968). Production of secondary aluminum alloy ingot totaled 633,997 tons, a shortfall from 1968 production of 1,200 tons. Remelt ingot data does not include alloys produced by primary producers from purchased scrap. A severe drop in the volume of pure aluminum reported as produced during the year was not overtaken by gains in production of other categories, especially the alloy AXS–679 and variations, and an overall modest shortfall is the result.

Data obtained through a Bureau of Mines canvass were combined with data made available to the Bureau by the Aluminum Smelters Research Institute. The latter covered operations of the institute's members and represent about 75 percent of the secondary aluminum smelter industry.

The aluminum beverage can recycling program begun by Reynolds Metals Co. was intensified during the year by alerting the public to the value of recycling as an aid in solving the problems of litter and solid waste disposal. Experimental can reclamation programs in Los Angeles and Miami won such acclaim that expansion plans were formulated for application in several more cities during 1970. A price of 10 cents per pound for aluminum cans turned in to collection centers was possible because of high scrap prices, and many civic groups were becoming involved in the collection program.

Table 5.—Production and shipments of secondary aluminum alloys, by independent smelters

(Short tons) [1]

	1968		1969 p	
	Production [2]	Shipments [2]	Production [2]	Shipments [2]
Pure aluminum (Al minimum, 97.0 percent)	72,132	72,335	47,641	47,480
Aluminum-silicon:				
95/5 Al-Si, 356, etc. (maximum Cu 0.6 percent)	19,804	19,924	17,285	17,234
13 percent Si, 360, etc. (maximum Cu, 0.6 percent)	42,668	42,634	46,082	45,419
Aluminum-silicon (Cu, 0.6 to 2 percent)	8,160	8,305	7,770	7,826
No. 12 and variations	6,997	7,150	6,208	6,310
Aluminum-copper (maximum Si, 1.5 percent)	762	775	779	768
No. 319 and variations	49,672	49,903	50,883	49,942
Nos. 122, 138	726	721	363	337
AXS–679 and variations	338,495	333,846	356,444	353,419
Aluminum-silicon-copper-nickel	28,234	27,973	25,223	25,422
Deoxidizing and other destructive uses:				
Grades 1 and 2	16,932	16,596	19,579	19,730
Grades 3 and 4	10,186	10,457	12,093	12,314
Aluminum-base hardeners	7,001	7,026	6,679	6,432
Aluminum-magnesium	1,039	1,142	905	896
Aluminum-zinc	7,067	7,312	6,440	6,658
Miscellaneous	25,317	25,597	29,623	30,186
Total	635,192	631,696	633,997	630,373

p Preliminary.
[1] Gross weight, including copper, silicon, and other alloying elements. Secondary smelters used 25,021 and 28,731 tons of primary aluminum in 1968 and 1969, respectively, in producing secondary aluminum-base alloys.
[2] No allowance was made for consumption or receipts by producing plants.

In the spring, a formerly closed plant in Buffalo, N.Y., which had recently been acquired by Sitkin Smelting & Refining Co. poured its first metal under the new ownership, operating as Sitkin-Greenfield, Inc. At the outset the plant was primarily a converting facility but was under full production of foundry ingot later in the year. A thoroughly modern air pollution control system was also being installed.

CONSUMPTION

On July 20, 1969, two American astronauts landed on the moon, and the role played by aluminum was easily visible to the more than one billion people who watched the event on television. For example, the Saturn launch vehicle is essentially all aluminum, and use of aluminum foil on the landing module (LEM) as the astronauts went about their tasks on the surface of the moon was obvious to viewers. In addition to many aluminum applications in the space program, demand continued to develop in the aviation industry where use of the new giant jet transports began. Aluminum is used in the Boeing 747 plane, for example, in its frame and skin as plate, sheet, and forgings. Other large new aircraft were also creating big demand.

According to figures prepared by the Aluminum Association from industry estimates, the percentage distribution of aluminum metal shipments to the Nation's various using industries was as follow:

Industry	Percent of total 1968	Percent of total 1969
Building and construction	22.5	21.8
Transportation	19.7	18.4
Electrical	13.2	13.2
Containers and packaging	10.2	11.0
Consumer durables	9.9	9.7
Machinery and equipment	6.9	6.5
Exports	6.4	9.3
Other	11.2	10.2
Total	100.0	100.0

Although the volume of primary aluminum sold or used by producers continued its upward trend of recent years (increases were 6 percent in 1966, 6 percent in 1967, 8.5 percent in 1968, and 12 percent in 1969), apparent consumption in the United States decreased 0.1 percent in 1969. Since exports rose markedly in 1969, it appeared that overseas markets absorbed the difference between the amount offered in the market place by producers and that quantity consumed domestically.

The building and construction industry continued to be aluminum's principal market in 1969, but vigorous growth was lacking. The leveling off of the rate of new construction starts, brought about by anti-inflation measures, began to manifest itself. A sizable offset effect came from hefty increases in the numbers of mobile homes that were constructed. Use of aluminum in mobile homes increased 35 percent in 1969 and was up to 124,000 tons at yearend.

The use of aluminum by the transportation sector also continued to climb, and the major consumer within this segment was again the automotive industry, particularly passenger automobiles, which took more than one-third of the aluminum entering the transporation market.

Aluminum also found increasing favor in the electrical industry where its use included underground distribution cable and aluminum main trunk feeder lines in commerical construction. The telephone industry used aluminum in an increasing percentage of its wiring systems during the year. Many electronic device-makers were using more aluminum in components in 1969.

A growth of about 10 percent in the use of aluminum in food and beverage packaging occurred during 1969. The easy-opening aluminum can-end showed a big gain, especially in beer and soft drink cans. As 1969 ended it was estimated that 98 percent of the beer cans and 70 percent of the soft drink cans were equipped with easy-open tops. Also, all-aluminum beer cans continued to gain favor at a rapid rate, displacing conventional steel-based cans used for this purpose.

A special supplement to a regular issue of American Metal Market used as its theme, "Aluminum . . . Meeting the Needs of the Nation in the 70's."[4] Consumption developments were covered.

[4] American Metal Market. 1969 Aluminum Supplement, Aluminum . . . Meeting the Needs of the Nation in the 70's Nov. 19, 1969, Sec. 2, 50 pp.

Table 6.—Apparent consumption of aluminum in the United States

(Short tons)

Year	Primary sold or used by producers	Imports (net) [1]	Recovery from old scrap [2]	Recovery from new scrap [2]	Total apparent consumption
1965	2,786,584	306,819	159,704	481,014	3,734,121
1966	2,958,274	350,400	136,876	556,155	4,001,705
1967	3,136,136	174,723	128,504	569,247	4,008,610
1968	3,403,055	r 442,273	154,711	662,197	r 4,662,236
1969 p	3,821,001	−17,118	140,395	715,781	4,660,059

p Preliminary. r Revised.
[1] Crude and semicrude. Includes ingot equivalent of scrap imports and exports (weight multiplied by 0.9).
[2] Aluminum content.

Table 7.—Net shipments of aluminum wrought and cast products [1] by producers

(Short tons)

	1968 r	1969 p
Wrought products:		
Sheet, plate, and foil	1,956,637	2,135,926
Rolled and continuous cast rod and bar; wire	468,255	480,840
Extruded rod, bar, pipe, shapes, drawn and welded tubing and rolled structural shapes	935,660	987,710
Powder, flake, paste	138,186	138,436
Forgings	86,285	83,494
Total	3,585,023	3,826,406
Castings:		
Sand	106,192	110,421
Permanent mold	192,334	217,022
Die	489,420	513,798
Others	6,147	7,799
Total	[2] 794,093	[2] 849,040
Grand total	4,379,116	4,675,446

r Revised. p Preliminary.
[1] Derived by subtracting the sum of producers's domestic receipts of each mill shape from the domestic industry's gross shipments of that shape.
[2] Subject to possible upward revision of approximately 10 to 15 percent.

Table 8.—Distribution of wrought products

(Percent)

	1968 r	1969 p
Sheet, plate, and foil:		
Non-heat-treatable	42.0	44.4
Heat-treatable	5.4	4.1
Foil	7.1	7.3
Rolled and continuous cast rod and bar; wire:		
Rod, bar, etc	1.8	1.9
Bare wire, conductor and non-conductor	1.4	1.2
Bare cable (including steel-reinforced)	6.9	6.2
Wire and cable, insulated or covered	3.0	3.3
Extruded rod, bar, pipe, tube, and shapes:		
Alloys other than 2000 and 7000 series	[1] 21.9	22.0
Alloys in 2000 and 7000 series	1.4	1.3
Tubing:		
Drawn	1.3	1.2
Welded, non-heat-treatable [2]	1.5	1.3
Powder, flake, and paste:		
Atomized	3.4	3.2
Flaked	(3)	(3)
Paste	.3	.3
Powder, n.e.c	.2	.1
Forgings (including impact extrusions)	2.4	2.2
Total	100.0	100.0

r Revised. p Preliminary.
[1] Includes a small amount of rolled structural shapes.
[2] Includes a small amount of heat-treatable welded tubing.
[3] Less than .1 percent.

A 12-acre complex to accomodate a wide variety of prototype housing units, from vacation cottages to a small garden apartment development, has been created at Alcoa's technical center at Merwin, Pa., about 28 miles northeast of Pittsburgh. The company is developing the tract to prove in practice the feasibility and durability of new systems and concepts aimed at achieving housing that can be efficiently mass-produced. Emphasis will be on aluminum. One fascinating innovation is the use of aluminum extrusions to supplant the traditional wooden two-by-four used in studding and other framing components. Factory manufactured trusses and studding can be fastened quickly to horizontal plates that have been premarked and prepunched. The studs are slotted at each end to receive fasteners. Such aluminum members are said to be very strong, fireproof, and termite free. Fabricated to exact dimensions, they will not warp, and are prepunched to allow passage of wiring and other utilities. Conventional siding may then be applied, or modular aluminum construction can be used, and if this is done, a house can be framed in by three or four men in 1 day and covered the second day.

The whole project is dedicated to innovation and on-the-job trial. Alcoa employees working at the technical center will live in the various units as they are erected and report regularly on their findings.[5]

STOCKS

Stocks of aluminum ingot in the hands of primary producers at yearend 1969 were down to 42,975 tons, less than one-third of an average week's shipments, as based upon an average of monthly shipments reported throughout the year. Stocks 1 year earlier had been 70,914 tons. Reduction plants also carried inventories of ingot and of aluminum in process.

On the other hand, and for the second straight year, inventories at yearend 1969 of secondary aluminum ingot were up 14 percent over the previous year's close. Based on total shipments for 1969, the yearend inventory of 32,650 tons was equal to almost 3 weeks' supply of secondary ingot. Inventories of purchased aluminum scrap in the hands of consumers at yearend totaled 47,516 tons, an increase of 6.6 percent over those at yearend of 1968, and equal to slightly more than 2 weeks' supply based upon the total volume melted or consumed during the year.

PRICES

The rising trend in aluminum prices continued during 1969. Unalloyed primary aluminum ingot prices rose from 26 cents per pound for 99.5 percent purity as the year commenced, to 27 cents early in January and increased to 28 cents in October 1969. Prices for 99.99 percent super-pure ingot also rose in parallel action from 41.5 cents per pound at the outset of 1969 to 43.5 cents per pound by yearend. Posted prices of major producer alloys and most semifabricated products also increased about 2 cents per pound during the year. Sustained demand throughout the year and low producer and primary consumer inventories throughout the world were cited by the industry as reasons for the increases. Some industry quarters expressed a view that the price increases were not reflective of demand so much as moves by the industry to develop a strong price structure, and that list prices were only rarely what a customer actually paid for his primary metal.

The price quotation service of the American Metal Market reflected that prices of various grades of smelter alloys generally had also risen during 1969. There were three price adjustments during the year, but not all alloys changed in price each time there was a change. In the schedule changes posted April 11, 1969, for example, the permanent mold casting alloy, D 132, which is used in making automotive pistons, went from 30.5 to 32.0 cents per pound (in 20 thousand-pound lots) down to 29.75 cents per pound. Alloy 218 dropped from 32.75 to 33.75 cents per pound to 32.50 cents per pound. Generally,

[5] Metals Week Magazine. Alcoa's New Housing Concepts. V. 40, No. 49, Dec. 8, 1968, pp. 3–5.

however, alloy prices ranged upward during the year from 1.25 cents per pound to 1.75 cents per pound. The popular 380 (AXS-679) and variations rose from a wide-ranged 24.5 to 27.0 cents per pound as the year began to a firm 26.5 to 27.0 cents by yearend. The most widely used permanent mold casting alloy, No. 319, started the year at 25.75 to 26.75 cents per pound and closed out the year at 28 cents.

FOREIGN TRADE

United States foreign trade in aluminum turned strikingly during 1969, reversing the trade balance of recent years. Imports of metal fell sharply (29.6 percent) below those of 1968, while exports rose 64 percent and exceeded imports by slightly more than 17,000 tons. Just 1 year previously, in 1968, there had been an import surplus of more than 442,000 tons.

Among the classes of aluminum showing greatest growth in exports were ingots, slabs, crude metal and scrap. Exports of these forms as a group, almost doubled in 1969. Japan was by far the heaviest buyer of all three classes, taking 22 percent of the total of all aluminum exported from the United States. Other buyers were West Germany with 14 percent, and Belgium-Luxembourg with 7 percent. Belgium-Luxembourg's purchases were predominately semi-fabricated forms, and West Germany took large tonnages of semis and an unusually heavy volume of scrap.

Canada continued to dominate as supplier of imported aluminum, to the United States. The drop in total aluminum imports was partially paralleled by Canada's shipments to the United States, which fell 16 percent. While Canada's total exports to the United States were lower in 1969, her share of the United States foreign aluminum purchases rose from 66 percent in 1968 to 78 percent in 1969.

Effective January 1, 1969, in accordance with "Kennedy round" trade agreements, duties on certain unwrought and wrought aluminum products were further reduced and, during the year, were as follows: (in coils), 2.0 cents per pound; unwrought (other than aluminum silicon alloys, 1.1 cents per pound; wrought (bars, plates, sheets, strip), 2.3 cents per pound.

Table 9.—U.S. exports of aluminum, by classes

Class	1968		1969	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Crude and semicrude:				
Ingots, slabs, and crude	180,279	$85,855	344,414	$172,137
Scrap	49,427	16,017	86,255	33,827
Plates, sheets, bars, etc	114,062	77,418	135,707	99,596
Castings and forgings	3,527	10,104	4,360	10,473
Semifabricated forms, n.e.c	3,538	6,235	4,134	7,722
Total	350,833	195,629	574,870	323,755
Manufactures:				
Foil and leaf	4,070	6,937	5,300	8,481
Powders and pastes (aluminum and aluminum bronze) (aluminum content)	1,287	1,593	1,299	1,510
Wire and cable	11,635	10,177	10,082	7,942
Total	16,992	18,707	16,681	17,933
Grand total	367,825	214,336	591,551	341,688

Table 10.—U.S. exports of aluminum by classes and countries

Country	1968						1969					
	Ingots, slabs, and crude		Plates, sheets bars, etc. [1]		Scrap		Ingots, slabs, and crude		Plates, sheets, bars, etc. [1]		Scrap	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Argentina	9,970	$4,644	121	$69	------	--------	14,446	$7,223	1,802	$1,263	------	------
Australia	2,783	1,365	2,194	1,640	59	$18	115	56	1,001	732	------	---------
Belgium-Luxembourg	32,509	14,631	204	292	215	59	37,046	17,560	244	485	974	$364
Brazil	10,125	4,680	47	69	------	---------	17,508	8,735	2,370	1,770	------	---------
Canada	6,144	3,287	80,099	57,170	1,430	430	9,754	6,326	88,405	68,036	9,039	3,554
Chile	763	389	390	199	16	3	1,600	803	102	184	2	1
Colombia	6,632	3,183	103	95	------	---------	33	22	213	396	3	2
El Salvador	1,134	634	215	128	------	---------	1,210	655	607	366	------	---------
France	12,085	5,673	654	611	266	88	29,862	14,494	621	793	5,010	2,023
Germany, West	8,459	4,064	3,548	3,523	17,947	5,656	47,020	23,406	4,374	4,344	28,596	11,240
Ghana	162	91	21	22	------	---------	12	19	55	57	------	---------
Hong Kong	2,196	1,076	122	122	45	15	2,594	1,341	73	79	23	7
India	3,452	1,594	71	85	------	---------	1,106	586	62	80	------	---------
Iran	2,604	1,274	200	205	3	1	6,146	3,151	268	302	------	---------
Israel	881	423	465	671	------	---------	2,116	1,104	1,004	1,513	------	---------
Italy	377	189	1,978	3,120	7,437	2,429	10,478	5,347	2,126	3,583	20,291	7,982
Jamaica	144	90	157	179	------	---------	71	50	299	445	7	3
Japan	20,389	8,736	2,734	2,842	13,478	4,340	109,698	53,915	3,246	3,800	10,860	3,998
Korea, South	9,195	4,552	21	27	589	158	9,545	4,778	102	93	224	64
Mexico	1,124	587	6,374	3,997	3	1	569	328	9,831	6,407	29	5
Netherlands	1,817	788	776	1,045	1,454	487	2,088	1,001	1,107	1,496	2,522	1,022
New Zealand	1,802	919	61	90	------	---------	1,179	691	45	83	------	---------
Pakistan	6,790	3,252	1,575	1,101	125	42	361	196	790	594	------	---------
Panama	862	384	134	89	54	18	767	368	116	264	59	20
Peru	1,412	695	112	161	528	317	1,262	643	78	122	578	301
Philippines	7,046	3,583	27	51	15	7	5,087	2,747	85	134	128	45
South Africa, Republic of	2,868	1,429	1,968	1,391	------	---------	4,661	2,488	1,854	1,511	------	---------
Spain	723	470	235	793	307	67	21	10	91	138	370	122
Sweden	2,956	1,482	496	477	------	---------	1,522	805	2,870	2,620	39	19
Switzerland	2,779	1,413	216	214	20	7	5,097	2,763	294	295	323	131
Taiwan	3,826	1,802	211	293	760	227	2,416	1,165	121	164	745	218
Thailand	2,897	1,530	29	45	------	---------	3,081	1,544	209	169	------	---------
United Kingdom	9,459	4,979	3,517	3,604	4,587	1,615	4,935	2,586	5,324	5,757	6,253	2,634
Venezuela	273	155	2,156	1,688	35	12	112	75	1,650	1,742	46	17
Vietnam, South	------	---------	6,655	3,969	------	---------	4	5	7,659	5,179	------	---------
Other	3,641	1,812	3,241	3,680	54	20	10,892	5,151	5,103	2,795	134	55
Total	180,279	85,855	121,127	93,757	49,427	16,017	344,414	172,137	144,201	117,791	86,255	33,827

[1] Includes plates, sheets, bars, extrusions, forgings, and unclassified semifabricated forms.

Table 11.—U.S. imports for consumption of aluminum, by classes

Class	1968 Short tons	1968 Value (thousands)	1969 Short tons	1969 Value (thousands)
Crude and semicrude:				
Metals and alloys, crude	685,699	$298,759	468,236	$214,845
Circles and disks	7,756	5,451	7,014	4,610
Plates, sheets, etc. n.e.c	42,243	27,311	37,579	24,343
Rods and bars	12,136	9,054	12,616	9,601
Pipes, tubes, etc	7,751	5,691	3,457	3,471
Scrap	37,521	12,134	28,850	11,003
Total	r 793,106	r 358,400	557,752	267,873
Manufactures:				
Foil	2,105	3,633	1,924	3,405
Leaf (5.5 by 5.5 inches)	(1)	16	(1)	34
Flakes and powders	289	270	773	597
Wire	715	582	837	777
Total	3,109	4,501	3,534	4,813
Grand total	r 796,215	r 362,901	561,286	272,686

r Revised.
1 1968: 2,624,000 leaves and 15,155,726 square inches of leaf; 1969: 2,690,000 leaves and 78,143,447 square inches.

Table 12.—U.S. imports for consumption of aluminum, by classes and countries

Country	1968						1969					
	Metal, and alloys, crude		Plates, sheets bars, etc.[1]		Scrap		Metal, and alloys, crude		Plates, sheets, bars, etc.[1]		Scrap	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Australia	------	---------	249	$190	224	$71	25	$10	224	$156	------	---------
Austria	------	---------	r 1,677	r 1,237	------	---------	9	6	2,568	1,937	------	---------
Belgium-Luxembourg	------	---------	9,486	5,678	185	57	15	10	7,000	4,403	------	---------
Canada	483,608	$210,301	r 13,475	r 9,587	27,924	8,738	401,423	183,863	8,175	6,919	26,352	$10,194
France	11,521	4,861	r 5,944	r 5,288	------	---------	2,664	1,288	2,082	1,652	1	1
Germany, West	(2)	1	r 3,141	r 2,557	30	7	11	12	2,297	1,822	------	---------
Ghana	47,477	23,564	------	---------	------	---------	5,823	2,876	------	---------	------	---------
Greece	12,436	4,937	16	11	------	---------	1,107	424	37	23	------	---------
Italy	(2)	1	r 11,259	r 6,547	------	---------	1	17	8,521	5,381	------	---------
Japan	951	437	r 12,164	r 7,959	------	---------	724	376	16,089	10,417	------	---------
Norway	89,740	38,919	1,645	890	960	372	50,198	23,198	944	522	------	---------
Poland	15,681	5,886	------	---------	165	59	4,078	1,643	------	---------	661	242
Spain	5,542	2,138	1,776	980	300	102	------	---------	2,974	1,723	596	227
Sweden	------	---------	169	122	581	191	------	---------	12	19	33	10
Switzerland	3,858	1,440	r 190	r 180	------	---------	------	---------	200	181	------	---------
United Kingdom	7,448	3,128	r 202	r 202	5,839	2,121	1,706	922	137	222	65	18
Venezuela	2,227	1,002	------	---------	857	314	------	---------	1	1	231	88
Yugoslavia	------	---------	r 8,248	r 5,916	------	---------	341	148	8,722	6,237	2	2
Other	5,210	2,144	r 245	r 163	456	102	111	52	683	410	909	221
Total	685,699	298,759	r 69,886	r 47,507	37,521	12,134	468,236	214,845	60,666	42,025	28,850	11,003

r Revised.
[1] Includes circles, disks, bars, rods, plates, sheets, pipes, etc.
[2] Less than ½ unit.

WORLD REVIEW

The world's primary aluminum output showed another substantial increase in 1969 when it rose 12.5 percent above that of the previous year, a rate far in excess of the annual average increases for the decade of the sixties. Two countries were new to the list of primary producers during 1969: Iceland with 13,600 tons and South Korea with 6,950 tons. Among the free world producers notable increases in output were recorded for the Netherlands, Canada, Japan, Australia, and the United States. Although only estimated, three controlled economy nations showed large increases in primary aluminum output: Rumania, mainland China, and the U.S.S.R.

Among established aluminum producing nations, Australia, India, Japan, the Netherlands, West Germany, and the United States had large increases in existing primary aluminum-producing capacity during 1969, with the greatest gain made by Japan. Five countries, Australia, India, Japan, Poland, and the United States, saw entirely new reduction plants go on stream during 1969.

Capacities of the world's primary aluminum plants at the end of 1969 are detailed in table 14. The directory of aluminum ingot producers and semifabricators of the free world, which was first released by the U.S. Department of Commerce in 1968, was revised late in 1969.[6]

[6] U.S. Department of Commerce, Business and Defense Services Administration. Foreign Free World Producers of Aluminum. Primary Ingot, Sheet, Plate, Foil and Extrusions. December 1968, with Revision of Mar. 3, 1970, 34 pp.

Table 13.—World production of aluminum by countries

(Short tons)

Country	1967	1968	1969 p
North America:			
Canada	975,439	978,699	1,098,079
Mexico	23,714	24,822	35,696
United States	3,269,259	3,255,042	3,793,062
South America:			
Brazil	41,600	45,700	47,620
Surinam [1]	34,279	48,000	58,558
Venezuela	3,400	11,100	15,200
Europe:			
Austria	86,800	94,687	105,800
Czechoslovakia [e] [2]	72,000	72,000	72,000
France	398,100	403,300	409,100
Germany:			
East [e] [2]	88,000	88,000	88,000
West	278,700	283,765	289,599
Greece	79,000	84,000	88,000
Hungary	68,000	69,000	71,000
Iceland	----------	----------	13,600
Italy	140,851	156,912	158,908
Netherlands	35,000	54,000	79,000
Norway	397,915	516,000	564,000
Poland [2]	101,700	103,000	106,704
Rumania	58,187	84,000	98,800
Spain	86,180	98,000	113,600
Sweden	37,809	61,500	73,634
Switzerland	79,697	84,700	85,098
U.S.S.R. [e] (primary)	1,064,000	1,102,000	1,213,000
United Kingdom	43,006	42,000	37,258
Yugoslavia [2]	49,100	53,000	53,300
Africa:			
Cameroon, Republic of	53,268	50,000	51,500
Ghana	43,752	120,040	124,680
Asia:			
China, mainland [e]	88,000	99,000	132,000
India	106,068	132,300	144,579
Japan [3]	421,123	531,209	626,984
Korea, South	----------	----------	6,950
Taiwan	17,020	22,000	24,371
Oceania: Australia	102,286	107,300	139,354
Total [4]	r 8,343,253	8,875,076	10,019,034

[e] Estimate. p Preliminary. r Revised.
[1] Exports.
[2] Includes secondary.
[3] Includes super-purity: 1967, 3,176; 1968, 3,912; and 1969, 4,059.
[4] Totals are of listed figures only.

Table 14.—World producers of primary aluminum

(Thousand short tons)

Country, company, and plant location	Annual capacity, yearend 1969	Ownership
FREE WORLD		
NORTH AMERICA		
United States:		
Aluminum Company of America (Alcoa):		Self 100 percent.
Alcoa, Tenn	194	
Badin, N. C	110	
Evansville (Warrick), Ind	175	
Massena, N. Y	125	
Point Comfort, Tex	175	
Rockdale, Tex	219	
Vancouver, Wash	100	
Wenatchee, Wash	175	
Total	1,273	
Reynolds Metals Co.:		Self 100 percent.
Arkadelphia, Ark	63	
Corpus Christi (San Patricio), Tex	110	
Jones Mills, Ark	122	
Listerhill, (Sheffield), Ala	220	
Longview, Wash	150	
Massena, N. Y	128	
Troutdale, Oreg	100	
Total	894	
Kaiser Aluminum & Chemical Corp.:		Self 100 percent.
Chalmette, La	260	
Mead, Wash	206	
Ravenswood, W. Va	163	
Tacoma, Wash	93	
Total	722	
Intalco Aluminum Corp. Ferndale (Bellingham), Wash	265	American Metal Climax, Inc., 50 percent, Howmet Corp. 25 percent, Péchiney Enterprises, Inc. 25 percent.
Ormet Corp., Hannibal, Ohio	240	Olin Corp. 50 percent; Revere Copper & Brass Inc. 50 percent.
Anaconda Aluminum Co., Columbia Falls, Mont	175	The Anaconda Co. 100 percent.
Consolidated Aluminum Corp. (Conalco), New Johnsonville, Tenn	140	Swiss Aluminum, Ltd. (Alusuisse) 100 percent.
Harvey Aluminum (Inc.), The Dalles, Oreg	91	Martin Marietta Corp. 87.2 percent.
National-Southwire Aluminum Co., Hawesville, Ky	44	National Steel Corp. 50 percent. Southwire Co. 50 percent.
Total United States	3,844	
Canada:		
Aluminium Company of Canada, Ltd.		Alcan Aluminium Ltd.
Arvida, Quebec	435	
Beauharnois, Quebec	45	
Isle Maligne Quebec	130	
Kitimat, British Columbia	300	
Shawinigan Falls, Quebec	90	
Total	1,000	
Canadian British Aluminium Co., Ltd. (CBA), Baie Comeau, Quebec	110	Reynolds Metals Co. 83.5 percent. Tube Investments, Ltd. 16.5 percent.
Total	1,110	
Mexico:		
Aluminio, S.A. de C.V., Vera Cruz	33	Aluminum Co. of America 44 percent. Private Mexican Interests 56 percent.
Total North America	5,132	
SOUTH AMERICA		
Brazil:		
Aluminio Minas Gerais, S.A., Saramenha, Minas Gerais	26	Alcan Aluminium Ltd.
Cia. Brasileira de Aluminio S.A. (C.B.A.), Sorocaba, Saõ Paulo	23	Industria Votorantim, Ltd. 80 percent. Government 20 percent.
Surinam:		
Suriname Aluminium Co. (Suralco), Paranam	52	Aluminum Co. of America 100 percent.
Venezuela:		
Aluminio del Caroni, S.A. (Alcasa), Matanzas	12	Reynolds Metals Co. 50 percent. Government 50 percent.
Total South America	113	

Table 14.—World producers of primary aluminum—Continued
(Thousand short tons)

Country, company, and plant location	Annual capacity, yearend 1969	Ownership
FREE WORLD—Continued		
EUROPE		
Austria:		
Salzburger Aluminium G.m.b.H. (SAG), Lend, Salzburg	13	Alusuisse.
Vereinigte Metallwerke Ranshofen-Berndorf, A.G. (VMRB) Ranshofen	82	Government.
Total	95	
France:		
Compagnie Péchiney:		Self 100 percent.
Auzat, Ariège	23	
Chedde, Haute-Savoie	9	
La Praz, Savoie	4	
L'Argentière, Haute-Alpes	22	
La Saussaz, Savoie	13	
Nogueres, Basses-Pyrénées	121	
Rioupéroux-Isère	23	
St. Jean de Maurienne-Savoie	82	
Sabart-Ariege	24	
Societé d'Electrochemie, d'Electrometallurgie et des Acieries Electriques d'Ugine (Ugine):		Ugine-Kuhlman S.A.
Lannemezan-Haute Pyrénées	58	
Venthon-Savoie	28	
Total	407	
Germany, West:		
Aluminium-Hütte Rheinfelden G.m.b.H., Rheinfelden, Baden	69	Alusuisse.
Vereinigte Aluminium-Werke A.G. (VAW):		Government.
Erftwerke, Grevenbroich	40	
Innwerke, Toging	77	
Lippenwerke, Lunen	55	
Rheinwerke	50	
Total	291	
Greece:		
Aluminium de Grèce S.A. (ADG), Distomon	83	Pechiney 72 percent, Ugine 18 percent, Government 10 percent.
Iceland:		
Icelandic Aluminium Co., Hafnarfjordur	30	Alusuisse.
Italy:		
Alcan Alluminio Italiano S.p.A.:		
Borgo-Franco d'Ivrea	7	Alcan.
Montecantini-Edison S.p.A.:		
Bolzano	66	Government 11 percent, Montecantini Edison 89 percent.
Mori	26	
Societe Alluminio Veneto per Azioni S.p.A. (SAVA):		Alusuisse.
Fusina	33	
Portó Marghera	30	
Total	162	
Netherlands:		
Aluminium Delfzijl N.V. (Aldel), Delfzijl	79	Hoogovens 50 percent, Alusuisse 33 percent, Billiton 17 percent.
Norway:		
Alnor A/S (Alnor), Karmay Island	85	Harvey 49 percent, Norsk Hydro 51 percent.
A/S Ardal og Sunndal Verk (ASV):		
Ardal	127	Government 50 percent, Alcan 50 percent.
Høyanger	33	
Sunndalsora	132	
Det Norske Nitridaktieselskap (DNN):		
Eydehavn	13	Alcan 50 percent, British Aluminium 50 percent.
Tysseldal	22	
Mosjøen Aluminiumverk A/S (Mosal), Mosjoen	99	Alcoa 50 percent, Elekem 50 percent,
Søer-Norge Aluminium A/S (Soral), Husnes	66	Alusuisse 100 percent.
Total	577	

Table 14.—World producers of primary aluminum—Continued

(Thousand short tons)

Country, company, and plant location	Annual capacity, yearend 1969	Ownership
FREE WORLD—Continued		
EUROPE—Continued		
Spain:		
Aluminio Espanol S.A. (Alumespa), Sabinanigo, Huesca	14	Pechiney.
Aluminio de Galicia, S.A. (Alugasa), La Coruña	38	Pechiney 70 percent, Endasa 15 percent, Government 15 percent.
Empresa Nacional del Aluminio, S.A. (Endasa):		Government 54 percent, Alcan 25 percent, Spanish interests 21 percent.
Aviles	40	
Valladolid	26	
Total	118	
Sweden: A/B Svenska Aluminiumkompaniet (Sako), Sundsvall, Kubikenborg	74	Svenska Metallverken 79 percent, Alcan 21 percent.
Switzerland:		
Swiss Aluminium Ltd. (Alusuisse):		Alusuisse 100 percent.
Chippis	40	
Steg	33	
Usine d'Aluminium Martigny, S.A., Martigny	12	Self 100 percent.
Total	85	
United Kingdom: The British Aluminium Co., Ltd. (Baco).		Tube Investments, Ltd. 49 percent, Reynolds Metals Co. 48 percent.
Kinlochleven, Scotland	12	
Lochaber (Ft. William), Scotland	28	
Total	40	
Yugoslavia: State-owned works:		State owned.
Kidricevo, Slovenia	55	
Lozovac	7	
Razine	4	
Total	66	
Total Europe	2,107	
AFRICA		
Cameroon: Compagine Camerounaise de l'Aluminium Péchiney-Ugine (Alucam), Edea	58	Péchiney 48 percent, Ugine 12 percent, Cobeal 10 percent, Comal Cie, 30 percent.
Ghana: Volta Aluminium Corp. (Valco), Tema	121	Kaiser 90 percent, Reynolds 10 percent.
Total Africa	179	
ASIA		
India:		
Aluminium Corp. of India Ltd. (Alucoin), Asansol, West Bengal	10	Self 100 percent.
Hindustan Aluminium Corp. Ltd. (Hindalco), Rendkoot, Uttar Pradesh	83	Kaiser 27 percent, Birla and Indian Interests, 73 percent.
Indian Aluminium Co. Ltd. (Indal):		Alcan 65 percent, Indian Interests, 35 percent.
Belgaum, Bombay	33	
Alupuram, Kerala	19	
Hirakud, Orissa	28	
Madras Aluminium Co. Ltd. (Malco), Mettur, Madras	28	Montecantini Edison 27 percent, Madras State Government 73 percent.
Total	201	
Japan:		
Mitsubishi Chemical Industries, Ltd., Naoetsu	123	Self 100 percent.
Nippon Light Metal Co. Ltd. (NKK):		Alcan 50 percent, Japanese interests 50 percent.
Kambara	120	
Hokkaido (Tomakomai)	64	
Niigata	66	
Showa Denko K. K.:		Self 100 percent.
Chiba	90	
Kitakata	48	
Omachi	28	
Sumitomo Chemical Co., Ltd.:		Self 100 percent.
Isoura	64	
Kikumoto	36	
Nagoya	55	
Total	694	

Table 14.—World producers of primary aluminum—Continued

(Thousand short tons)

Country, company, and plant location	Annual capacity, yearend 1969	Ownership
FREE WORLD—Continued		
ASIA—Continued		
South Korea:		
Korean Aluminum Co. (S. Korea, Han Kuk), Ulsan	18	Korean interests 100 percent.
Taiwan: Taiwan Aluminium Corp. (Taialco), Kaohsiung (Takao)	42	Government.
Total Asia	955	
OCEANIA		
Australia: Alcan Australia, Ltd., Kurri-Kurri	30	Alcan 80 percent, Other interests, 20 percent.
Alcoa of Australia Pty. Ltd., Point Henry (Geelong)	99	Alcoa 51 percent, Australian interests 49 percent.
Comalco Industries Pty. Ltd., Bell Bay, Tasmania	81	Kaiser 50 percent, Conzinc Rio Tinto of Australia, Ltd. 50 percent.
Total	210	
Total free world	8,733	
COMMUNIST COUNTRIES		
EUROPE		
Czechoslovakia: Ziar Aluminium Works, Ziar-on-Hron	68	State owned.
Germany, East: Electrochemisches Kombinat:		State owned.
Bitterfeld	55	
Lautawerk	20	
Total	75	
Hungary: Magyarsoviet Bauxite Ipar:		State owned.
Ajka	19	
Inota	32	
Tatabanya	15	
Total	66	
Poland: Ministry of Heavy Industry:		State owned.
Konin Works (1)	61	
Konin Works (2)	47	
Skawina Works	61	
Total	169	
Slatina	112	State owned.
Tarnaveni	13	
Total	125	
U.S.S.R.:		
Bogoslovsk (Krasnoturinsk), Sverdlovskaya Oblast, Urals	155	State owned.
Bratsk, Irkutskaya Oblast, Siberia	295	
Irkutsk (Shelekhovo), Irkutskaya Oblast, Siberia	220	
Kamensk-Ural'skiy, Sverdlovskaya Oblast ,Urals	150	
Kanaker (Yerevan), Armenia	80	
Kandalaksha, Murmanskaya Oblast	35	
Krasnoyarsk, Krasnoyarskiy Kray, Siberia	250	
Nadvoitsy, Karelskaya, A.S.S.R.	40	
Novokuznetsk (Stalinsk), Kemeroyskaya Oblast, Siberia	175	
Sumgait (Kirovabad), Azerbaijan	90	
Volgograd (Stalingrad) Volgogradskaya Oblast	135	
Volkhov (Zvanka), Leningrad Oblast	22	
Zaporozhye (Dneprovsk), Zaporozh-Skaya Oblast, Ukraine	80	
Total	1,727	
Total Europe	2,230	
ASIA		
China, mainland: Twenty locations	210	
North Korea: Three locations	39	
Total Asia	249	
Total communist countries	2,765	

Australia.—Australia saw its third aluminum smelter go into operation on November 14, 1969, when Alcan Australia Limited and associated Australian investors inauguarated the 30,000-ton-per-year smelter at Kurri Kurri, 25 miles west of New Castle in New South Wales. As soon as the plant was operational, expansion to 50,000 tons was begun. Alcoa of Australia's Point Henry smelter in Victoria matured from 40,000 tons to 99,200-ton-per-year capacity. Australia also welcomed plans by Comalco Industries Pty. Ltd. to spend $9 million to increase output at its Ball Bay, Tasmania, plant from its present 80,000-ton-per-annum capacity via a third line of reduction furnaces, to about 105,000 tons by 1972. This will establish Bell Bay as Australia's largest primary aluminum smelter.

In addition, alumina refinery capacity and bauxite mine production boomed in 1969 and came close to pushing the United States out of its leading slot among the world's alumina producing nations. Details are in the Minerals Yearbook chapter on Bauxite.

Production from Australia's burgeoning aluminum metal plants was destined for consumption domestically, particularly in construction, packaging, and transportation sectors. Under promising marketing arrangements, success in expanding markets in Southeast Asia, Japan, and elsewhere seemed assured, at least to the mid-seventies.

By the end of 1969, Australia's metal capacity stood at 210,000 short tons per year, up from 127,000 tons 1 year earlier.

France.—Lack of low-cost electricity confined France's primary aluminum output to a 1-percent increase, despite strong demand. Additional power will be made available in 1970, which should permit an increase in production from about 410,000 tons in 1969 to about 450,000 tons within 2 years.

Although there was little increase in primary aluminum production in France during 1969, considerable progress was achieved in the output of secondary aluminum. Against an output of 69,000 tons in 1967 and 81,100 tons in 1968, France produced nearly 100,000 tons in 1969.

Germany, West.—Consumption of aluminum rose to an alltime high in 1969 and, since all capacity in the nation was being used, much was imported. About one-third of the imports come from common market sources. Looking ahead, West German consumption by 1975 was expected to rise about 70 percent over that of 1969.

To keep pace with such requirements, expansion of existing plants and construction of new units was under way that would increase West Germany's capacity by about 650,000 to 770,000 tons per year by 1972. The Vereinigte Aluminium-Werke plant at Innwerk doubled its production during the year. Among the first to be operational was the 22,000-ton-per-year Gebrueder Giulini G.m.b.H. smelter at Ludwigshafen.

In late 1969, Kaiser Aluminum & Chemical Corp. joined with Preussag A.G. to form a new major integrated aluminum complex to serve Germany, Italy, Belgium, and Switzerland. The new firm, Kaiser-Preussag Aluminium, will be equally held, and a smelter already begun by the two companies at Voerde was contributed to the pooled operation. This operation will boost fabricating facilities plus production and marketing components for a variety of aluminum products. Headquarters of Kaiser-Preussag is at Düsseldorf. The firm will have about 2,000 employees when at full operational status. Other plants also were on the way.

Secondary aluminum was also under great pressure, and in 1969 production rose about 24 percent over that of the previous year.

Iceland.—Initial production of primary aluminum began during the summer of 1969 at Iceland's first aluminum plant located at Hafnarfjördhur, near Reykjavik. Ultimate planned output is around 85,000 tons by 1975, to be achieved in annual increments, depending upon expansion of the plant's power supplies. The Icelandic Aluminium Co. Ltd., a subsidiary of Alusuisse, was to use alumina from the parent company at startup, but later intends to use alumina produced in Australia by a Swiss-Australian consortium known as Nabalco Pty, Ltd.

India.—India's primary aluminum production capacity in 1969 was 200,000 tons per year, and a target goal of 300,000 tons, considered to be approaching adequacy, were expected by mid-decade.

Until a very few years ago, India's aluminum consumption went almost exclusively into kitchen utensils, simple household appliances, and window frames. By 1969 it was being used extensively as a substitute for costly imported copper and its alloys, and for uses normally employing such metals as stainless steel, silver, gold, nickel, zinc, plastics, etc. Bauxite is relatively plentiful in India, whereas most other ores of nonferrous metals are not adequate.

In 1969 there were four companies actually producing aluminum from six smelters in India; two new firms, including the Government-owned Bharat Aluminium Co., Ltd., had entirely new plants on the drawing boards. The $60 million Belgaum plant of the Indian Aluminium Co. (owned 35 percent by Indian shareholders and 65 percent by Alcan Aluminium, Ltd.) in Mysore State went into production in October 1969; rated capacity was 33,000 tons per year. It produced about 5,000 tons in 1969, but was expected to turn out a near capacity tonnage in 1970.

Consumption of seconday aluminum in India approached 14,500 tons in 1969, which is equal to the amount used in the United States in about 3 weeks.

Iran.—In December 1969 the German firm of Klöckner-Humboldt-Deutz and their consortial partners, Brown, Boveri and Co., A.C. of Mannheim announced receipt of an order from the Iranian Aluminium Co. Ltd. (Iralco) for erection of Iran's first aluminum smelter to cost about $40 million. Site is about 200 miles southwest of Teheran. The 45,000-ton-per-year smelter will be in the industrial area of Araq, where transportation and climate are favorable. Alumina will be imported. Two potlines are planned, each containing 140 cells operating on 70 kiloamps with discontinuous and baked anodes. The plant foundry will be equipped with four 30-ton holding furnaces and a homogenization furnace.

Power facilities, carbon electrode production, laboratory, workshop, and all other necessary facilities are to be built at the site. The site will be served with special railroad equipment and via the Persian Gulf port of Bandar Shapur.

Japan.—Japan's rapid economic growth in the 1960's influenced growth in aluminum demand beyond even the most optimistic estimates of the industry. Long and short-term forecasts were under constant upward revision, and demand for more than 1 million tons per year appeared likely by 1970. Japan's capacity by 1969 was around 700,000 tons; the difference was supplied by imports. There are five companies in Japan engaged in aluminum smelting and in 1969 there were 10 plants actively operating. Also, there were seven projects under way to expand Japan's near future aluminum capacity.

The 64,000-ton-per-year reduction plant of the Nippon Light Metal Co. Ltd., (NKK) at Tomakomai, Hokkaido, became operational late in the year, and produced about 1,600 tons of primary aluminum in 1969. Full output was anticipated in 1970. An adjacent site was being prepared for construction of an alumina refinery which would be completed in 1972. Alcan supplied technical aid to the project and also assisted in establishing raw materials supply. Nippon Light Metal was also projecting an increase in the capacity of its Niigata plant from the present 66,000 tons per year to 155,000 by 1972 with some on stream production in 1971.

Korea, South.—In July 1969, South Korea's first aluminum reduction plant was offically inaugurated at Ulsan, north of Pusan on the Sea of Japan. Capacity was around 17,500 short tons, but production in 1969 was about 3,500 tons with full output anticipated in 1970. Japanese aluminum interests lent technical and other assistance. An extrusion plant was located nearby, and at Seoul a 2,000-ton-per-year aluminum foil plant was contemplated.

Netherlands.—On April 14, 1969, Koninklijke Nederlandsche Hoogovens en Staalfabrieken N.V. and N.V. Billiton Maatschappij announced the bringing together of their aluminum interests in an equally held company known as Holland Aluminium N.V. Among the units brought into Holland Aluminium was Aluminium Delfzijl (Aldel) which operates the Netherlands' only primary aluminum smelter, enlarged to 79,000 tons per year capacity in 1968. In 1969, decision was made to lengthen potlines to increase capacity to about 106,000 tons. This will be done in two stages with some increases scheduled for 1970 and ultimate step-up to be ready in 1971.

Toward mid-1969, the French aluminum producer, Péchiney, announced plans to build Holland's second smelter, of about 83,000-ton-per-year capacity, near Flushing in the province of Zeeland. Aiming at production in 1973, output will be sold to the Benelux countries and France. The location near the North Sea will also make overseas export possible.

New Zealand.—In October 1969, Kaiser Engineers & Constructors, Inc., was awarded a contract which ultimately will result in New Zealand's first primary aluminum smelter. Owner and operator will be New Zealand Aluminium Smelters, Ltd., a firm owned 50 percent by Australia's Comalco Industries Pty. Ltd. and 25 percent each by two Japanese aluminum producers, Showa Denko K.K. and Sumitomo Chemical Co., Ltd. By late 1971, output from the plant's initial capacity of 85,000 short tons will begin. Increased capacity, as needed and up to 250,000 short tons, has been incorporated in the plans. The NZ $92 million plant will be located near Bluff, close to the southerly tip of New Zealand's South Island where a deep water harbor and low-cost electric power from the NZ $98 million Lake Manapouri hydroelectric project (now under construction) will be available. Alumina will be supplied by Comalco from Australian bauxite mined at Weipa and refined at Gladstone, Queensland.

Norway.—A very dry summer in 1969 resulted in a shortage of hydroelectricity, which caused some of the eight Norwegian aluminum smelters to curtail output. Heavy demand, mostly export, then led to reduction in stocks because of the curtailment in production.

Construction of the first stages of a new smelter for Elektro Kemisk A/S (Elkem) and Alcoa, at Lista in Southern Norway, started in 1969. This 36,000-ton facility is scheduled to become operational early in 1971.

Det Norske Nitridaktieselskap increased output at their 22,000-ton plant at Tyssedal in South Central Norway during 1969 by about 4,500 tons.

Poland.—The Government-owned aluminum smelting complex at Konin may have been almost doubled in size during 1969 if reported startup at the new Konin-2 reduction plant is correct. Konin-1 has a capacity of around 60,000 tons, and Konin-2 is said to be capable of about 48,000 additional tons when it begins operation. At present, the plant is understood to be importing its alumina, and work is going forward on a direct bauxite-to-aluminum process, but all details are very sketchy. Another plant in Poland, at Skawina, has about the same productive capability as Konin-1.

Rumania.—Rumania's productive capacity increased 33 percent in 1969 over previous years when expanded facilities went into operation at the Slatina reduction plant, raising capability of the plant to 112,500 tons. The country's total capacity is 125,000 tons. Availability of adequate electricity, labor, and of some raw materials are cited as reasons for the choice of Slatina as the locale for this Government-owned and operated plant.

TECHNOLOGY

Producer interest has been growing in the concept of increasing aluminum potline efficiency by adding lithium carbonate to the cryolite baths. While most of the major producers have experimented with lithium compounds in the laboratory, it appears that during 1969 interest in lithium has received new impetus.[7] Individual producers have purchased sufficient lithium carbonate to intimate testing on production-size potlines. The addition of lithium carbonate, which converts to lithium fluoride and carbon dioxide in the bath, can theoretically increase a cell's capacity by 15 percent. The use of lithium carbonate must be justified by factors such as cost of the compound and need for reduced power requirements. No major changes are required in the cell for the use of lithium carbonate. For any expansions or new plants contemplated by producers, lithium carbonate will certainly be an important consideration in plant design and operation.

In laboratory studies it was found that although LiF and Li_3AlF_6 increased the electrical conductivity, the effect of the former is more pronounced and more attrac-

[7] Metals Week. Lithium Use in Potlines Climbing. V. 40, No. 9, Mar. 3, 1969, p. 6.

tive with regard to the technology of aluminum production.[8]

The Bureau of Mines developed a method of electro-winning aluminum from molten $ALCl_3$. Anode current efficiencies of 64 to 84 percent were attained.[9] In addition, a procedure was patented by the Department of the Interior for extracting aluminum values from the mineral dawsonite which occurs in oil shale.[10] The product is a substantially sulfur-free sodium aluminate.

Of particular interest to conservationists is a method of producing alumina from a wide range of aluminiferous raw materials.[11] It may be possible to use waste materials such as clay and slate overburden from coal mines, flyashes, and slags in this aluminum oxide manufacturing process. The procedure involves the extraction of aluminates by aqueous soda solutions, desilication of the solution, followed by carbonization to obtain crystalline aluminum hydroxide, and finally calcination of the hydroxide to yield sintered aluminum oxide. The method gives no waste products, since the aluminum oxide, cement, and combustion gases are all utilized.

A cooperative effort between the National Bureau of Standards and private industry has resulted in the production of the highest purity aluminum in the United States, and probably the world.[12] This aluminum, containing less than 0.2 parts per million in impurties, is an excellent conductor of electricity at very low temperatures. Therefore, it has potential for use in large cryogenic-magnet devices used in accelerators, bubble chambers, and magnetohydrodynamic applications.

Electric batteries using aluminum metal or aluminum compounds were reported as having possible application in electric automobiles. One of these systems utilized a battery of solid Al-Li alloy anodes, active carbon plate cathodes, and a fused LiCl-KCl electrolyte.[13]

Aluminum is being increasingly used to replace copper in the electrical industry. The short-term difficulty for manufacturers and users is not so much the price differential between copper and aluminum as the fluctuations in the price of copper. For the long term, it is expected that the cost of conductivity by copper will be at least three times that of using aluminum.[14]

Technological improvements are continuing in the automotive field and such improvements will contribute to increased aluminum use in automobiles.[15] Development of the hypereutectoid Al-Si alloys will continue, giving them improved wear resistance so as to eliminate completely the need for cast iron cylinder liners. In the face of rising copper costs, aluminum may find use in car radiators as new radiator plants, designed to use aluminum, are built. Aluminum-coated steel may be employed to give the extra protection needed against road de-icing compounds.

A draw die cladding process has been developed that can decorate aluminum shapes with strip material; for example, stainless steel, copper, and plastic/metal laminates.[16] Doors fabricated from stainless steel clad aluminum extrusions cost 50 percent less than a door made with roll-formed shapes. The saving in cost and weight can be especially valuable in the furniture industry.

The Bureau of Mines continued to investigate reclamation and recycling of aluminum as part of its solid waste effort. In one of the projects, residue from municipal incinerators was processed to yield a nonferrous fraction containing mostly aluminum with smaller amounts of other metals such as zinc and copper. This fraction was fed to a molten salt sweating furnace, and the product was electrorefined at

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[8] Matiasovsky, K., V. Danek, and M. Malinovsky. Effect of LiF and Li_3AlF_6 on the Electrical Conductivity of Cryolite-Alumina Melts. J. Electrochem. Soc., 116, No. 10, October 1969, p. 1381.

[9] Singleton, E. L., D. E. Kirby and T. A. Sullivan. Electrowinning Aluminum From Aluminum Chloride. BuMines Rept. of Inv. 7212, December 1968, 19 pp.

[10] Hite, R. J. (assigned to United States of America, represented by Secretary of the Interior). Process for Extracting Aluminum Values from Oil Shale. U.S. Pat. 3,481,695, Dec. 2, 1969.

[11] Singhal, R. K. Aluminum Without Bauxite. Can. Min. J., v. 90, No. 11, November 1969, p. 69.

[12] National Bureau of Standards Technical News Bulletin. Ultrapure Aluminum Produced. V. 53, No. 5, May 1969, p. 110.

[13] Rightmire, R. A., J. W. Sprague, W. N. Sorensen, T. H. Hacha, and J. E. Metcalfe. A Sealed Lithium Chloride, Fused Salt Secondary Battery. Soc. Auto. Eng. J., v. 77, No. 5, May 1969, p. 123.

[14] Gillespie, B. D. Aluminum and the Electrical Industry. Electronics and Power, v. 14, June 1968, p. 231.

[15] Sjogren, G. O. H. Automobile Materials and Processing in the Next Decade. Mach. Shop and Eng. Mfr., v. 30, No. 1, January 1969, p. 20; v. 30, No. 2, February 1969, p. 23.

[16] Chu, A. New Process Clads Extrusions With Stainless Steel. Mod. Metals, v. 25, No. 8, September 1969, p. 37.

an average cathode current efficiency of 77 percent. The refined product contained over 99 percent aluminum.

In another project, a laboratory investigation was conducted of a sinter-leach method to recover aluminum and fluorine from waste carbon potlining residues from secondary cryolite recovery operations in aluminum reduction plants. Ultimate processing and treatment resulted in a recovery of high percentages of aluminum and fluorine as a mixture of synthetic cryolite and alumina.[17]

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[17] Good, P. D. and W. G. Gruzensky. Extraction of Aluminum and Fluorine From Leached Potlining Residues. BuMines Rept. of Inv. 7264, June 1969, 9 pp.

Antimony

By L. E. Davis [1]

A depleted surplus, high consumption, lower imports, dwindling industry stocks, and higher prices comprised the domestic antimony story in 1969. Available supply was short of demand, and prices rose without interruption. Prices began the year at $7 per long ton unit for 60 percent lump ore in the European market and had reached $25 by yearend. No quotations were listed for domestic ores in 1969. Metal price advances were equally spectacular. Domestic primary metal rose from 44 cents per pound in January to $1.04 in mid-December. Imported metal prices nearly tripled, advancing to $3 in the same period.

Domestic mine production rose to the highest level since 1952, primary smelter production rose for the second successive year, primary consumption dropped appreciably below the 1968 figure, and imports were in a 3-year decline.

Effective January 1, 1969, the "General Modification of Tariff Schedules of the U.S.," Federal Register Document 67–14749, filed on December 18, 1967, reduced the import duty on antimony metal, TSUS No. 632.02, from 1.8 cents to 1.5 cents per pound. Further reductions are scheduled for the metal each year through 1972.

Legislation and Government Programs.—On March 12, the General Services Administration (GSA) announced the sale of all remaining antimony stocks available for disposal under Public Law 88–615, dated October 2, 1964. Of the 2,383 tons sold, 252 tons was liquated ore and the remainder was metal of all grades. Remaining in excess of the stockpile objective was 21,463 tons, 159 tons of which was nonstockpile grade. In August, a reassessment of antimony stockpile objectives by the Office of Emergency Preparedness (OEP) increased the objective to 50,500 tons, eliminating the previously declared surplus. Additionally, GSA sold the remainder of the more than 10,000 tons of stockpiled antimonial lead, for which there were no stockpile objectives.

DOMESTIC PRODUCTION

MINE PRODUCTION

Output of cathode metal from the electrolytic plant of Sunshine Mining Co., Coeur d'Alene district, Idaho, represented a very high percentage of domestic antimony production in 1969. Silver ores from the Sunshine mine and adjacent properties were the source for the metal. Overall production rose nearly 10 percent above that in 1968. The company announced that a new antimony plant and a new silver refinery would be built, and that construction of the facilities probably will be placed open for bids early in 1970.

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[1] Physical scientist, Western Field Operation Center, Spokane, Wash.

Table 1.—Salient antimony statistics

(Short tons)

	1965	1966	1967	1968	1969
United States:					
Production:					
Primary:					
Mine	845	927	892	856	938
Smelter [1]	12,389	14,539	12,466	12,489	13,203
Secondary	24,321	24,258	23,664	23,699	23,840
Exports of ore, metal and alloys	14	29	82	109	207
Imports, general (antimony content)	14,879	19,712	17,419	17,343	17,032
Consumption [1]	16,919	19,681	17,350	18,520	17,843
Price: New York, average cents per pound	45.75	45.75	45.75	45.75	57.57
World: Production	69,456	67,627	63,565	67,737	72,059

[1] Includes primary antimony content of antimonial lead produced at primary lead smelters.

About 25 tons of metal contained in antimony concentrates produced at the Stampede mine, Kantishna district, Alaska, in 1969 and prior years, was shipped to Nagoya Japan. In Nevada, the Gold Creek mine, Elko County, and the Smokey claims, Humboldt County, yielded very small tonnages of antimony ore that was consigned to the Laredo, Tex., smelter of the National Lead Co.

The Stibnite mine, Sanders County, Mont., was idle in 1969, but late in the year the property was sold to the U.S. Antimony Corp. The purchase agreement was signed December 3, 1969, and the price of $60,000 was to be paid in installments by November 1, 1973. Deeper development of the Wells Fargo mine, Stevens County, Wash., was resumed following winter shutdown. Miners were drifting on veins intersected by the 500-foot adit completed in 1968. Development ore was stockpiled. Values were mostly in antimony and silver. Some diamond drilling was conducted in an attempt to locate a possible parallel structure.

SMELTER PRODUCTION

Primary.—Production of antimony metal, oxide, and other products was nearly 6 percent above the 1968 figure. Domestic sources supplied 17 percent of the total, chiefly as a coproduct from silver ores or a byproduct of lead ores. Foreign antimony ores and concentrates or byproduct antimony from lead ores yielded 83 percent at the primary production. About 74 percent of the byproduct antimony recovered at primary lead refineries was consumed at the refinery in the manufacture of antimonial lead; the remainder was processed to oxide. Primary smelter products were divided as follow: Oxide, 59 percent; metal 24 percent; antimonial lead, 14 percent; and sulfide and residues, 3 percent.

National Lead Co. at Laredo, Tex., and Sunshine Mining Co., Big Creek, Idaho, produced antimony metal. McGeen Chemical Co., M & T Chemicals, Inc., and Harshaw Chemical Co. were the principal producers of antimony oxide; Foote Mineral Co. and Hummel Chemical Co. processed most of the ore that was consumed as a sulfide. American Smelting and Refining Co. was the major producer of byproduct antimony.

Secondary.—Secondary antimony recovery, from lead scrap, was slightly higher than in 1968. The overall increase was credited to secondary lead plants as recoveries at primary lead smelters declined about 25 tons. Manufacturers and foundries recovered 705 tons of antimony in processing scrap, 36 tons more than in 1968. Old scrap sources represented 88 percent of the total secondary antimony consisting of the following: Batteries, 70 percent; type metal, 19 percent; babbit, 5 percent; and all other material, 6 percent. Drosses and residues were the sole sources for secondary antimony recovered from new scrap, contributing 12 percent of the total. Over 3,900 tons of primary antimony was required to supplement the secondary metal available in order to meet consumer specifications; this was 470 tons more than in 1968.

Table 2.—Antimony mine production and shipments in the United States

(Short tons)

Year	Antimony concentrate	Antimony	
	Quantity	Produced	Shipped
1965	4,711	845	848
1966	5,582	927	930
1967	5,402	892	828
1968	5,263	856	941
1969	5,707	938	943

Table 3.—Primary antimony produced in the United States
(Short tons, antimony content)

Year	Class of material produced					Total
	Metal	Oxide	Sulfide	Residues	Byproduct antimonial lead	
1965	4,216	6,485	94	205	1,389	12,389
1966	4,567	7,794	126	219	1,833	14,539
1967	4,002	6,612	71	249	1,532	12,466
1968	3,617	6,518	133	417	1,804	12,489
1969	3,129	7,746	95	330	1,903	13,203

Table 4.—Secondary antimony produced in the United States, by kind of scrap and form of recovery
(Short tons, antimony content)

Kind of scrap	1968	1969
New scrap:		
Lead-base	2,586	2,860
Tin-base	86	62
Total	2,672	2,922
Old scrap:		
Lead-base	20,998	20,893
Tin-base	29	25
Total	21,027	20,918
Grand total	23,699	23,840

Form of recovery	1968	1969
In antimonial lead [1]	17,365	17,948
In other lead alloys	6,309	5,879
In tin-base alloys	25	13
Total	23,699	23,840
Value (millions)	$21.7	$27.4

[1] Includes 203 tons of antimony recovered in antimonial lead from secondary sources at primary plants in 1968 and 179 tons in 1969.

Table 5.—Byproduct antimonial lead produced at primary lead refineries in the United States
(Short tons)

Year	Gross weight	Antimony content				
		From domestic ores [1]	From foreign ores [2]	From scrap	Total	
					Quantity	Percent
1965	27,895	998	391	595	1,984	7.1
1966	24,059	1,417	416	286	2,119	8.8
1967	18,608	983	549	185	1,717	9.2
1968	28,363	1,300	504	203	2,007	7.1
1969	24,741	1,174	729	179	2,082	8.4

[1] Includes primary residues and a small quantity of antimony ore.
[2] Includes foreign base bullion and small quantities of foreign antimony ore.

CONSUMPTION AND USES

Industrial antimony requirements were satisfied from both primary and secondary sources. Total consumption eased to 41,683 tons in 1969 from 42,220 tons in 1968. Primary antimony accounted for 43 percent of the total (17,843 tons), and secondary metal accounted for 57 percent (23,840). The manufacture of antimonial lead and other hard-lead alloys consumed virtually all secondary antimony production. The Bureau of Mines does not receive reports on secondary antimony consumption. Therefore, tables 6 and 7 are confined to industrial consumption, by use, for primary metal only.

Primary antimony consumption was nearly 4 percent below the comparable 1968 figure. Requirements for metal products were lower in most categories. Notable exceptions were for use in bearings and bearing metal, type metal, and collapsible tubes and foil. No change was reported for sheet and pipe use. The quantity of antimony used in nonmetal products dropped

Table 6.—Industrial consumption of primary antimony in the United States

(Short tons, antimony content)

Year	Class of material consumed						Total
	Ore and concentrate	Metal	Oxide	Sulfide	Residues	Byproduct antimonial lead	
1965	404	6,992	7,847	81	206	1,389	16,919
1966	450	6,269	10,829	81	219	1,833	19,681
1967	312	5,666	9,514	77	249	1,532	17,350
1968	299	6,561	9,363	75	418	1,804	18,520
1969	507	6,275	8,756	72	330	1,903	17,843

Table 7.—Industrial consumption of primary antimony in the United States, by class of material produced

(Short tons, antimony content)

Product	1965	1966	1967	1968	1969
METAL PRODUCTS					
Ammunition	36	154	209	156	115
Antimonial lead	6,382	6,285	5,539	6,817	6,723
Bearing metal and bearings	821	731	653	755	758
Cable covering	68	164	141	178	55
Castings	76	62	54	46	33
Collapsible tubes and foil	49	44	31	50	56
Sheet and pipe	104	107	118	105	105
Solder	244	155	184	255	242
Type metal	642	515	382	423	541
Other	214	219	223	258	137
Total	8,636	8,436	7,534	9,043	8,765
NONMETAL PRODUCTS					
Ammunition primers	16	27	30	33	37
Fireworks	46	50	43	37	30
Flameproofing chemicals and compounds	1,971	3,188	3,454	2,774	2,096
Ceramics and glass	1,853	2,074	1,884	2,037	2,108
Matches	W	------	------	------	------
Pigments	855	832	665	859	722
Plastics	1,469	2,224	1,785	2,318	2,558
Rubber products	477	870	948	440	433
Other	1,596	1,980	1,007	979	1,094
Total	8,283	11,245	9,816	9,477	9,078
Grand total	16,919	19,681	17,350	18,520	17,843

W Withheld to avoid disclosing individual company confidential data; included with, "Other."

nearly 400 tons, owing chiefly to a marked decline for use in flameproofing chemicals and compounds. Increases were reported for use in plastics, ceramics and glass, and ammunition primers. Of the nearly 1,100 tons classified under "other" nonmetal products, Leukonin, a sodium antimonate used as an opacifier in enamel frits, represented more than 50 percent of the total. An additional 29 percent was consumed as antimony chloride (penta- and tri-), in a wide variety of applications.

No use trends could be established from 1969 consumption data. Military needs, unusually high prices, and supply shortages have disrupted what has been considered the normal trend to a gradual rise in consumption. There was no evidence to indicate a wider use of substitute materials.

STOCKS

Reports received by the Bureau of Mines have indicated that yearend industry stocks were the lowest in 20 years. Sharp declines in ore and concentrate and in metal stocks were chiefly responsible for the overall low inventory at yearend. All other stock, except sulfide, were above the 1968 level. Most stocks dropped to their lowest point in 1969 in the middle of the second quarter, near the end of the East Coast dock strike. Except for metal stocks, they gradually increased throughout the remainder of the year. Demand exceeded supply for both metal and oxide during most of 1969.

Table 8.—Industry stocks of primary antimony in the United States, December 31

(Short tons, antimony content)

Stocks	1965	1966	1967	1968	1969
Ore and concentrate	2,735	2,720	2,469	2,791	2,227
Metal	1,585	1,572	1,719	1,323	1,273
Oxide	2,705	3,093	2,704	1,921	2,053
Sulfide	98	131	80	127	108
Residues and slags	1,088	519	916	199	307
Antimonial lead [1]	411	531	462	265	371
Total	8,622	8,566	8,350	6,626	6,339

[1] Inventories from primary sources at primary lead smelters only.

PRICES

Quotations on domestic ore prices were discontinued late in 1968 because they were unrealistic; these quotations were not reinstated during 1969. Beginning quotations for 60 percent European lump ores were $7 to $7.10 per long ton unit, and ended the year at $24 to $25. The domestic quotation for 99.5 percent antimony metal, in bulk New York, was listed at 45.75 cents per pound on January 6, and 105.75 cents on December 29. Imported metal of equal grade, duty paid New York in 5-ton lots, began the year at 43.5 to 44.0 cents and rose to $3 by yearend. Oxide was quoted at 47.5 cents per pound in carload lots in January and ended the year at 53.5 to 65.5 cents. Late in the year, M & T Chemicals, Inc., announced a 32-cent advance, to 97.5 cents per pound for antimony trioxide, effective January 1, 1970, and Stauffer Chemical Co. increased the price of antimony trichloride to $1.40 per pound, effective the same date.

Table 9.—Antimony price ranges in 1969

	Price
Type of antimony:	
Domestic metal [1] ____per pound	$0.44–1.04
Foreign metal [2] ____do	0.425–3.00
Antimony trioxide [3] ____do	0.475–0.655

[1] RMM brand, f.o.b., Laredo, Tex.
[2] Duty-paid delivery, New York.
[3] Quoted in Metals Week.

FOREIGN TRADE

Antimony Exports—alloys, metal, scrap, and waste—totaled 207 tons, almost double that of the preceding year, and the value was nearly four times the 1968 figure. Consignments were made to 21 countries. The Netherlands was the leading importer with 70 tons, followed by Canada at 30 tons. The quantity and value of antimony oxide exports increased to 142 tons and $125,895. Canada received more than half the total at 72 tons.

General imports, all forms, were about 3 percent lower compared with 1968. Imports of ore and concentrate were appreciably higher, but metal and oxide declined 62 and 2 percent, respectively. The Republic of South Africa, Bolivia, and Mexico again supplied a high percentage of the ore and concentrate imports (97 percent based on metal content). Belgium-Luxembourg, the United Kingdom, and Yugoslavia were the chief sources for metal imports (66 percent). The United Kingdom also was the major supplier of oxide (59 percent).

Other imports included 411 tons of alloy containing 83 percent or more antimony, 73 percent of which came from Mexico and the United Kingdom; 59 tons of tartar emetic from Italy and Japan; and 8 tons of other antimony compounds from West Germany and the United Kingdom. Total value of these materials was $482,000.

Table 10.—U.S. imports [1] of antimony by countries

Year and country	Antimony ore: Short tons (gross weight)	Antimony ore: Antimony content: Short tons	Antimony ore: Antimony content: Value (thousands)	Antimony metal [2]: Short tons (gross weight)	Antimony metal [2]: Value (thousands)	Antimony oxide: Short tons (gross weight)	Antimony oxide: Value (thousands)
1967	22,647	10,517	$4,090	2,681	$1,866	5,098	$3,762
1968:							
Algeria	43	15	5	------	------	------	------
Belgium-Luxembourg	------	------	------	598	476	1,336	1,033
Bolivia	3,979	2,521	1,139	33	18	------	------
Canada	------	------	------	(3)	16	------	------
Chile	77	51	26	12	4	9	5
France	------	------	------	50	30	869	655
Germany, West	------	------	------	(3)	2	183	135
Honduras	250	98	44	------	------	------	------
Italy	------	------	------	11	7	------	------
Japan	------	------	------	------	------	119	82
Mexico	8,664	2,606	459	255	146	------	------
Morocco	198	75	28	------	------	------	------
Netherlands	------	------	------	------	------	58	45
Peru	77	52	21	133	87	------	------
South Africa, Republic of	8,389	5,196	2,423	------	------	------	------
Thailand	------	------	------	155	105	------	------
United Kingdom	------	------	------	288	224	2,227	1,585
Yugoslavia	------	------	------	1,229	972	------	------
Total	21,677	10,614	4,145	2,764	2,087	4,801	3,540
1969:							
Argentina	------	------	------	28	34	------	------
Belgium-Luxembourg	------	------	------	218	237	896	786
Bolivia	4,431	2,802	1,618	35	27	------	------
Canada	------	------	------	1	28	4	5
Chile	65	52	17	------	------	------	------
France	------	------	------	------	------	846	755
Germany, West	------	------	------	(3)	8	20	15
Guatemala	95	47	18	------	------	------	------
Honduras	203	81	36	------	------	------	------
Japan	------	------	------	------	------	122	87
Mexico	8,541	2,265	383	181	97	1	1
Morocco	21	8	4	------	------	------	------
Netherlands	------	------	------	------	------	48	39
Peru	366	217	126	14	11	------	------
South Africa, Republic of	10,436	6,626	3,046	------	------	------	------
Switzerland	------	------	------	55	69	------	------
Thailand	------	------	------	43	30	------	------
United Kingdom	------	------	------	269	232	2,778	2,164
Yugoslavia	------	------	------	198	166	------	------
Total	24,158	12,098	5,248	1,042	939	4,715	3,852

[1] Data are general imports; that is, they include antimony imported for immediate consumption plus material entering bonded warehouses.

[2] Includes data for needle or liquated antimony for the following countries (value in thousands): 1968, United Kingdom, 15 tons ($10); 1969, 23 tons ($18); 1968, Belgium-Luxembourg 45 tons ($32); 1969, 39 tons ($33). Does not include alloy containing 83 percent or more of antimony.

[3] Less than ½ unit.

Table 11.—U.S. imports for consumption of antimony

Year	Antimony ore			Needle or liquated		Antimony metal [1]		Antimony oxide	
	Short tons (gross weight)	Antimony content		Short tons (gross weight)	Value (thousands)	Short tons (gross weight)	Value (thousands)	Short tons (gross weight)	Value (thousands)
		Short tons	Value (thousands)						
1967	22,647	10,517	$4,090	29	$18	2,654	$1,849	5,098	$3,762
1968	21,677	10,614	4,145	60	42	2,693	2,037	4,801	3,540
1969	24,158	12,098	5,248	62	51	980	888	4,715	3,852

[1] Does not include alloy containing 83 percent or more of antimony; 1967—Mexico 50 short tons ($39,139), Peru 122 short tons ($70,553), United Kingdom 140 short tons ($79,636), Belgium-Luxembourg 11 short tons ($7,882), Czechoslovakia 33 short tons ($18,383). 1968—Mexico 193 short tons ($157,102), Peru 351 short tons ($230,845), United Kingdom 87 short tons ($55,894), France 24 short tons ($14,528), Japan 59 short tons ($35,345). 1969—Mexico 200 short tons ($185,533), Peru 95 short tons ($72,706), United Kingdom 100 short tons ($83,928), Turkey 16 short tons ($19,548).

WORLD REVIEW

The world supply-demand balance, or lack of same, in 1969 was the product of a number of influencing factors. Demand exceeded supply in all major consuming countries. Japanese consumption rose following increased smelting capacity. The U.S.S.R., unable to obtain antimony from mainland China, was seeking sources of supply in Western markets. European demand was higher than in 1968. The Canton Fairs yielded little antimony to other than Japanese industry although some material was reported available on the European market at virtually unacceptable high prices. A spokesman for Japanese industry stated early in 1969 that contracts with Bolivia, South Africa, and mainland China would supply present antimony requirements. Late in the year, the spokesman announced that the agreements would provide needs in 1970 despite an increased smelter capacity.

Higher production rates, compared with 1968, were reported for 10 foreign countries, but only two, Bolivia and the Republic of South Africa, had significant increases. Production from Mexican mines declined for the sixth successive year.

About mid-year, Consolidated Murchison Goldfields and Development Co., Ltd., Republic of South Africa, announced that milling capacity would be increased to 45,000 tons per month. In late 1970, when expansion is completed, the company will be milling approximately twice the ore tonnage milled in 1968. Murchison exported 25,800 tons of antimony concentrates in 1969, up from 22,035 tons in 1968. New England Antimony Mines N.L. sold and delivered 150 tons of antimony from its mine in New South Wales, Australia, during the last 6 months of 1969. The company plans to place its small flotation plant on a 24-hour, 7-day-week basis to meet demand. Drilling by Mideast Minerals N.L. in the Coster field area near Heathcote, Victoria, Australia, revealed a vein structure assaying 17.8 to 19.3 percent antimony. Delta Mines drilled along the west margin of the granite plug on its northern British Columbia property and found an extensive area carrying antimony values. One hole returned an intersection of 40 feet averaging over 3 percent antimony.

Table 12.—World production of antimony (content of ore except as indicated) by countries

(Short tons)

Country	1967	1968	1969 p
North America:			
Canada [1]	634	580	423
Guatemala	33	10	110
Honduras	------	286	125
Mexico [2]	4,121	3,819	3,471
United States	892	856	938
South America:			
Bolivia [2]	12,432	12,276	14,484
Peru (recoverable) [2]	r 818	900	944
Europe:			
Austria (recoverable)	212	178	176
Czechoslovakia e [3]	r 550	660	660
France	r 184	---	---
Italy	405	865	1,272
Portugal	25	55	50
Spain	135	146	135
U.S.S.R. e	r 7,100	7,200	7,300
Yugoslavia (metal)	2,533	1,935	2,246
Africa:			
Algeria	r 112	60	66
Morocco	1,753	1,336	1,551
South Africa, Republic of	13,666	18,514	20,080
Asia:			
Burma e [2]	88	88	88
China, mainland e	13,200	13,200	13,200
Japan	19	21	6
Korea, South	73	34	e80
Pakistan e	129	93	e90
Malaysia (Sarawak)	34	25	43
Thailand e	1,131	223	827
Turkey [4]	2,244	3,446	2,811
Oceania: Australia [5]	r 1,042	931	933
Total [6]	r 63,565	67,737	72,059

e Estimate. p Preliminary. r Revised.
[1] Antimony content of smelter products.
[2] Includes antimony content of smelter products derived from mixed ores.
[3] Figures reported in previous issues were estimated metal output including metal derived from imported Turkish ores.
[4] Includes ore and concentrates.
[5] Includes antimony in lead concentrates.
[6] Totals are of listed figures only.

Production at antimony mining and processing operations in Kirghizia, U.S.S.R., was reported by Novosti to have increased by 30 percent. The antimony metal obtained by zone smelting contains virtually no admixtures of other metals, and the resulting trioxide exceeds world market specifications. A new treatment plant for the recovery of antimony was installed as an addition to the substantial increase in capacity of the lead refinery of the Heboken organization of Belgium, completed in 1968.

During 1969, a Japanese Government-sponsored survey mission was in Bolivia, Columbia, and Paraguay to study the possibility of increasing exports of primary products from the three countries to Japan. The mineral products surveyed in Bolivia by the mission included antimony.

TECHNOLOGY

Results of recent research at Gould-National Batteries, Inc., Minneapolis, Minn., were published.[2] The work shows that the addition of tin to the 4.5 percent antimony alloy retards the age-hardening process and, in high-current-density anodic corrosion, decreases the anodic corrosion-resistance of the alloy. Tin additions do not alter the ultimate tensile strength of as-cast lead-4.5 percent antimony, and additions up to 0.5 percent tin improve the castability only very slightly.

A manuscript on "Electrodeposition of Lead-Antimony Alloys" was received in

[2] Mao, F. W., J. G. Larson, and P. Rao. Effect of Small Additions of Tin on Some Properties of Lead-4.5 percent Antimony Alloy. J. Inst. Metals, v. 97, November 1969, pp. 343–350.

October 1969 for publication by the Journal of the Electrochemical Society.[3] Two fluoborate solutions capable of producing sound, thick lead-antimony deposits are described. Property data for some deposits are presented, as well as the influence of operating conditions and both composition and antimony concentration of deposits.

An article in the June 1969 issue of Mining Magazine abstracts a publication on "Determination of Antimony and Arsenic Values."[4] Spectrographic determinations of antimony and arsenic in ores, especially iron ore, were made and gave a sufficiently strong antimony and arsenic line.

Two United States patents were issued during the year pertaining to the recovery of antimony from ores and from lead in the refining process. U.S. Patent 3,432,255, issued March 11, 1969, covers a hydrochlorination process for treating molybdenite or ores of antimony, bismuth, or tin for the extraction of values therefrom. Finely divided ore is contacted with hydrogen chloride and either air or oxygen at a temperature of preferably 500° to 700° C for a period of time sufficient to volatilize the desired metal in chloride form but not to volatalize any appreciable amount of chlorides of other commonly associated metals. The desired volatile metal is recovered by condensation. U.S. Patent 3,479,179, issued November 18, 1969, covers a method for refining decopperized lead of antimony, arsenic, tin and zinc impurities. The molten lead is treated with sodium hydroxide in the absence of oxygen, and the resulting zinc and arsenic-containing slag is withdrawn. The remaining molten lead is treated with sodium hydroxide at a temperature of about 500° C in the presence of an increased concentration of oxygen, and the resulting antimony-containing slag is withdrawn, leaving the purified lead.

[3] Dini, J. W., and J. R. Helms. Material Science Division, Sandia Laboratories, Livermore, Calif.

[4] Ch. Prvchera, Rudodobiv. V. 23, No. 11, 1968, p. 42.

Asbestos

By Charles L. Readling [1]

U.S. production (shipments) of asbestos increased 4 percent to establish a record high in output, surpassing the previous high set in 1966. However, overall demand for asbestos in 1969 declined slightly primarily as a result of tight money conditions, and the resulting high interest rates restricted the availability of mortgage funds for home building. Imports decreased 6 percent from those of 1968.

Canada, the largest asbestos producer, increased output (shipments) 4 percent over that of 1968.

Legislation and Government Programs.—The Tax Reform Act of 1969, signed by the President on December 30, 1969, reduced domestic asbestos depletion rates from 23 percent to 22 percent effective with taxable years beginning after October 9, 1969. The General Services Administration (GSA) in 1969 disposed of 2,294 short tons of amosite, 2,663 tons of crocidolite, and 336 tons of chrysotile from Government inventories.

DOMESTIC PRODUCTION

Asbestos production in the United States in 1969 increased 4 percent in volume and 2 percent in value. Production was from four States: 60 percent from California; with Vermont second in rank; followed by Arizona and North Carolina.

[1] Mineral specialist, Bureau of Mines, Minneapolis, Minn.

Table 1.—Salient asbestos statistics

	1965	1966	1967	1968	1969
United States:					
Production (sales) short tons	118,275	125,928	123,189	120,690	125,936
Value thousands	$10,162	$11,056	$11,102	$10,406	$10,648
Exports and reexports (unmanufactured) short tons	43,126	46,996	47,718	41,236	36,173
Value thousands	$5,294	$5,763	$6,025	$4,679	$4,979
Exports and reexports of asbestos products (value) thousands	$19,139	$21,963	$23,767	$24,527	$28,183
Imports for consumption (unmanufactured) short tons	719,559	726,459	645,112	737,909	694,558
Value thousands	$70,457	$73,100	$65,743	$72,930	$76,422
Consumption, apparent [1] short tons	794,708	805,391	720,583	817,363	784,321
World: Production do	3,101,994	3,275,262	3,207,259	3,290,370	NA

NA Not available.
[1] Measured by quantity produced, plus imports, minus exports.

Table 2.—Stockpile objective and Government inventories as of December 31, 1969

(Short tons)

Mineral	Stockpile objective	Inventories			
		National	Supplemental	Defense Production Act	Total
Amosite	40,000	11,705	51,983	---	63,688
Chrysotile	13,700	6,224	7,576	908	14,708
Subspecification	------	152	2,692	908	3,752
Crocidolite	------	1,565	44,034	---	45,599

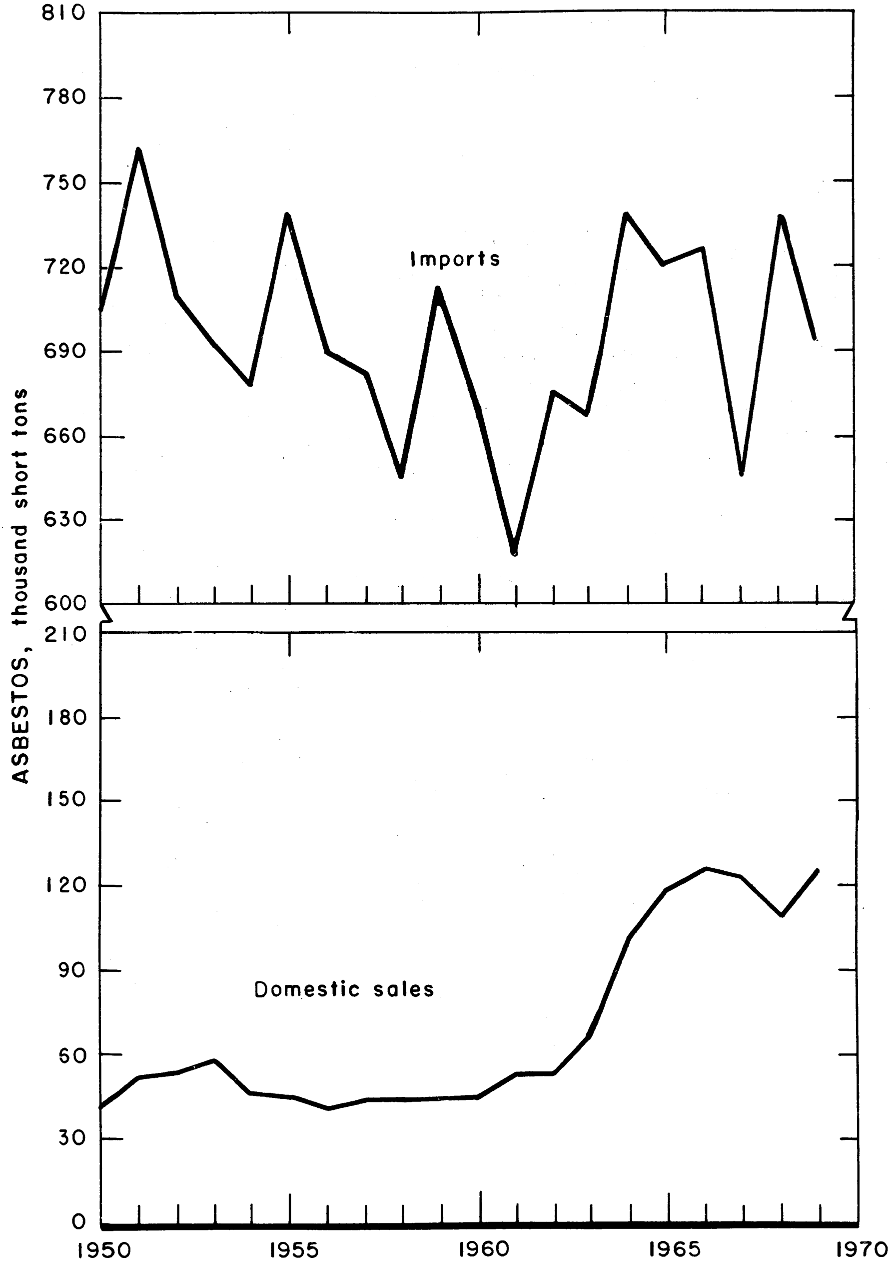

Figure 1.—United States production (sales) and imports of asbestos.

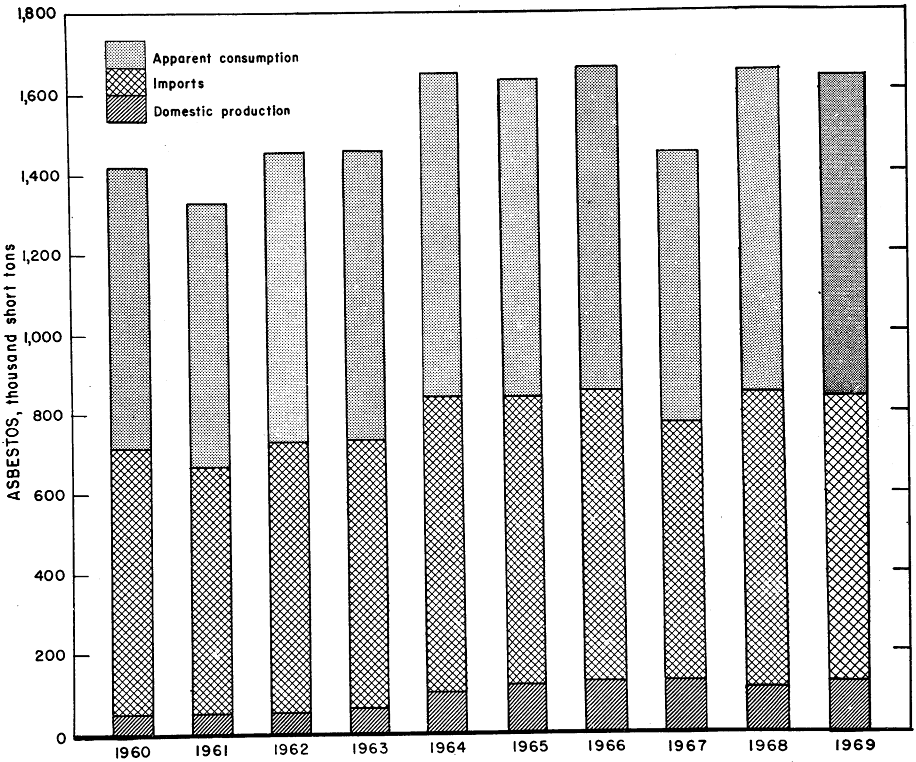

Figure 2.—Domestic supply and consumption of asbestos.

Production in California increased only slightly from 75,592 tons in 1968 to 75,828 tons in 1969; value decreased $183,000. Both quantity and value of output in Vermont rose 9 percent. Production in Arizona increased almost 30 percent. North Carolina reversed a downward trend to gain 18 percent over 1968 production. Nearly all the U.S. production was short fiber, which supplied 16 percent of domestic requirements. Asbestos producers in the U.S. are listed in the following tabulation:

State and company	County	Name of mine	Type of asbestos
Arizona:			
Asbestos Manufacturing Co	Gila	Phillips	Chrysotile.
Jaquays Mining Corp	do	Chrysotile	Do.
Metate Asbestos Corp	do	Lucky Seven	Do.
California:			
Atlas Asbestos Corp	Fresno	Santa Cruz	Do.
Coalinga Asbestos Co	do	Coalinga	Do.
Pacific Asbestos Corp	Calaveras	Pacific Asbestos	Do.
Union Carbide Corp	San Benito	Joe No. 5	Do.
North Carolina:			
Powhatan Mining Co	Yancey	Burnsville	Anthophyllite.
Vermont:			
GAF	Orleans	Lowell	Chrysotile.

CONSUMPTION AND USES

Direct and indirect uses for asbestos number about 3,000, but most of the consumption is in a few applications. An estimated 70 percent of the world's production of all types of fiber was used in asbestos cement-building materials and asbestos cement pipe.[2] The second largest use was in the floor tile industry, with U.S. consumption estimated at about 200,000 tons. Other significant uses were in the manufacture of brake linings, gaskets, clutch facings, plastics, roofing compounds, electrical and heat insulations, and textiles.

A slowdown in the building and construction industries during 1969 was reflected in a 4-percent drop in apparent consumption from the 1968 level. Chrysotile asbestos accounted for over 96 percent of the total amount consumed in the United States in 1969. Amosite accounted for slightly over 2 percent, and crocidolite accounted for less than 2 percent.

[2] Industrial Minerals (London). No. 28, January 1970, p. 12.

PRICES [3]

Effective January 1, 1969, quoted prices for Vermont, Quebec, and British Columbia asbestos were increased from 4 percent to 12 percent across grades. The increases reportedly were needed to offset higher costs of materials, labor, and equipment. Prices were not published for California chrysotile and North Carolina anthophyllite asbestos.

Quotations for Canadian (Quebec) chrysotile, f.o.b. mine, were as follows, as of January 1, 1969:

Grade	Description	Per short ton
Group No. 1	Crude	Can$1,480
Group No. 2	do	800
Group No. 3	Spinning fiber	385–630
Group No. 4	Shingle fiber	212–360
Group No. 5	Paper fiber	152–180
Group No. 6	Waste, stucco or plaster	110
Group No. 7	Refuse or shorts	50– 92

Prices for British Columbia, Canada, chrysotile asbestos, f.o.b. Vancouver, were as follows, as of January 1, 1969:

Grade	Description	Per short ton
AAA	Nonferrous spinning fiber	Can$845
AA	do	673
A	do	508
AC	Asbestos cement fiber	363
AK	Shingle fiber	249
CP	do	234
AS	do	217
CT	do	211
AX	do	193
CY	do	136
AY	do	136

Prices for Arizona chrysotile asbestos have remained unchanged since August 1, 1968. Quotations, f.o.b. Globe were as follows:

Grade	Description	Per short ton
Group No. 1	Crude	$1,410–1,650
Group No. 2	do	700– 950
AAA		800
Group No. 3	Nonferrous filtering and spinning	425– 700
Group No. 4	Nonferrous plastic and filtering	400– 500
Group No. 5	Plastic and filtering	385– 425
Group No. 6	Refuse or shorts	250
Group No. 7	do	65– 90

As of January 1, 1969, Vermont chrysotile asbestos, f.o.b. Morrisville, was priced as follows:

Grade	Description	Per short ton
Group No. 3	Spinning and filtering	$356–382
Group No. 4	Shingle fiber	195–331
Group No. 5	Paper fiber	141–165
Group No. 6	Waste, stucco or plaster fiber	102
Group No. 7	Shorts and floats	47– 85

Market quotations were unavailable for African asbestos because sales were negotiated privately. The Cape Asbestos group produces nine grades of crocidolite (blue) asbestos and 17 grades of amosite. The following values were calculated from U.S. Department of Commerce import data:

Imports	Per short ton	
	1968	1969
Amosite: South Africa, Republic of	$149	$153
Chrysotile:		
Rhodesia, Southern	184	---
South Africa, Republic of	194	192
Crocidolite: South Africa, Republic of	193	189

[3] Asbestos. V. 51, No. 6, December 1969, p. 56.

FOREIGN TRADE

U.S. exports of manufactured asbestos products in 1969 increased 15 percent in value over those in 1968. Shipments were made to more than 90 countries. Canada accounted for 35 percent of the total value; West Germany, 7 percent; and Venezuela, Australia, and the United Kingdom each accounted for 4 percent. Canada received 74 percent of reexports of asbestos products; Chile and the United Kingdom accounted for 11 percent each, and Mexico accounted for the remainder. Though imports for consumption of asbestos in 1969 declined almost 6 percent in quantity from the 1968 level, value increased almost $3.5 million. Imports of amosite from the Republic of South Africa in 1969 were almost 29 percent less than the previous year; crocidolite from the same source declined 24 percent. Imports of low-iron spinning length chrysotile from British Columbia increased to 6,192 tons from 6,086 tons in 1968, and imports of all grades from this source increased from 20,943 tons to 28,831 tons during the same period.

Table 3.—U.S. exports and reexports of asbestos and asbestos products

Product	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)
EXPORTS				
Unmanufactured:				
Crude and spinning fibers___short tons__	872	$193	1,419	$314
Nonspinning fibers_____do____	17,066	2,308	14,407	2,274
Waste and refuse_____do____	23,279	2,176	18,696	2,038
Total_____do____	41,217	4,677	34,522	4,626
Products:				
Gaskets and packing_____do____	2,415	5,895	2,519	6,917
Brake linings_____do____	4,374	5,724	4,519	6,804
Clutch facings, including linings number__	3,436,934	2,318	3,749,035	2,966
Textiles and yarn_____short tons__	3,450	1,802	4,402	2,420
Shingles and clapboard_____do____	10,651	1,944	8,606	1,599
Articles of asbestos cement_____do____	5,896	1,628	5,120	1,779
Manufactures, n.e.c_____	NA	5,193	NA	5,673
Total_____	------	24,504	------	28,158
REEXPORTS				
Unmanufactured:				
Crude and spinning fibers___short tons__	------	------	589	122
Nonspinning fibers_____do____	19	2	1,062	231
Total_____do____	19	2	1,651	353
Products:				
Gaskets and packing_____do____	3	1	3	4
Brake linings_____do____	(1)	1	------	------
Clutch facings, including linings number__	------	------	2,281	2
Shingles and clapboard_____short tons__	47	9	72	14
Articles of asbestos cement_____do____	42	3	------	------
Manufactures, n.e.c_____	NA	9	NA	5
Total_____	------	23	------	25

NA Not available.
[1] Less than ½ unit.

No asbestos was received from Southern Rhodesia in 1969, having been embargoed by Presidential order dated January 5, 1967. The small quantities received through 1968 probably were entered from bonded warehouses or shipped from stocks in other countries which were exported from Southern Rhodesia prior to December 1966.

Table 4.—U.S. imports for consumption of asbestos (unmanufactured), by classes and countries

Year and country	Crude (including blue fiber) Short tons	Crude (including blue fiber) Value (thousands)	Textile fiber Short tons	Textile fiber Value (thousands)	All other Short tons	All other Value (thousands)	Total Short tons	Total Value (thousands)
1968								
Bolivia	1	$2	------	------	3	$3	4	$5
Canada	57	32	15,318	$5,869	674,008	59,450	689,383	65,351
Cyprus	16	3	------	------	------	------	16	3
Finland	578	32	110	6	3,774	219	4,462	257
France	------	------	------	------	30	4	30	4
Italy	2	1	------	------	3	3	5	4
Mozambique	150	20	------	------	742	165	892	185
Panama	------	------	------	------	54	3	54	3
Portugal	------	------	------	------	24	2	24	2
Rhodesia, Southern	85	16	------	------	2,734	504	2,819	520
South Africa, Republic of	37,249	6,260	5	1	1,233	274	38,487	6,535
Southern Africa, n.e.c	80	16	------	------	------	------	80	16
Yugoslavia	------	------	1,653	45	------	------	1,653	45
Total	38,218	6,382	17,086	5,921	682,605	60,627	737,909	72,930
1969								
Angola	------	------	------	------	62	5	62	5
Canada	2,851	393	15,974	5,928	636,606	64,438	655,431	70,759
Finland	1,277	61	------	------	4,958	280	6,235	341
France	30	4	------	------	------	------	30	4
Italy	1	(1)	------	------	1	2	2	2
Malta and Gozo	------	------	------	------	1	2	1	2
Mozambique	55	8	------	------	217	18	272	26
Portugal	20	1	------	------	395	35	415	36
South Africa, Republic of	28,026	4,774	------	------	1,664	321	29,690	5,095
Southern Africa, n.e.c	245	48	------	------	------	------	245	48
United Kingdom	31	5	------	------	265	11	296	16
Yugoslavia	280	9	------	------	1,599	79	1,879	88
Total	32,816	5,303	15,974	5,928	645,768	65,191	694,558	76,422

[1] Less than ½ unit.

Table 5.—U.S. imports for consumption of asbestos from specified countries, by grades

(Short tons)

Grade	1968 Canada	1968 Southern Rhodesia	1968 Republic of South Africa	1969 Canada	1969 Republic of South Africa
Chrysotile					
Crudes	57	85	2,817	2,851	2,850
Spinning fibers	15,318	-----	5	15,974	------
All other	674,008	2,734	1,233	636,606	1,664
Crocidolite (blue)	-------	-----	13,965	-------	10,558
Amosite	-------	-----	20,467	-------	14,618
Total	689,383	2,819	38,487	655,431	29,690

WORLD REVIEW

Australia.—Australian asbestos output has been less than 1,000 tons annually since the cessation of crocidolite production at Wittenoom, Western Australia at the end of 1966. However, Pacific Asbestos Ltd., plans a mining and milling operation at the company's property near Barraba, New South Wales to produce 65,000 tons of short-fiber chrysotile annually.[4] Mining was to be by open pit methods.

[4] Industrial Minerals. No. 28, January 1970, p. 29.

Table 6.—World production of asbestos, by countries

(Short tons)

Country [1]	1967	1968	1969 p
North America:			
Canada (sales)	1,452,104	1,509,697	1,576,874
United States (sold or used by producers)	123,189	120,690	125,936
South America:			
Argentina	551	381	NA
Brazil [2]	r 2,487	4,806	NA
Europe:			
Bulgaria	r 1,653	e 1,653	e 1,653
Finland [3]	11,601	14,484	e 15,432
France	165	---------	---------
Italy	111,402	114,020	e 111,333
Portugal	57	112	e 55
U.S.S.R. e	847,676	881,848	1,102,310
Yugoslavia	9,944	11,456	12,634
Africa:			
Kenya	56	---------	NA
Mozambique	559	132	NA
Rhodesia, Southern	e 107,255	e 94,799	NA
South Africa, Republic of	268,482	260,530	e 281,089
Swaziland	40,154	42,946	NA
United Arab Republic	2,135	2,868	NA
Asia:			
China, mainland e	165,000	165,000	176,000
Cyprus	r 21,782	21,293	21,385
India	r 7,732	9,992	e 11,023
Japan	27,037	24,251	e 12,677
Korea, South	2,388	3,650	NA
Philippines	64	35	49
Taiwan	631	1,323	3,396
Turkey	2,421	3,509	e 3,748
Oceania: Australia	734	895	e 816
Total [4]	r 3,207,259	3,290,370	NA

e Estimate. p Preliminary. r Revised. NA Not available.
[1] Negligible quantities also produced in Bolivia, Czechoslovakia, Eritrea, Malagasy, North Korea, and Rumania.
[2] Bahia and Goias only for 1967, Goias only for 1968.
[3] Includes asbestos flour.
[4] Total is of listed figures only.

Table 7.—Canada: Shipments [1] of asbestos, by grades

(Short tons)

Grade	1965	1966	1967	1968	1969
Quebec, milled group:					
3 (spinning) [2]	21,356	28,716	25,391	32,248	29,291
4 (shingle)	322,772	371,837	336,568	335,807	326,146
5 (paper)	168,759	190,278	185,450	193,446	204,208
6 (stucco)	208,682	229,426	244,021	255,648	242,126
7 (refuse)	506,497	512,030	490,087	542,124	539,413
8 (sand)	6,088	8,706	7,149	3,037	2,023
Newfoundland, Ontario, and British Columbia	153,401	138,288	154,345	147,389	233,669
Total	1,387,555	1,479,281	1,443,011	1,509,699	1,576,876

[1] Includes tonnage for own use.
[2] Includes crude No. 1, No. 2, and other.

Source: Dominion Bureau of Statistics.

Canada.—Production as measured by sales increased 4 percent to 1,576,874 tons in 1969.

At Thetford Mines, Quebec, Asbestos Corporation Ltd. continued development of the Penhale orebody on the company's Vimy Ridge property. Shaft sinking, begun in 1968, reached a depth of 600 feet by the end of 1969. At the King-Beaver mine, a new ore preparation and storage plant was completed in December at a cost of Can$2.5 million. The company also announced that ore reserves at yearend were as follows:[5]

[5] Asbestos Corporation Ltd. Annual Report. Montreal, 1969, p. 3.

Mine	Thousand short tons
King-Beaver Mine	41,662
British Canadian Mine	63,645
Normandie Mine	9,906
Asbestos Hill	18,738
Other Properties	10,611
Total	144,562

Drilling by Abitibi Asbestos Mining Ltd. on property in Maizerets Township in Quebec has indicated an estimated 102.8 million tons of ore containing medium length chrysotile fiber. Survey work, bulk sampling tests, and feasibility studies were still in progress at yearend, but an annual output of 75,000 tons of fiber is envisaged.[6]

Cassiar Asbestos Corp. Ltd. announced plans to expand mill capacity at its Cassiar, British Columbia, mine from 75,000 tons of fiber annually to 100,000 tons. Total cost for the one-third increase in capacity was estimated at Can$4.3 million; completion was scheduled for December 1970.[7]

At the Canadian Johns-Manville Co. Ltd. Jeffrey open pit mine at Asbestos, Quebec, capacity is being expanded from 600,000 to 700,000 tons of fiber annually with completion scheduled next year. The company also increased output at its Reeves mine in Ontario. Underground exploration of an asbestos prospect located in Garrison Township, about 25 miles east of Matheson, northern Ontario, also was conducted by the company.[8]

Greece.—A tentative agreement between Cerro Corporation of New York and Hellenic Asbestos, S.A., an operating company of Hellenic Industrial Development Bank (HIDB), was announced for development of the latter's asbestos mines at Zidani Kozanis. If further studies indicate economic feasibility, the mines would be put into production through establishment of a 40,000-ton-per-year capacity fiber plant. Total cost of the project was placed at $15 million, of which Cerro Corp. was to contribute $5.8 million, the balance made available by HIDB. Exploration, studies, and equipping of an existing small pilot plant for asbestos processing were to be completed in 1970.[9]

Mexico.—A deposit of an estimated 1.2 million tons of recoverable chrysotile asbestos fiber was discovered near Ciudad Victoria, Tamaulipas. A new company to be known as Cia. Nacional de Asbestos has been established to develop the orebody. The Federal government was to have a 51-percent share in the company, and private interests will own the remaining 49 percent. A 300-ton-per-day plant was scheduled to begin operation in early 1971. Mexico currently has no domestic production of asbestos, and imports—primarily from Canada and the United States—average about 30,000 short tons annually. However, completion of the Cia. Nacional de Asbestos project would result in Mexico's first production of short fiber chrysotile asbestos and could reduce imports by one-third.[10]

Another deposit of asbestos-bearing rock was discovered during routine exploration by Freemex S.A., a wholly owned subsidiary of Freeport Sulphur Co., and Cía. Metalúrgica Peñoles. The deposit reportedly ranges in thickness from 93 to 385 feet and contains substantial tonnages of commercial material.[11]

South Africa, Republic of.—The Republic of South Africa again ranked third among the asbestos-producing countries of the world, with an estimated output of 281,000 short tons. Cape Province crocidolite comprised approximately 50 percent of the output; amosite, one-third; chrysotile, about 15 percent; the remainder, Transvaal Blue from the Northern Transvaal.

Construction of the Msauli Asbestos Ltd. milling plant near Barberton, Eastern Transvaal, was completed the latter part of the year. The $6 million complex will increase production capacity to 50,000 tons of fiber annually, 75 percent of which will be exported via the port of Lourcenço Marques. The new mill can treat approximately 1,000 tons per day on a two-shift basis. Crude ore is obtained from the largest chrysotile mine in South Africa. An article describing the operation was published.[12] Late in the year, Valley Asbestos (Pty.) Ltd. located a deposit of anthophyllite in the Northern Transvaal, and was

[6] Industrial Minerals (London). No. 28, January 1970, p. 21.
[7] Cassiar Asbestos Corporation Ltd. Annual Report. Toronto, 1969, p. 12.
[8] Mining Journal (London). V. 274, No. 7014, Jan. 23, 1970, p. 73.
[9] U.S. Embassy, Athens. State Department Airgram A-55, Feb. 11, 1970.
[10] Mining Magazine (London). V. 121, No. 6, December 1969, p. 495.
[11] Industrial Minerals (London). No. 26, September 1969, p. 52.
[12] Mining and Minerals Engineering. Asbestos in South Africa. V. 5, No. 2, February 1969, pp. 45–49.

conducting drilling operations there at year-end.[13]

Swaziland.—Although 1969 data are not available, production continued from the Havelock mine, Swaziland's sole producer. London Rhodesian Mining & Land Co. Ltd. (Lonrho) conducted exploration on an asbestos property at Emlembe, adjacent to Turner & Newall's Havelock mine.[14]

U.S.S.R.—The U.S.S.R. continued to be one of the world's leading asbestos suppliers with an estimated output of 1.1 million short tons, 25 percent more than in 1968. The No. 6 plant at the Urals asbestos complex was completed.[15] The plant, which has a rated annual capacity of 12 million tons, will process low-grade material produced mainly as a by-product of other operations capable of utilizing only higher-grade ore.

Exports in 1968 totaled 334,660 tons, an increase of 6 percent over the 314,380 tons reported for the previous year. Principal markets were Eastern Europe, France, Germany (East and West), and Japan. The bulk of the Soviet production, however, was retained for domestic use in manufacturing a variety of asbestos products.

Over 85 percent of the total Soviet reserves are in the Urals and Kazakhstan, and the remainder mostly in Eastern Siberia.

TECHNOLOGY

Technological advances in 1969 related mainly to development of new asbestos products and uses. A new aluminized asbestos cloth having an extremely high reflectivity and good wear properties became available for the production of fire resistant clothing. The use of asbestos in building products and plastics continued to expand. Research-based development of asbestos products was discussed.[16]

Medical research on the effects of asbestos on human health continued in 1969. The outcome of current endeavors to solve the problems of air, water, and soil pollution will have great impact on workers in the mining, manufacturing, and construction industries as well as the general public. Dust control and respiratory equipment from many companies were described.[17]

Two types of containers designed to provide dust-free mixing of asbestos insulating cement were submitted to Insulation Industry Hygiene Research Program (IIHRP), and field testing of them started in September. Both containers are waterproof plastic bags in which the materials will be packaged at the factory. Both provide means for introducing water into the bag and mixing the cement to the desired consistency before opening the bag. The bags differ mainly in the manner in which water is introduced. They will be tested to determine optimum bag size and worker acceptability.[18]

A first-year grant of $53,818 was made by the U.S. Department of Health, Education and Welfare to Dr. Ross W. Smith, associate professor of metallurgy, Mackay School of Mines, University of Nevada, for a study of the aqueous surface chemistry of asbestos minerals.[19] The significance of the study is its possible use in medical research on the known hazards of various species of asbestos on human health. The Mackay study was to continue through August 1972.

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[13] U.S. Embassy, Johannesburg. State Department Airgram A-186, Dec. 9, 1969.
[14] Asbestos. V. 51, No. 6, December 1969, p. 24.
[15] Mining Journal (London). V. 274, No. 7011, Jan. 2, 1970, p. 11.
[16] The South African Mining and Engineering Journal. V. 81, No. 4013, Pt. 1, Jan. 2, 1970, pp. 9–10, 13–15.
[17] Asbestos. V. 51, No. 6, December 1969, pp. 14, 16, 18.
[18] Asbestos. V. 51, No. 4, October 1969, p. 16.
[19] Skillings' Mining Review. V. 58, No. 50, Dec. 13, 1969, p. 28.

Barite

By W. Gene Diamond[1]

Barite sold or used in the United States in 1969 totaled nearly 1.1 million short tons and exceeded 1 million short tons for the first time since 1957. This represented a 16-percent increase in quantity and a 15-percent increase in value over 1968 figures. Imports of primary barite for consumption decreased 7 percent to 614,000 tons in 1969.

DOMESTIC PRODUCTION

Barite was mined by open pit and underground methods in seven States in 1969. Production in Nevada, Missouri, Arkansas, and Georgia supplied nearly 89 percent of total 1969 output. Nevada replaced Missouri as the leading producing State.

Alaska Barite Co. was purchased by Inlet Oil Corp. and other investors for $2 million. The transaction included the mine, loading facilities, barite processing plant at Kenai, and ore reserves at Castle Island near Petersburg.[2]

Leading producing States of ground and crushed barite included Louisiana, Missouri, Arkansas, and Georgia. Most of the chemical-grade barite was ground in Missouri, Georgia, California, and Tennessee. Output of chemical and well-drilling grades increased along with crude-barite production.

[1] Supervisory statistician, Bureau of Mines, Bartlesville, Okla.
[2] Mining Record. V. 80, No. 34, Aug. 27, 1959, p. 7.

Table 1.—Salient barite and barium-chemical statistics

(Thousand short tons and thousand dollars)

	1965	1966	1967	1968	1969
United States:					
Barite (primary):					
Mine or plant production	846	1,007	944	NA	NA
Sold or used by producers	852	947	962	[1] 927	1,077
Value	$10,192	$11,259	$11,604	[1] $13,706	$15,753
Imports for consumption	712	699	532	663	614
Value	$5,553	$5,764	$4,655	$5,666	$5,549
Consumption [2]	1,388	1,417	1,371	NA	NA
Ground and crushed sold by producers	1,169	1,209	1,144	1,266	1,537
Value	$29,444	$30,641	$28,754	$30,563	$37,297
Barium chemicals sold by producers	125	133	113	136	139
Value	$17,935	$19,109	$16,283	$18,811	$19,101
World: Production	3,899	4,068	3,933	4,017	4,188

NA Not available.
[1] Data not comparable to previous years.
[2] Includes some witherite.

Table 2.—Barite (primary) sold or used by producers in the United States by States

(Thousand short tons and thousand dollars)

State	1968[1] Quantity	1968[1] Value	1969 Quantity	1969 Value
Alaska	91	W	W	W
Arkansas	166	$3,839	210	$4,616
California	W	W	W	W
Georgia	140	2,874	124	3,116
Missouri	284	4,102	304	4,220
Nevada	216	1,511	320	2,275
North Carolina	W	W	-----	------
Tennessee	21	362	16	295
Undistributed	8	1,019	103	1,229
Total[2]	927	13,706	1,077	15,753

W Withheld to avoid disclosing individual company confidential data.
[1] 1968 includes 222,828 short tons chemical-grade valued at $4,250,142 and 703,892 short tons drilling-grade valued at $9,455,166.
[2] Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

The principal use of ground barite was as a weighting agent in oil- and gas-well drilling muds. Because of its high specific gravity, barite in drilling mud restrains high gas and oil pressures encountered at their formation levels, and thus prevents caving and blowouts. The increased tonnage used for well drilling in 1969, which accounted for 77 percent of the total market, was due primarily to increased drilling activity in the United States.

Producers of ground and crushed barite from both domestic and imported material in 1969 reported increased quantities of barite used for chemicals, glass, and well drilling; decreases were indicated for the paint and rubber industries. The glass industry used chemical-grade barite as flux, oxidizer, and decolorizer. In paint, rubber, and other materials it was used primarily as a filler or extender.

Major producers of barium chemicals from barite included the following: J. T. Baker Chemical Co., Phillipsburg, N.J.; Chemical Products Corp., Cartersville, Ga.; Chicago Copper & Chemical Co., Blue Island, Ill.; Chemetron Corp., Huntington, W. Va.; The Great Western Sugar Co., Johnstown, Colo.; Inorganic Chemicals Division, FMC Corp., Modesto, Calif.; Mallinckrodt Chemical Works, St. Louis, Mo.; Ozark Smelting and Mining Division, Sherwin Williams Co., Coffeyville, Kans.; PPG Industries, Inc.; Chemical Division, New Martinsville, W. Va.; Chas. Pfizer & Co., Inc., Easton, Pa.; and Sherwin Williams Co., Ashtabula, Ohio.

Table 3.—Ground and crushed barite sold by producers [1]

Use[2]	1967 Short tons	1967 Percent of total	1968 Short tons	1968 Percent of total	1969 Short tons	1969 Percent of total
Barium chemicals[3]	170,096	13	175,830	13	177,570	11
Glass	76,220	6	71,770	5	72,706	5
Filler or extender:						
Paint	59,698	5	60,894	4	52,306	3
Rubber	31,039	2	41,639	3	14,177	1
Other filler	NA		NA		(4)	
Well drilling	964,982	73	1,006,418	73	1,235,229	77
Other uses	12,964	1	20,907	2	52,754	3
Total	1,314,999	100	1,377,458	100	1,604,742	100

NA Not available.
[1] Includes imported barite.
[2] Uses reported by producers of ground and crushed barite, except for barium chemicals.
[3] Quantities reported by consumers.
[4] Included with other uses to avoid disclosing individual company confidential data.

Table 4.—Barium chemicals produced and used or sold by producers[1] in the United States in 1969

Chemical	Plants	Produced (Short tons)	Sold or used by producers: Short tons	Value
Barium carbonate	7	81,760	77,165	$8,151,331
Other barium chemicals[2]	(3)	57,276	52,920	10,949,970
Total[4]	9	139,036	130,085	19,101,301

[1] Only data reported by barium chemical producers that consume barite (primary) are included.
[2] Includes barium acetate, black ash, blanc fixe, chloride, hydrate, nitrate, oxide, peroxide, sulfate, and other compounds for which separate data may not be revealed.
[3] Black ash and lithopone, 2 plants; acetate, 1; chloride, 3; hydroxide, 3; nitrate, 1; oxide, 1; peroxide, 1; sulfate, 2.
[4] A plant producing more than 1 product is counted only once in arriving at total.

Other companies which gave further processing to barium chemicals included: Barium Chemicals, Inc., Steubenville, Ohio; Eastman Kodak Co., Rochester, N.Y.; Ethyl Corp., Baton Rouge, La., The Glidden Co., Baltimore, Md.; and Inorganic Chemicals Division, FMC Corp., Carteret, N.J.

Among the barium chemicals, barium chloride was used for case-hardening iron and steel, producing magnesium metal, and in water treatment; barium carbonate was used in making glass ceramic glazes, and enamels; and barium hydroxide was added to ceramic products and lubricating oils and was used in the process of refining sugar beets.

PRICES

Prices of crude and ground barite, as published in trade journals, serve as a general guide and do not necessarily reflect actual transactions. Prices generally are negotitated between buyers and sellers.

Quoted prices of ground barite, drilling-mud grade, increased in February, in July, and in December. Prices quoted for imported barite, drilling-mud grade, went up in July and in December.

Table 5.—Price quotations for crude and ground barite in 1969

Item	Price per short ton	Item	Price per short ton
Chemical grade, f.o.b. shipping point, carlots:		Drilling-mud grade, f.o.b. shipping point, carlots: 83–93 percent $BaSO_4$, 3–12 percent Fe, specific gravity 4.20–4.30:	
Hand picked, 95 percent $BaSO_4$, 1 percent Fe	$20–20.50	Crude, bulk	$12–16
Flotation or magnetic separation; 96–97.5 percent $BaSO_4$, 0.3–0.7 percent Fe (add $3 for 100-pound bags)	25–26.50	Some restricted sales	11.50
Water-ground; 99.5 percent $BaSO_4$, 325 mesh, 50-pound bags	45–49	Ground	23–34
		Imported crude, bulk, c.i.f. gulf ports	10–19

Source: Engineering and Mining Journal.

FOREIGN TRADE

Exports of lithopone (a mixture of zinc sulfide and barium sulfate used as a paint pigment) in 1969 decreased 6 percent compared with 1968 exports. The value of exported lithopone was up 6 percent as the 1969 average value increased to 13.8 cents per pound. Principal countries receiving lithopone were South Vietnam, Venezuela, Canada and Ireland.

Imports of crude barite for consumption totaled 614,000 short tons in 1969, down 7

Table 6.—U.S. exports of lithopone

Year	Short tons	Value (thousands)
1967	735	$267
1968	1,300	281
1969	1,086	300

percent from 1968 imports. The average value at foreign ports of imports for consumption in 1969 was $9.03 per short ton. Declared values of crude barite at foreign ports were as follows for the indicated countries:

Country:	Value per ton
Canada	$8.51
Greece	9.82
Ireland	7.56
Italy	11.78
Mexico	7.84
Morocco	10.64
Peru	9.84

The imported barite entered the United States through the following customs districts: New Orleans, La., 47.7 percent; Larado, Tex., 23.1 percent; Port Arthur, Tex., 17.0 percent; Houston, Tex., 9.0 percent; and Galveston, Tex., El Paso, Tex., and San Diego, Calif., 3.2 percent.

Barium chemicals imported for consumption included lithopone, blanc fixe (precipitated barium sulfate), and barium chloride, hydroxide, nitrate, and precipitated carbonate. Lithopone was received from West Germany, the Netherlands, and Canada. Imports of blanc fixe originated mainly in West Germany, France, Italy, and the Netherlands. Barium chloride imports were from France, West Germany, Belgium-Luxembourg, Italy, and the Netherlands. Imported barium nitrate came from West Germany, the U.S.S.R., and the Netherlands. Precipitated barium carbonate was imported from West Germany and the Netherlands. The United Kingdom supplied all witherite (barium carbonate mineral) imports.

Table 7.—U.S. imports for consumption of barite, by countries

(Thousand short tons and thousand dollars)

Type and country	1968 Quantity	1968 Value	1969 Quantity	1969 Value
Crude barite:				
Algeria	17	$190	5	$65
Brazil	---	---	7	47
Canada	104	911	107	913
France [1]	8	106	---	---
Greece	75	622	54	533
Ireland	144	1,094	111	836
Italy	22	275	59	697
Mexico	131	839	121	949
Morocco	56	587	41	441
Peru	94	937	98	966
Turkey	12	105	11	102
Total	663	5,666	614	5,549
Ground barite:				
Canada	---	---	2	221
France	---	---	(2)	5
Italy	---	---	(2)	8
Total	---	---	2	234

[1] Revised. Previously reported as Panama.
[2] Less than ½ unit.

Table 8.—U.S. imports for consumption of barium chemicals

Year	Lithopone: Short tons	Lithopone: Value (thousands)	Blanc fixe (precipitated barium sulfate): Short tons	Blanc fixe: Value (thousands)	Barium chloride: Short tons	Barium chloride: Value (thousands)	Barium hydroxide: Short tons	Barium hydroxide: Value (thousands)
1967	116	$22	2,249	$282	979	$120	---	---
1968	246	37	2,783	397	1,413	149	---	---
1969	261	40	2,705	399	1,083	118	7	$1

Year	Barium nitrate: Short tons	Barium nitrate: Value (thousands)	Barium carbonate, precipitated: Short tons	Barium carbonate, precipitated: Value (thousands)	Other barium compounds: Short tons	Other barium compounds: Value (thousands)
1967	1,046	$153	813	$54	156	$73
1968	710	103	656	43	415	151
1969	1,035	144	887	70	944	381

Table 9.—U.S. imports for consumption of crude, unground, and crushed or ground witherite

Year	Crude, unground: Short tons	Crude, unground: Value (thousands)	Crushed or ground: Short tons	Crushed or ground: Value (thousands)
1967	1,260	$53	25	$3
1968	2,029	59	25	17
1969	392	15	67	7

WORLD REVIEW

Afghanistan.—Exploration activities discovered one occurrance of barite in quantities suitable for mining. The deposit, approximately 25 miles northwest of Charikar in Parwan Province, occurs in thin veins in association with galena and sphalerite mineralization. Estimated reserves total 220,000 short tons, of which 61,000 tons could be mined by open pit methods.[3]

Australia.—Jedda Exploration Ltd. was developing a barite property in South Australia near Orroroo. The company planned a treatment plant capable of handling 50,000 tons of ore per year. South Australian Barytes Ltd., the current barite producer, can process 15,000 tons per year at its plant.[4]

Canada.—Cape Chemical Co., Montreal, announced plans to develop a 100,000-ton barite deposit at Brockfield in central Nova Scotia in 1970. This would be Canada's first domestic source of pharmaceutical-grade barite.[5]

Italy.—S.p.A. Industrie Minerarie Meridionali constructed a barite-processing plant at Naples. The capacity of the plant is 10,000 tons per year. The new plant will process lump barite from the company's mine at Bagni San Filippo in southern Italy.[6]

Liberia.—Dresser Industries, Inc., continued exploration for barite under a concession granted by the Liberian Government. Survey work started in 1968 will continue into 1970. The barite veins extend over a wide area and reserves are estimated to be large.[7]

Mexico.—Negociación Minera Eulalio Gutierrez constructed a concentrating, grinding, and bagging plant capable of processing 150 tons of barite per day. The plant is at the company mine near Saltillo, Coahuila State.[8]

Thailand.—The country's first barite-processing plant will be built in the southern Province of Songkhla. Barite Thailand Co. Ltd., owned 51 percent by Huey Yai Mine Co. Ltd. and 49 percent by National Lead Co. and Paul F. Scholla & Associates, will operate the mill. Drilling-mud grade barite will be produced.[9]

U.S.S.R.—The Achisai mining complex, 1,865 miles from Moscow, includes a lead deposit of hydrothermal origin that contains 10 to 15 percent barite. Barite concentrates contain 85 percent $BaSO_4$ with a recovery factor of 85 percent. Annual production is approximately 187,000 short tons.[10]

United Kingdom.—The Settlingstones mine, which had provided witherite since 1873, closed in March. The Longcleugh mine in West Allendale was being investigated as a possible source of witherite.[11]

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[3] Bureau of Mines. Mineral Trade Notes. V. 66, No. 6, June 1969, p. 4.

[4] Engineering and Mining Journal. V. 170, No. 5, May 1969, p. 165.

[5] Chemical Age. V. 99, No. 2630, Dec. 12, 1969, p. 27.

[6] Industrial Minerals (London). No. 21, June 1969, p. 39.

[7] Industrial Minerals (London). No. 23, August 1969, p. 32.

[8] Industrial Minerals (London). No. 20, May 1969, p. 32.

[9] Engineering and Mining Journal. V. 170, No. 11, November 1969, p. 172.

[10] Mining Magazine. V. 121, No. 4, October 1969, pp. 348–349.

[11] Mining & Mineral Engineering (London). V. 5, No. 8, August–September 1969, p. 59.

Table 10.—World production of barite, by countries

(Short tons)

Country [1]	1967	1968	1969 p
North America:			
Canada	172,270	138,059	141,392
Mexico	246,124	271,762	195,022
United States	944,081	[2] 926,729	[2] 1,077,208
South America:			
Argentina	24,308	17,833	e 17,800
Brazil	60,073	47,472	37,368
Chile	4,965	4,053	e 4,000
Colombia	6,622	8,344	13,494
Peru	205,691	p 73,460	e 73,400
Europe:			
Austria (marketable)	2,675	1,610	e 1,700
Czechoslovakia e	5,512	5,512	5,512
France	112,435	e 110,200	e 110,000
Germany:			
East e	33,069	33,069	33,069
West (marketable)	r 471,920	502,561	e 521,600
Greece	r 163,972	207,234	e 209,400
Ireland	83,776	157,630	176,960
Italy	169,828	224,849	266,658
Poland e	51,809	51,809	55,116
Rumania e	60,627	60,627	60,627
Spain	r 55,258	e 73,900	e 66,100
U.S.S.R. e	286,601	286,601	308,646
United Kingdom [3]	40,785	29,101	e 33,100
Yugoslavia	93,121	77,642	e 78,300
Africa:			
Algeria	r 34,562	49,587	e 35,300
Kenya	234	392	479
Morocco	99,779	86,157	95,835
South Africa, Republic of	1,646	572	3,900
Swaziland	623	979	629
United Arab Republic	1,413	411	NA
Asia:			
Burma	10,362	11,111	10,696
China, mainland e	110,231	132,277	154,323
India	56,997	57,009	57,094
Iran e	99,208	104,719	77,200
Japan	41,417	65,152	68,661
Korea:			
North e	121,254	121,254	121,254
South	---------	6	NA
Pakistan	r 6,946	11,416	e 11,400
Thailand	r 247	---------	---------
Turkey	34,822	22,369	36,376
Oceania: Australia	17,545	43,901	28,384
Total [4]	r 3,932,808	4,017,369	4,188,003

e Estimate. p Preliminary. r Revised. NA Not available.
[1] Barite is also produced in Bulgaria, Philippines, Portugal, and Southern Rhodesia, but data are not available.
[2] Sold or used by producers.
[3] Includes witherite.
[4] Total is of listed figures only.

TECHNOLOGY

Inlet Oil Corp., new owner of Alaska Barite Co., began barite exploration using a self-propelled barge containing geophysical and coring equipment and a chemical laboratory. A converted minesweeper with sophisticated navigation equipment also was used.[12]

[12] Engineering and Mining Journal. V. 171, No. 1, January 1970, p. 122.

Bauxite

By John R. Lewis [1]

The 8.5 percent increase in United States aluminum production to an alltime high in 1969 manifested itself throughout the domestic bauxite and alumina sectors. Domestic production of bauxite rose almost 11 percent; United States mainland imports for consumption rose nearly 13 percent; world production was up 14 percent. Alumina imported for use in making aluminum in the United States jumped 45 percent during the year, and was within sight of the 2-million-short-ton-per-year level just 2 years after hitting the 1-million-ton mark. The trend toward the conversion of bauxite to alumina in the bauxite source nations continued and alumina plants outside the United States continued to proliferate.

Legislation and Government Programs.—Percentage depletion provisions in the Federal tax laws were examined by the Congress during 1969, and rates on many minerals were changed under Public Law 91–172. The rate for percentage depletion on bauxite was lowered from 23 percent on domestically produced bauxite and 15 percent on foreign bauxite to 22 percent and 14 percent, respectively. The new rates were applicable to taxable years beginning after October 9, 1969.

Excesses of bauxite and alumina in the national stockpile were available for commercial sale or for exchange for items in deficit in the stockpile. However, activity in bauxite and alumina was negligible. No bauxite of any variety—that is, metal grade (Jamaica type or Surinam type), or refractory grade—was involved in sale or exchange during the year. Four hundred tons of aluminum oxide was sold from the stockpile, however.

Table 1.—Salient bauxite statistics

(Thousand long tons and thousand dollars)

	1965	1966	1967	1968	1969
United States:					
Production, crude ore (dry equivalent)	1,654	1,796	1,654	1,665	1,843
Value	$18,632	$20,095	$19,079	$23,752	$25,725
Exports (as shipped)	147	62	2	7	5
Imports for consumption [1]	11,199	11,529	11,594	10,976	12,180
Consumption (dry equivalent)	13,534	14,084	14,503	14,097	15,580
World: Production	36,849	40,041	43,889	45,221	51,528

[1] Includes bauxite imported for Government account. Import figures for Jamaica, Haiti, and Dominican Republic were adjusted by Bureau of Mines to dry equivalent. Other imports, which are virtually all dried, are on an as-shipped basis.

DOMESTIC PRODUCTION

Three States, led by Arkansas, again produced the entire United States output of bauxite in 1969. Total production of crude bauxite rose 10.7 percent above 1968 levels and stood at 1,843,000 long tons, stated as dry equivalent. Arkansas produced, as it has for many years, about 95 percent of total domestic output; Alabama and Georgia furnished the remainder

Bauxite was mined by five companies in Arkansas: Aluminum Company of America, (Alcoa), American Cyanamid Co., Reynolds Mining Corp., A. P. Green Refractories Co., and Stauffer Chemical Co. In addition to those above, Norton Co. and

[1] Physical scientist, Division of Nonferrous Metals.

Porocel Corp., operated processing plants only in Arkansas. In Alabama, bauxite was mined by Wilson-Snead Mining Co., Eufala Bauxite Mining Co., A. P. Green, and Harbison-Walker Refractories Co. Each of these companies also operated drying or calcining plants in Alabama. In Georgia, American Cyanamid Co. was the only bauxite producer in 1969 and also operated the State's sole drying mill at Andersonville.

Table 2.—Mine production of bauxite and shipments from mines and processing plants to consumers in the United States

(Thousand long tons and thousand dollars)

State and year	Mine production			Shipments from mines and processing plants to consumers		
	Crude	Dry equivalent	Value [1]	As shipped	Dry equivalent	Value [1]
Alabama and Georgia:						
1965	79	61	$658	57	56	$792
1966	102	78	656	85	82	1,108
1967	108	83	810	85	84	1,236
1968	110	83	694	74	69	898
1969	117	88	1,020	72	79	1,324
Arkansas:						
1965	1,911	1,593	17,974	2,008	1,729	20,293
1966	2,060	1,718	19,439	1,891	1,636	19,788
1967	1,943	1,571	18,269	2,022	1,742	21,343
1968	1,961	1,582	23,058	1,962	1,680	25,349
1969	2,116	1,755	24,706	2,044	1,765	26,304
Total United States: [2]						
1965	1,990	1,654	18,632	2,065	1,785	21,085
1966	2,162	1,796	20,095	1,976	1,718	20,896
1967	2,051	1,654	19,079	2,107	1,826	22,579
1968	2,071	1,665	23,752	2,036	1,749	26,247
1969	2,233	1,843	25,725	2,116	1,844	27,628

[1] Computed from selling prices and values assigned by producers and from estimates of the Bureau of Mines.
[2] Data may not add to total shown because of independent rounding.

A problem of bauxite mining in Arkansas, that of exploiting seams previously too deep to develop economically, was solved by the largest piece of open pit equipment ever used in the State. This machine, called the "Deeper Heaper," is a walking dragline that stands 17 stories high and weighs 1,600 tons, and is in use in the Bauxite, Arkansas area. Utilization of larger equipment to transport material from mine-to-plant was also instituted dur-

Table 3.—Recovery of dried, calcined, and activated bauxite in the United States

(Long tons)

Year	Crude ore treated	Processed bauxite recovered [1]: Total, As recovered	Processed bauxite recovered [1]: Total, Dry equivalent
1965	193,076	99,765	140,713
1966	202,443	117,326	157,206
1967	223,174	123,200	166,696
1968	209,900	107,722	152,106
1969	288,294	162,467	218,397

[1] Dried, calcined, and activated bauxite.

Table 4.—Capacities of domestic alumina plants, December 31, 1969 [1]

(Thousand short tons per year)

Company and plant	Capacity
Aluminum Company of America:	
Bauxite, Ark.	400
Mobile, Ala.	950
Point Comfort, Tex. [2]	900
Total	2,250
Harvey Aluminum, Inc.:	
St. Croix, Virgin Islands	350
Kaiser Aluminum & Chemical Corp.:	
Baton Rouge, La.	985
Gramercy, La.	620
Total	1,605
Ormet Corp.:	
Burnside, La.	550
Reynolds Metals Co.:	
Hurricane Creek, Ark.	840
San Patricio, Tex.	1,186
Total	2,026
Grand total	6,781

[1] Capacity may vary depending upon the bauxite being used.
[2] Capacity to be expanded to 1,080,000 short tons by summer 1971.

ing the year. Alcoa put a 54-ton truck into use in Arkansas, replacing a 22-tonner. In Australia, Alcoa went to a 100-ton giant instead of the 25-ton trucks previously employed.

A total of 7.34 million short tons of aluminum oxide was produced in the United States in 1969, of which 6.92 million tons were of the calcined variety, 432,356 short tons were trihydrated alumina, and the remainder was tabular and activated types.

Shipments of alumina and aluminum oxide products totaled 7.14 million tons; 6.7 million tons went to the aluminum industry; the balance went to the abrasive, chemical ceramic, and refractory industries.

In 1969 there were eight alumina plants in the continental United States and one in the Virgin Islands. Together, these nine plants were the source of all calcined alumina produced domestically.

CONSUMPTION AND USES

In 1969, 87 percent of all bauxite used in the United States was imported. Alumina production took 93.5 percent of both domestically produced and imported bauxite during the year. The rest went into refractories, chemicals (including aluminum sulfate and other aluminous chemicals used in water and sewage treatment, dyestuffs, leather tanning, and sizing of paper) and abrasives. Bauxite was also used, in lesser quantities, in high alumina cements, low-density insulation, as an adsorbent or catalyst by the petroleum refiners, and in welding rod coatings and fluxes. It was also used as a flux in making steel and ferroalloys. Fused bauxite was used as abrasive grains in bonded or coated abrasives.

Beyond its preponderant use in making aluminum, alumina was also used for abrasive, refractory, and chemical applications where a high degree of purity is desired. Minor uses included production of artificial sapphires and thread guides for textile plants.

The percentage of domestic bauxite shipments, by various silica content ranges, follow:

SiO_2 percent	1965	1966	1967	1968	1969
Less than 8	5	10	4	15	15
8 to 15	64	60	73	53	55
More than 15	31	30	23	32	30

The aluminum industry received 94 percent of all alumina shipments made in 1969, with the abrasive, chemical, ceramic, and refractory industries taking most of the remainder.

Calcined alumina consumed by primary aluminum reduction plants totaled 6.9 million short tons. The quantities of bauxite and alumina consumed in making 1 ton of aluminum have trended downward in recent years:

	1965	1966	1967	1968	1969
Bauxite long dry tons	4.136	4.088	3.993	3.838	3.671
Alumina short tons	1.891	1.904	1.878	1.845	1.817
Aluminum short tons	1.000	1.000	1.000	1.000	1.000

According to an estimate by C. H. Kline & Co., expenditures for raw materials by the U.S. ceramics industry exceeded $500 million for the first time in 1969. Among others, estimated consumption of bauxite was set at 570,000 tons.

Table 5.—Bauxite consumed in the United States in 1969, by grades

(Long tons, dry equivalent)

Grade	Domestic origin	Foreign origin	Total
Crude	992,311	5,070,717	6,063,028
Dried	812,691	8,043,802	8,856,493
Activated	38,392	----------	38,392
Calcined	132,355	490,211	622,566
Total	1,975,749	13,604,730	15,580,479

A new plant for the production of calcined aluminum silicate products for use in refractories, ceramics, etc., was completed in the fall of 1969 on an 800-acre site near Andersonville, Ga. Known as the Mulcoa plant (Mullite Corporation of America), it was constructed and will be operated by C. E. Minerals. The completely automated plant, to be run on a 24-hour day, 7-day-per-week basis, can turn out 100,000 tons per year of calcined aggregates, including bauxites, for use in the manufacture of high alumina refractories. Kilns will be gas fired. Raw material reserves in Georgia are estimated to be more than 50 million tons. Products are expected to be used by refractory, foundry, and ceramic firms in the United States, France, West Germany, Italy, and Japan.

Bauxite from mines in Arkansas and Georgia was used, beginning in the spring of 1969, in a new aluminum sulfate facility built by American Cyanamid Co. at Monticello, Miss. The product was to go to paper manufacturers and water treating plants throughout the Southeast. A similar plant, with a capacity of 20,000 tons annually, was put into operation at Springfield, Tenn., during the year by Midland Chemical Co., while Monsanto Co. discontinued production of aluminum sulfate at Everett, Mass. Total aluminum sulfate production in the United States rose about 7 percent in 1969 to 1,165,000 short tons.

In the summer, Kaiser Chemical, a division of Kaiser Aluminum & Chemical Corp. announced plans to double capacity at its Germercy, La., aluminum fluoride plant. Production, up to 66,000 tons per year, will be possible at the facility, beginning early in 1970. Aluminum fluoride is mostly used in production of primary aluminum metal. Hydrogen fluoride gas is reacted with alumina trihydrate to make the aluminum fluoride.

In July, Alcoa announced introduction of beta alumina, a calcined alumina said to weigh less by volume than existing aluminas having comparable insulating properties. The product has a lower theoretical density than ordinary alpha alumina particles and has potential application in sintered refractory shapes for use in corrosive alkali atmospheres, in specialized technical ceramics, and in abrasive and polishing compounds.

Table 6.—Bauxite consumed in the United States, by industries

(Thousand long tons, dry equivalent)

Year and industry	Domestic	Foreign	Total [1]
1968:			
Alumina	1,836	11,329	13,165
Abrasive [2]	W	225	[3] 225
Chemical	135	190	326
Refractory	21	290	311
Other	23	47	70
Total [1] [2]	2,015	12,081	14,097
1969:			
Alumina	1,749	12,825	14,574
Abrasive [2]	W	254	[3] 254
Chemical	140	177	318
Refractory	58	308	366
Other	29	40	69
Total [1] [2]	1,976	13,605	15,580

W Withheld to avoid disclosing individual company confidential data; included with "Other."
[1] Data may not add to totals shown because of independent rounding.
[2] Includes consumption by Canadian abrasive industry.
[3] Excludes domestic.

Table 7.—Production and shipments of selected aluminum salts in the United States in 1968

Item	Number of producing plants	Production (short tons)	Total shipments including interplant transfers: Short tons	Total shipments including interplant transfers: Value (thousand)
Aluminum sulfate:				
Commercial (17 percent Al_2O_3)	67	1,178,971	1,147,217	$46,606
Municipal (17 percent Al_2O_3)	3	4,588	NA	NA
Iron-free (17 percent Al_2O_3)	21	77,753	47,549	3,040
Aluminum chloride:				
Liquid (32° Be) Crystal (32° Be)	9	22,267	9,885	820
Anhydrous (100 percent $AlCl_3$)	6	36,237	35,488	9,721
Aluminum fluoride, technical	6	138,971	138,294	26,753
Aluminum hydroxide, trihydrate (100 percent $Al_2O_3 3H_2O$)	8	298,451	270,320	21,070
Other inorganic aluminum compounds [1]	NA	NA	NA	19,844
Total	NA	NA	NA	120,724

NA Not available.
[1] Includes sodium aluminate, light aluminum hydroxide, cryolite, and alums.

Source: Data are based upon Bureau of the Census report Form MA-28E.1, Annual Report on Shipments and Production of Inorganic Chemicals.

STOCKS

All stocks, crude and processed combined, decreased 12 percent, or about 434,000 long tons in 1969. All of the change was in stocks held by consumers rather than those in the hands of producers and processors.

Table 8.—Stocks of bauxite in the United States [1]

(Long tons)

Year	Producers and processors		Consumers [2]	
	Crude	Processed [3]	Crude	Processed [3]
1965	1,007,020	8,689	419,525	1,609,104
1966	1,129,759	10,424	414,446	2,167,741
1967	1,091,926	9,975	405,870	2,078,018
1968	1,036,665	9,622	292,298	2,247,131
1969	1,092,146	10,134	907,997	1,141,388

[1] Excludes strategic stockpile.
[2] Includes stocks of Domestic and Foreign Bauxite.
[3] Dried, calcined, and activated.

PRICES

The price of bauxite in bulk form at the mines ranged from $7 to $10 per ton throughout 1969, according to Oil, Paint and Drug Reporter. This listed price had persisted for more than 1 year. The average value of imported bauxite consumed by domestic alumina plants was $17.44 per long dry ton.

The average value of calcined alumina, as determined from producer reports was $0.0339 per pound, the same as the previous year. The value of imported calcined alumina classified as aluminum oxide for use in producing aluminum was $0.0358 per pound.

The average value of crude, undried, domestic bauxite shipments, f.o.b. mine or plant, rose again in 1969 from $11.46 per long ton in 1968 to $11.50 per long ton. Value data for dried, for calcined, and for activated bauxite were company confidential.

	Atlantic ports, f.o.b. cars	
	December 1968	December 1969
Calcined, crushed (abrasive grade)	[1 2] $35.80	[3] $35.80–36.30
Refractory grade	[4] 43.05	[5] 39.55
Same, super calcined	NA	[6] 43.05
Dried bauxite, crushed, chemical grade (60 percent Al_2O_3, 6 percent SiO_2, 1.25 percent Fe)	15.90–16.90	15.90–16.90

NA Not available.
[1] 87 percent minimum Al_2O_3.
[2] Penalties for SiO_2 content more than 7 percent.
[3] 87.25 percent minimum Al_2O_3.
[4] 87.5 percent minimum Al_2O_3.
[5] 87.75 percent minimum Al_2O_3.
[6] 88 percent minimum Al_2O_3.

Source: Engineering and Mining Journal, December, 1969.

Table 9.—Market quotations on alumina and aluminum compounds

Compounds	Dec. 30, 1968	Dec. 29, 1969
Alumina, calcined, bags, carlots, works ... per pound	$0.0530–0.0555	$0.0530–0.0555
Aluminum hydrate, heavy bags, carlots, freight equalized ... per pound	.0400	0.0400
Aluminum sulfate, commercial, ground, bags, carlots, works, freight equalized ... per ton	58.25	58.25
Aluminum sulfate, iron-free, bags, carlots, works, freight equalized ... per 100 pounds	4.1525	4.1525

Source: Oil, Paint and Drug Reporter.

Table 10.—Average value of U.S. exports and imports of bauxite

(Per long ton)

Type and country	Average value port of shipment 1968	1969
Exports: Bauxite and bauxite concentrate	$49.14	$86.47
Imports:		
Crude and dried:		
Dominican Republic [1]	14.83	16.05
Germany, West	------	9.00
Greece	9.09	8.09
Guinea	4.93	4.76
Guyana	9.06	9.15
Haiti [1]	10.74	13.55
Jamaica [1]	14.45	15.35
Surinam	9.50	9.61
Trinidad and Tobago	------	9.00
Venezuela	8.94	9.05
Average	12.78	13.61
Calcined: [2]		
Canada	43.70	38.02
Guyana	31.41	30.46
Surinam	24.61	27.36
Average	30.43	30.09

[1] Dry equivalent tons adjusted by the Bureau of Mines used in computation.
[2] For refractory use.
Note: Bauxite is not subject to an ad valorem rate of duty and the average values reported may be arbitrary for accountancy between allied firms, etc. Consequently the data do not necessarily reflect market values in the country of origin.

FOREIGN TRADE

Exports of bauxite and concentrates of aluminum decreased about 28 percent in 1969 and were down to 5,276 long tons valued at $456,242. There was a sizable increase in value per ton, from $49.14 in 1968 to $86.47 per ton in 1969. Slightly more than 92 percent was sent to Canada, six other nations shared the remainder. Exports of alumina rose again in 1969 by more than 13 percent to 976,000 short tons valued at $69 million. Seven nations, headed by the U.S.S.R. with 31 percent, took all but 1 percent of U.S. exports. Following the U.S.S.R. was Canada with 29 percent; Ghana, 17 percent; Mexico and Norway, each 8 percent; Venezuela, 4 percent; and India, 2 percent; 48 additional nations took the remaining 1 percent of the exported alumina.

Exports of aluminum sulfate dropped one-third, to 12,275 short tons valued at $366,902. Venezuela again took the greatest proportion in 1969 with 72 percent. Guatemala followed with 9.5 percent; Canada's take was deeply cut and constituted only 6.6 percent of the total; Dominican Republic took 5 percent, and 13 other nations took the balance of 8.9 percent. Aluminum hydroxide exports were on a par with those of the previous year at 26,396 short tons, valued at $3,515,573. They were shipped to 49 countries, headed by Sweden with 46 percent; then Mexico with 28 percent; Canada with 10 percent; and West Germany with 5 percent. Artificial corundum totalling 17,000 tons and valued at $6,775,446 went to 37 separate nations including a small amount to Egypt. The industrial nations of the world were the principal buyers. Canada took 49 percent; the United Kingdom, 10 percent; Japan, 7 percent; Italy, 6 percent; France, 5 percent; and West Germany, 3 percent. Finally, among "other aluminum compounds," there were exports of 22,166 short tons in 1969 valued at $6,668,000. Sixty-four foreign nations took these products, led by Australia, Colombia, Taiwan, Surinam, Argentina, and Norway.

Imports of bauxite rose 11 percent in 1969 to more than 12 million long dry tons. Jamaica provided the United States with 59 percent of its imported bauxite; Surinam furnished 23 percent, the Dominican Republic sent 8 percent, and Haiti, Venezuela and Guyana were import sources for most of the remainder. Bauxite import data do not include shipments to the U.S. Virgin Islands. Imports of alumina for use in producing aluminum rose dramatically, from 1,317,000 short tons in 1968 to 1,912,000 short tons in 1969, an increase of 45 percent. These imports were reflective of the trend toward greater alumina production outside the United States rather than within the nation's borders. The greatest increase in shipments of alumina to the United States was Australia's 88-percent increase to 1,310,000 short tons from 698,000 tons, 1 year previously. This volume was 69 percent of all alumina imported. Surinam and Jamaica supplied most of the rest of the nation's imported alumina, and the United States bought no alumina from Guyana in 1969 for the first time in about 6 years. Imports of aluminum hydroxide and other oxides not elsewhere specified came from 12 countries and totaled 13,257 short tons worth $2,073,000. Canada supplied 84 percent, West Germany supplied 6 percent and Austria, 5 percent, Jamaica, formerly a big supplier, sent none.

Table 11.—U.S. imports for consumption of bauxite (crude and dried) by countries [1]

(Thousand long tons and thousand dollars)

Country	1967		1968		1969	
	Quantity	Value	Quantity	Value	Quantity	Value
Dominican Republic	824	$12,574	783	$11,615	918	$14,738
Guyana	380	3,612	390	3,532	333	3,048
Haiti	313	3,402	399	4,286	599	8,119
Jamaica	6,968	101,223	6,385	92,257	7,132	109,461
Surinam	2,990	29,553	2,865	27,216	2,816	27,070
Venezuela	96	884	107	957	338	3,062
Other countries	23	170	47	365	44	304
Total	11,594	151,418	10,976	140,228	12,180	165,802

[1] Official Bureau of the Census data for Jamaican, Haitian, and Dominican Republic bauxite have been converted to dry equivalent by deducting 13.6 percent free moisture for Jamaican and Haitian, and 17.7 percent for Dominican Republic, in 1967 and 1968; in 1969, Jamaican is 16 percent, Haitian 12.5 percent and Dominican Republic 17.7 percent. Other imports, which are virtually all dried, are on as-shipped basis.

Table 12.—U.S. imports for consumption of alumina for use in producing aluminum, by countries

(Thousand short tons and thousand dollars)

Country	1968		1969	
	Quantity	Value	Quantity	Value
Australia	698	$37,581	1,310	$70,029
Guyana	24	1,448	-----	-------
Jamaica	109	6,708	104	6,955
Japan	11	601	68	4,098
Leeward and Windward Islands	-----	-------	25	1,859
Surinam	475	26,923	403	23,189
Other countries	([1])	34	2	203
Total	1,317	73,295	1,912	106,333

[1] Less than ½ unit.

WORLD REVIEW

Production of bauxite throughout the world made a 14-percent annual gain in 1969, thus continuing the existing trend at a very healthy rate. Australia took most of the high-performance honors by increasing its output from 4.9 million tons in 1968 to 7.8 million tons in 1969, an increase of 59 percent. After a production setback in 1968 amounting to about 8 percent, Jamaica recovered in 1969 with a 23-percent production improvement, which was even a 13-percent increase over its record year of 1967. Jamaica furnished 20 percent of the world's bauxite in 1969 and thus retained a commanding lead. Second was Australia with 15 percent; followed by Surinam with 12 percent. Australia thus edged Surinam out of second place and into third position among world bauxite producing nations during 1969. Although Greece is not large among the world's producers, it continued to make a creditable showing in 1969 with another increase; this time it was 11 percent; in 1968 Greece's output was up 5 percent.

The ratio of world bauxite production to world aluminum production was 5.7 to 1 in 1969.

As world alumina production capacity continued to increase, it appeared that the free world will add about 1 million tons of capacity per year each year in the foreseeable future.

At yearend the free world alumina production capacity was estimated and compared as follows:

	Thousand short tons	
	1968	1969
North America, including Jamaica and Virgin Islands	9,190	10,848
South America	1,334	1,593
Europe	2,620	2,890
Africa	551	606
Asia	1,558	2,200
Oceania	1,747	1,963
Totals	17,000	20,100

Table 13.—World production of bauxite by countries

(Thousand long tons)

Country	1967	1968	1969 p
North America: [1]			
Dominican Republic (shipments)	r 967	978	1,076
Haiti	354	438	654
Jamaica	[2] 9,119	8,389	10,333
United States	1,654	1,665	1,843
South America:			
Brazil	298	309	e 343
Guyana	r 3,327	[3] 3,662	3,700
Surinam	r 5,379	5,569	5,451
Europe:			
France	2,768	2,670	2,729
Germany, West	2	3	3
Greece	1,632	1,722	1,909
Hungary	1,624	1,928	1,901
Italy	238	213	212
Rumania e	15	20	20
Spain	5	6	5
U.S.S.R. e [4]	5,000	5,000	5,100
Yugoslavia	2,097	2,039	2,094
Africa:			
Ghana	345	280	265
Guinea	1,613	2,084	2,420
Mozambique	6	3	4
Rhodesia, Southern	e 2	NA	NA
Sierra Leone	336	414	438
Asia:			
China, mainland e [5]	344	374	443
India	776	921	976
Indonesia	906	865	758
Malaysia (West Malaysia)	885	786	1,056
Pakistan	(6)	1	3
Turkey	21	------	------
Oceania: Australia	r 4,176	4,882	7,792
Total [7]	43,889	45,221	51,528

e Estimate. p Preliminary. r Revised. NA Not available.
[1] Dry bauxite equivalent of crude ore.
[2] May include 122,300 tons of cement-grade bauxite.
Source: Statistical Summary of the Mineral Industry, 1963–68. Institute of Geological Sciences.
[4] Excludes nepheline concentrates and alunite ores.
[5] Data shown include only bauxite (diasporic) for aluminum manufacture; in addition 98,000 to 196,800 tons were produced each year for refractories.
[6] Less than ½ unit.
[7] Totals are of listed figures only.

Australia.—Australia appears headed for the world lead in alumina production and should overtake the U.S. lead by 1975. By yearend 1969, Australian alumina capacity was 1.8 million tons per year compared with about 5.6 million in the United States. By 1972, Australian firms will have added another million tons.

In late 1969, Comalco Industries Pty. Ltd., owned by Kaiser and by Conzinc Riotinto of Australia was planning what would be by far the world's largest alumina plant, eventually capable of producing 5 million tons per year. The plant will be located at Weipa in northern Queensland, with initial output targeted at 700,000 tons per year when it starts in 1974. Ultimate output data was not set. Comalco also operates Australia's oldest alumina refinery and, on November 1, 1969, obtained direct equity in Queensland Alumina Ltd. by acquiring part of the interests of Kaiser and Conzinc Riotinto of Australia. Queensland, in turn, was again expanding its Gladstone plant and by 1970 would be up to 1.3 million tons per year and 2.6 million by 1972. Comalco's bauxite production and processing facilities at Weipa were under appropriate parallel expansion. Output could be around 10 million tons per year by 1975.

AMAX Bauxite Corp., a subsidiary of American Metal Climax, Inc., was proceeding with its project to produce 1.2 million long tons per year of alumina at a plant in the vicinity of Port Warrender in northern Western Australia. Bauxite will come from the Mitchell Plateau in the North Kimberly District. The earlier plans for a 600,000-ton-per-year plant proved uneconomic because of high construction costs in the remote area and because of need to build a town, a seaport, watersupply, power plant, roads, air strip, and a communications system. Total capital requirements for the project were preliminarily estimated at $300 million. To supply this plant, AMAX would mine bauxite at a rate of 2.8 million tons per year.

Nabalco Pty. Ltd., a Swiss-Australian consortium in which Colonial Sugar Refining has a 30-percent share, began development of its large (250 million long tons) bauxite holdings at Gove (also called "Nhulambuy") Northern Territory. A treatment plant will be built and should reach its 1-million-ton-per-year capacity by 1974. An alumina refinery by the same operators is expected to start operating in 1972 at an ultimate rate of 500,000 tons per year. A town to house 4,000 people must also be constructed. Aboriginal tribesmen in the Gove area obtained writs in 1969 holding up further development of the bauxite reserves until the aboriginals' claims of land rights over the area were heard.

In December, Alcoa of Australia, Ltd., announced plans to expand alumina output at Kwinana in Western Australia to 1.25 million tons per year and also to build a second alumina refinery capable of 420,000 tons per year at Pinjarra, 50 miles south of Perth and 30 miles south of the Kwinana plant. Ore from a new open pit mine will travel to Pinjarra over a 15- to 20-mile conveyor belt system.

Bauxite began moving in greater quantities late in 1969 when a 55,000-ton ocean-going ore carrier began service between the Weipa mines and the Gladstone alumina plant in Queensland. Christened the "Clutha Oceanic," the ship will work mostly for Comalco Industries Pty. Ltd. Comalco also ordered two more ore carriers from Italian shipyards in 1969.

Brazil.—Alumínio Minas Gerais S.A., subsidiary of Alcan Aluminium Ltd., announced plans at midyear to develop a $30 million bauxite mining project capable of an annual output of 1 million tons per year. The major high-grade reserve, which was investigated for about 5 years, occurs not far from the Amazon River in the state of Pará in northeastern Brazil. A drying plant and ocean shipping facilities will be built on the Amazon. The bauxite will mainly be shipped to Alcan's alumina plants at Arvida, Quebec, Canada, and shipments were expected to begin in 1973.[2]

Cameroon.—A company formed with Cameroonian Government participation during 1969 to undertake further exploration of the bauxite reserves at Minim Martap had begun work by April. First reports suggested that the alumina content in sizable proportions of the established 1.5 billion tons of reserves may exceed 42–43 percent for the entire deposit. A company known as Alucam (owned primarily by Pechiney and Ugine-Kuhlman) operates a primary aluminum smelter at Edea that depends upon alumina imported from Guinea. Development of bauxite reserves within Cameroon would, therefore, help

[2] Alcan Aluminium Limited. 1969 Annual Report. Feb. 11, 1970, 33 pp.

lead to an integrated industry within the country.

Colombia.—Kaiser Aluminum & Chemical Corp. filed firm mining applications with the Colombian Ministry of Mines and Petroleum during 1969 for bauxite deposits in the Cauca Department. According to reports, the Ministry was agreeable to Kaiser's proposal to export output from the deposit. Kaiser was expecting to prospect intensively during 1969, but no date was set by which the economical feasibility of the deposit was to be determined.[3]

Fiji.—Bauxite Fiji Ltd., formed by Showa Denko, Sumitomo Chemical and Nippon Light Metal Co. Ltd., is proceeding with plans to establish a bauxite mine on the second largest island on the Fiji Group, Vanua Levu. Bauxite is estimated to total 6 million tons. Shipments to Japan of 250,000 tons per year will begin in 1972. Mineral exploration offshore and by aerial survey techniques are continuing.

France.—A new underground bauxite mine at La Baume Sud, which is operated by the Pechiney Co., has reserves estimated at 2.75 million short tons, with an average alumina content of 56 percent. Production increased in 1969 above the 420,000 tons produced in 1968.

French Guiana.—First steps were taken leading to an Alcoa-Pechiney joint venture in which up to 1 million tons of bauxite would be mined annually in French Guiana. Before the company can proceed, plans must be negotiated with the Bureau de Recherches Géologiques et Minierès of France, which controls the bauxite reserves of the South American possession. The bauxite would be barged to the alumina plant of Surinam Aluminum Co., an Alcoa subsidiary, where additional refining capacity will have to be constructed. It will be about 2 years before the overall project goes into operation.

Ghana.—The Kaiser Aluminum & Chemical Corp. announced, in July, that it planned intensive exploratory drilling to determine quality and quantity of available reserves in Ghana. If and when adequate reserves could be determined, an alumina plant appeared a probable next step. Output of such a plant would go into the Tema primary aluminum plant operated by Valco, which is owned 90 percent by Kaiser and 10 percent by Reynolds Metals Co. It was estimated that 5 to 7 years would be needed to put the entire operation into working order.

Greece.—Under plans announced during the year, Aluminium de Grèce, S.A., operators of Greece's sole alumina-aluminum plant, were to increase the output of their facility at Aspra Spitia, Distomon from 250,000 metric tons of alumina and 75,000 metric tons of metal to 400,000 metric tons of alumina and about 90,000 tons of aluminum. The establishment in 1966 by Pechiney of this plant gave great impetus to the Greek bauxite mining industry. Government commitments to Pechiney to provide ample raw materials created encouragement to mine operators to carry out extensive exploration work and to add new and better equipment at already-existing mines. Increased domestic consumption was the goal without cutting into Greece's all important bauxite exports. Parnassus Bauxite, S.A. was successful in developing a new reserve of around 60 million tons. Eleusis Bauxite Mines, S.A. and Elikon Bauxite, S.A. both also increased their reserves and their 1969 production. The Government of Greece established bauxite export quotas for 1969 at 1,756,000 tons broken down by recipient countries: EEC Countries—580,000 tons; U.S.S.R.—450,000 tons; Czechoslovakia—215,000 tons; United States—85 tons, against 40,000 tons the year previous; and all other countries—426,000 tons. It was expected that the Government of Greece and Aristotle S. Onassis would ratify their agreement, under which Onassis would invest $600 million in an industrial complex 26 miles west of Athens. The complex would contain, among others, an integrated alumina-aluminum smelter with annual capacity of 500,000 metric tons of alumina and 160 to 250,000 tons of aluminum metal per year.

Guinea.—Work on the infrastructure of the giant Boke bauxite project got under way on October 3, 1969. Output from the complex, to begin operation in 1972–73, is expected to rise to 8 to 9 million tons annually within 3 years. Boke bauxite contains 55 to 60 percent alumina. Halco Mining (Inc.) is the 51 percent participant and operating partner in the joint venture with the Republic of Guinea, which holds the remainder of the interest. In September, Halco awarded contracts amounting to approximately $71 million

[3] Bureau of Mines. Mineral Trade Notes. V. 66, No. 3, March 1969, p. 4.

for construction of an 85-mile railroad line, dredging for a new port, construction of a townsite and other facilities. The rail link will stretch from Sangaredi where the bauxite deposits are located, to the new Port Kamsar on the Rio Numez River. Bauxite will go to the associates in Halco in proportion to their investment in the company: Alcan, 27 percent; Alcoa, 27 percent; Harvey Aluminum, 20 percent; Vereinigte Aluminium Werke, 10 percent Pechiney/Ugine Kuhlmann, 10 percent; and Montecantini Edison, 6 percent.

Haiti.—Reynolds Haitian Mines, subsidiary of Reynolds Metals Co., initiated use of five especially built, 35-ton aluminum bodied, heavy duty bauxite hauling vehicles for carrying sticky, moist bauxite from the mine down 10 miles of paved road with as much as a 12-percent grade to an ore stockpile. The light body has permitted carrying 40-ton loads with far less downtime than had been Reynolds' experience with 25-ton steel bodied trucks which had encountered heavy wear on tires, brakes, and engines.

India.—Aluminum metal, next to steel, is of prime importance to India because of the extensive bauxite deposits within the country. Other nonferrous metallic ores are very meager and where domestically produced aluminum can be used in place of expensive foreign metals, it is to India's advantage; aluminum has replaced much copper in the cable industry already. In fact, by 1969 there was a rough balance between India's bauxite supply and demand.

In February, a 10,000-ton trial load of bauxite was shipped from Goa on India's West Coast to Montecatini Edison of Italy. After a period of testing, the Italian aluminum company confirmed plans to establish an alumina-aluminum complex in Goa and further reported that it had applied for necessary industrial licenses. Other aluminum producers in West Germany, the Netherlands, and Japan (Nippon Light Metal) also appeared interested in experimental shipments during the year.

Indonesia.—Alcoa signed a contract on April 2, 1969 with the Mines Ministry of the Indonesian Government which permits Alcoa to prospect for bauxite throughout most of the country. Indonesian announcements indicated that Alcoa would spend $1.2 million on a 2-year survey which was to commence within 7 months. The announcements indicated that if ore is found in sufficient quantities, Alcoa may eventually invest $110 million in exploration and in developing mines, refineries, and other facilities.

Meanwhile, during 1969, P. N. Aneka Tambang contracted with Japanese companies to supply 800,000 tons of bauxite from Bintang Island. An equal amount was arranged for in 1970 and then 1 million tons per year for 8 more years. Bintang bauxite averages 53 percent alumina, contains an average of 5 percent silica, 1 percent titania, and about 10 percent moisture.

Jamaica.—First shipments of alumina from the newly completed $200 million plant of Alumina Partners of Jamaica (Alpart) at Nain, St. Elizabeth Parish were made on Monday, August 11, 1969; dedication of the plant was to be held early in 1970. Plants site is about 85 miles west of Kingston. The output of 950,000 short tons per year was believed to be the largest starting capacity of any alumina plant ever built.[4]

The facility processes bauxite from the Essex Valley of St. Elizabeth's Parish, which is hauled from pits to plant in 50-ton aluminum bodied trucks. Alumina from the plant is then transported in aluminum gondola cars on Alparts' own railroad system to Port Kaiser where it is shipped by water to the partners' various aluminum smelters. Owners of Alpart are Anaconda, Kaiser, and Reynolds.

Initial work was begun about midyear on the already announced alumina plant of Revere Jamaica Alumina Ltd., a subsidiary of Revere Copper & Brass Inc. The plant, located on the former Vauxhall Estate, will have an initial capacity of 220,000-ton-per-year. Land is available for the planned expansion of the plant to 660,000 tons of alumina per year.

Alcoa Minerals of Jamaica, Inc. plans to start operation of its alumina plant in 1971 with an initial capacity of 440,000 short tons of alumina. The plant is designed to process bauxite with an average silica content of 5.3 percent, which means that ore from many previously noncommercial bauxite deposits can be used. Another significant feature of Alcoa's agreement with the Government of Jamaica is

[4] Engineering and Mining Journal. First Alumina Shipment Made by Alpart's New Refinery in Jamaica. V. 170, No. 9, September 1969, p. 396.

that there is a limit on the amount of bauxite that the company may export.

Norway.—In the fall of 1969, a decision was made by A/S Årdal og Sunndal Verk to close down the Høyanger alumina plant because it was no longer a profitable operation. The 16,000-ton-per-year plant used the Pedersen process; this was Norway's only alumina plant.

Solomon Islands.—Mitsui Mining & Smelting Co., Ltd., a Japanese firm, has expressed belief that exploration undertaken on Rennell Island south of Guadalcanal in the British Solomon Islands Protectorate during 1969 will confirm reserves of about 100 million tons of 47 to 48 percent low-impurity bauxite. Mitsui hopes to mine at an ultimate rate of 2 million tons per year, beginning in 1972.

Surinam.—Development of the western Surinam bauxite reserves proposed by a consortium of Dutch, French, and U.S. aluminum companies remained in the negotiating stages throughout 1969.

Shipments of Surinam alumina to the U.S.S.R. were noted in 1969. One sale and shipment of 21,000 short tons was made by N. V. Billiton Maatschappij through its main offices in the Netherlands in May. Others included two shipments totaling about 22,000 short tons to the Soviet Union and one of 15,000 short tons in April to Hungary.

TECHNOLOGY

Gibbsite Corporation of America, a subsidiary of Colonial Oil & Gas Corp., of Rochester, N.Y., was in the process of erecting a test plant in Virginia for the production of alumina from gibbsite sand. The gibbsite occurs at very shallow depths in saprolite. The plant was to produce alumina under the corporation's patented Audite process at a cost that was expected to be attractive to the aluminum, glass, and abrasive industries. Gibbsite mining prospects, totaling at least 13,000 acres around Galax, Va., and throughout the mountainous ridge country of West Virginia, Virginia, and North Carolina had been obtained by late December 1969.

Successful manufacture of a new high-alumina, low-silica refractory that reduced chances of development of certain defects in the making of glass was reported by scientists from the Corning Glass Works and its subsidiary, Corhart Refractories Co.[5] Use of isostatic pressing was the key to successful manufacture of the new refractory, designated A–123 by Corhart. The refractory was designed for use in making specific alkali-lead-silica glasses, which tended to form leucite stones when melted in tanks containing certain refractory linings.

Another high-alumina refractory development was announced during the year by Foundry Equipment & Products Co., a division of Combustion Engineering, Inc. The product, called "85–RAM–HS," increases in strength as the temperature rises and chemical bonding occurs. Since the strength is achieved by chemical bonding, it is permanent and does not deteriorate when the refractory is cooled and subsequently heated up.[6]

Through the use of improved solvent extraction technology, metallurgists and chemical engineers at the Bureau of Mines Salt Lake City (Utah) Metallurgy Research Center were investigating ways of recovering metallurgical and/or refractory-grade alumina or aluminum chemicals from aluminum-bearing process and waste solutions. Major emphasis was placed on the production of alumina from copper waste dump leaching solutions from the Bingham Canyon, Utah, mine of the Kennecott Copper Corp. Pioneering studies, later confirmed in the laboratory, have demonstrated that solvent extraction techniques can be used to obtain high quality alumina at costs competitive with those for the conventional Bayer Process alumina. A final report is anticipated in 1970.

An analytical method was developed by the Bureau of Mines to determine the dawsonite, nahcolite, and nondawsonite alumina (called excess alumina) extractable from the Green River Formation oil shales. A total of 83 samples representing an 821-foot section of dawsonite-nahoco-

[5] John F. Wosinski and T. M. Wehrenberg. New Alumina Refractory for Lead Glasses. Presented at 71st Annual Meeting of American Ceramic Society, Spring, 1969. Available from Public Relations Department, Corning Glass Works, Corning, N.Y. 14830.

[6] American Metal Market. Alumina Refractory Developed by Foundry. V. 76, No. 113, June 17, 1969, p. 19.

lite-bearing shale from a core hole in the north part of Colorado's Piceance Creek Basin yielded nahcolite content to 53.3 percent, oil yields to 48.3 gallons per ton, and alumina yields to 5.8 percent. Use of these data to evaluate production potential, at least of the Green River section of the formation, was suggested.[7]

A patent was issued covering a method for extracting alumina from natural or artificial dawsonite.[8]

Two lime sinter processes (single-leach and double-leach) for recovering alumina from clay are evaluated in a Bureau of Mines report.[9]

In the course of an air pollution study and using commerical alkalized alumina sorbent pellets, the Bureau of Mines determined attritioning rates, SO_2 sorption rates, and sulfur loads that could be obtained. Results, using commercialized alkalized alumina compared with sorbent pellets prepared in the Bureau of Mines laboratory, were published.[10]

The Bureau of Mines studied three processes for preparing an intermediate compound, which is calcined to produce alkalized alumina. Considering process technology and raw material requirements, the precipitation of alumina hydroxide followed by the addition of carbon dioxide at 25° C to caustic solutions of aluminum hydroxide proved the most effective.[11]

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[7] Smith, John Ward, and Neil B. Young. Dawsonite and Nahcolite in Green River Formation Oil Shales. BuMines Rept. of Inv. 7286, 1969, 20 pp.

[8] Van Norstrand, Robert A. (assigned to Sinclair Research, Inc., New York, N.Y.). Production of Alumina From Dawsonite. U.S. Pat. 3,459,502, Aug. 5, 1969.

[9] Henn, John J., Paul W. Johnson, Earle B. Amey III, and Frank A. Peters. Methods for Producing Alumina From Clay. An Evaluation of Two Lime Sinter Processes. BuMines Rept. of Inv. 7299, 1969, 43 pp.

[10] Town, Joseph W., Phillip E. Sanker, and Hal J. Kelly. Alkalized-Alumina Attritioning and SO_2 Sorption Rates. BuMines Rept. of Inv. 7275, 1969, 29 pp.

[11] Oden, Laurance L., and Paul E. Francoeur. Preparing Alkalized Alumina. BuMines Rept. of Inv. 7294, 1969, 16 pp.

Beryllium

By Donald E. Eilertsen [1]

Bertrandite from Utah was heralded as a new commercial source of beryllium and a competitor of imported beryl. Production of beryllium metal and beryllium oxide were moderately large in 1969 and outputs of beryllium-copper master alloy and beryllium aluminum were second highest on record. Producers expanded their facilities further to brace for greater demand for their products.

Legislation and Government Programs.—Government yearend stocks of beryl, beryllium-copper master alloy, and beryllium metal are shown in table 2. Government inventories of beryl decreased 4,151 short tons during 1969.

[1] Physical scientist, Intermountain Field Operation Center, Denver, Colo.

Table 1.—Salient beryllium mineral statistics

	1965	1966	1967	1968	1969
United States:					
Beryl, approximately 11 percent BeO:					
Shipped from mines short tons	W	W	W	168	W
Imports do	7,791	2,147	9,511	3,822	6,422
Consumption do	5,845	6,026	7,087	r 9,244	[1] 8,483
Price, approximate, per unit BeO imported, cobbed beryl at port of exportation	$24	$25	$30	$34	$37
Bertrandite ore: Utah, low-grade, shipped from mines short tons	-----	-----	-----	-----	W
World production of beryl do	6,123	4,549	5,442	7,219	7.926

r Revised. NA Not available.
W Withheld to avoid disclosing individual company confidential data.
[1] Includes some bertrandite ore which was calculated as equivalent beryl containing 11 percent BeO.

Table 2.—Government yearend stocks of beryllium materials
(Short tons)

Material	National stockpile	Supplemental stockpile	All stocks
Beryl (11 percent BeO):			
Objective	13,622	1,593	15,215
Excess	4,680	3,141	7,821
Total	18,302	4,734	23,036
Beryllium-copper master alloy:			
Objective	1,075	3,675	4,750
Excess	-----	2,637	2,637
Total	1,075	6,312	7,387
Beryllium metal:			
Objective	-----	150	150
Excess	-----	79	79
Total	-----	229	229

Source: Office of Emergency Preparedness. Statistical Supplement Stockpile Report to the Congress OEP-4, July-December 1969.

DOMESTIC PRODUCTION

Production of beryllium metal and ceramic-beryllium oxide were moderately large. Outputs of beryllium-copper master alloy and beryllium aluminum were exceeded in only one prior year. Production data of these materials are not published to avoid revealing company confidential information.

The new bertrandite processing facility of The Brush Beryllium Co. near Delta, Utah, went on stream in September. The company mined bertrandite ore at its Roadside mine, processed the ore into beryllium hydroxide in its new facility at Delta, and shipped hydroxide to its Elmore, Ohio, plant. That hydroxide, together with hydroxide produced from imported beryl, was converted at the Ohio plant into beryllium metal, alloys, and compounds.

Kawecki Berylco Industries, Inc., processed imported beryl into beryllium metal, alloys and compounds at Reading, Pa., and also processed imported beryl into beryllium metal and hydroxide at Hazleton, Pa.

Other producers of beryllium mineral raw materials were Topaz Beryllium Co., a subsidiary of The Anaconda Company, which mined and stocked bertrandite ore at its operations near Delta, Utah; U.S. Beryllium Corp., which mined and milled some material and shipped a little beryllium mineral concentrate from operations near Lake George, Park County, Colo.; and a number of small producers of hand-sorted beryl in Colorado, Maine, New Mexico, and particularly South Dakota. Production data on domestic beryllium mineral raw materials and on beryllium metal, alloys, and compounds are withheld from publication to avoid disclosing individual company confidential data.

The Anaconda Company continued utilization studies on Utah bertrandite ore. Its subsidiary, General Astrometals Corp., Yonkers, N.Y., produced beryllium shapes from various types of beryllium.

Beryllium Metals & Chemicals Corp., Bessemer City, N.C., sold its facilities for producing electrorefined beryllium and beryllium shapes to General Astrometals.

Kawecki Berylco Industries, Inc., announced expansion of its facilities at Reading. Casting machines will produce furnaces capable of doubling the output of beryllium copper were being installed at Reading. Casting machines will produce beryllium ingots weighing up to 10 tons, and sheet-rolling equipment will roll beryllium sheets 4 feet wide by 15 feet long. A huge isostatic press was being installed at Hazleton for pressing beryllium powder and other powders under ultrahigh pressure into complex shapes.

CONSUMPTION AND USES

The beryllium and ceramic industries consumed 8,483 tons of beryl, including some bertrandite ore which was calculated as beryl equivalent. Kawecki Berylco Industries, Inc., Reading and Hazleton, Pa., and The Brush Beryllium Co., Elmore, Ohio, used beryl to produce beryllium metal, alloys, and compounds. The Brush Beryllium Co. also used beryllium hydroxide derived from its bertrandite mining and processing facilities near Delta, Utah, for the same purposes.

Lapp Insulator Co., LeRoy, N.Y., used ground beryl for making high-voltage electrical porcelain. Beryl Ores Co., Arvada, Colo., used a small amount of beryl to produce specialized materials for the ceramic and other industries.

The U.S. Atomic Energy Commission announced awards of 123 contracts for beryllium parts and materials valued at $4.68 million during fiscal year 1969, as compared to 107 contracts valued at $1.72 million in fiscal year 1968.[2]

The Government provides the biggest market for beryllium. The metal was utilized in numerous critical applications and also in research and development for special purposes. Beryllium was used in the Apollo flights to the moon. A beryllium inertial guidance platform at Cape Kennedy started the Saturn V rocket on a precise course. Many beryllium parts were used in the optical systems used by the astronauts to navigate the quarter-million miles to the moon. A beryllium-encased nuclear power system and beryllium-housed instru-

[2] U.S. Atomic Energy Commission. The Nuclear Industry—1969. Dec. 3, 1969, pp. 92–93.

ments were used on the moon to feel the lunar "pulse" and report back to earth. The metal is also used successfully in discs in various military aircraft brake systems, an application having commercial possibilities.

The Brush Beryllium Co., was the successful bidder on the $8 million beryllium portion of the Poseidon missile program and for brake discs for the F14 Navy fighter plane.

Beryllium-copper alloys continued to have extensive uses—in computers, business machines, electronic devices, aircraft, boats, and automobiles. Recently, it has been used to mold plastics into realistic wood-grained parts for furniture. Beryllium oxide (beryllia), once confined to small output for custom-fabricated parts, is mass produced for the growing electronic market, especially in the field of integrated circuits.

STOCKS

Consumers' stocks of hand-sorted beryl at yearend totaled 5,936 tons compared to 6,443 tons (revised) at yearend 1968. Dealers' stocks of beryl were unknown. Yearend stock of bertrandite ore is company confidential data.

PRICES AND SPECIFICATIONS

Prices of domestic beryl are negotiated between buyers and sellers and are not quoted in the trade press. The value of imported beryl at foreign ports was $412 per short ton. The published nominal price of imported beryl, 10 to 12 percent BeO, c.i.f. Philadelphia, Pa., was $42 to $45 per short-ton unit (20 pounds) of BeO.[3]

Published prices of various forms of beryllium metal; delivered, were as follows: Powder, 98-percent pure, $54 to $66 per pound; ¼-inch-diameter rod, $83 per pound; and billet, $70 per pound.

Quoted prices for various types of beryllium copper, f.o.b. mill, varied throughout the year. Master alloy, 4 percent beryllium, 5-pound ingots, was $48 per pound of beryllium content (copper at cost on date of shipment) until January 26, and afterward $49 per pound of contained beryllium. Alloy No. 25 containing 2 percent beryllium, in strip, rod, bar, and wire form, was priced at $2.62 per pound through January 26; $2.71 per pound through April 22; $2.76 per pound through August 4; $2.81 per pound into September; and afterward at $2.91 per pound. Casting ingot, No. 20–C, containing 2 to 2.25 percent beryllium, 5-pound ingots, was $1.79 per pound through January 26; $1.83 per pound through April 22; $1.88 per pound through August 4; $1.93 per pound into September; and afterward, $2.03 per pound.

[3] Metals Week. V. 40, Nos. 1–52, January–December 1969.

FOREIGN TRADE

Exports of unwrought and wrought beryllium metal and beryllium alloys and waste and scrap were the smallest in many years—69 percent below those of 1968. This was due largely to reduced shipments to West Germany (table 3).

Acquisitions of beryl from the Government stockpile and also the supply of bertrandite ore from the facilities of The Brush Beryllium Co. in Utah resulted in lowered imports of beryl. In addition to the beryllium imports listed in tables 4 and 5, other imports were as follows: 60 pounds of beryllium oxide or carbonate valued at $1,663 from Japan; and 1,041 pounds of other beryllium compounds valued at $14,804—90 percent from Switzerland and the remainder from France and Japan.

Table 3.—U.S. exports of beryllium alloys, wrought or unwrought, and waste and scrap [1]

Country	1968 Pounds	1968 Value (thousands)	1969 Pounds	1969 Value (thousands)
Austria	---	---	524	$43
Belgium-Luxembourg	51	$1	31	4
Canada	2,273	102	7,086	48
Denmark	---	---	67	1
France	915	65	4,446	230
Germany, West	55,994	208	4,686	39
India	304	1	44	1
Israel	2	(2)	15	1
Italy	12	1	1,809	10
Japan	6,162	124	2,298	72
Mexico	1,040	1	---	---
Netherlands	48	1	2,179	13
Spain	22	1	---	---
Sweden	---	---	13	(2)
Switzerland	---	---	2,387	9
United Kingdom	26,652	117	3,366	159
Total	93,475	622	28,951	630

[1] Consisting of beryllium lumps, single crystals, and powder; beryllium-base alloy powder; and beryllium rods, sheets, and wire.
[2] Less than ½ unit.

Table 4.—U.S. imports for consumption of beryl, by customs district and countries

Customs district and country	1968 Short tons	1968 Value (thousands)	1969 Short tons	1969 Value (thousands)
Philadelphia district:				
Angola	---	---	17	$7
Argentina	549	$214	600	227
Australia	124	53	13	6
Bolivia	15	5	---	---
Brazil	1,600	579	4,098	1,695
Burundi and Rwanda	176	60	143	55
Congo	---	---	70	27
Kenya	56	12	44	19
Malagasy Republic	52	16	78	27
Malaysia	---	---	11	4
Mozambique	140	88	69	30
Portugal	67	29	94	44
Rhodesia, Southern	97	32	---	---
South Africa, Republic of	359	131	691	308
Spain	23	7	3	1
Tanzania	---	---	22	9
United Kingdom	---	---	6	2
Uganda	398	129	295	117
Zambia	3	1	---	---
Total	3,659	1,356	6,254	2,578
New York City district:				
Australia	31	11	---	---
Brazil	99	34	---	---
Burundi and Rwanda	---	---	22	8
South Africa, Republic of	---	---	12	5
Uganda	33	12	---	---
Total	163	57	34	13
Baltimore district:				
Brazil	---	---	40	19
Mozambique	---	---	27	12
Uganda	---	---	67	26
Total	---	---	134	57
Grand total	3,822	1,413	6,422	2,648

Table 5.—U.S. imports of beryllium products in 1969, by countries

Country	Beryllium, unwrought, waste and scrap		Beryllium, wrought	
	Pounds	Value (thousands)	Pounds	Value (thousands)
France	2,235	$143	25	$12
Japan	---	---	18	1
United Kingdom	1,453	135	---	---
Total	3,688	278	43	13

WORLD REVIEW

Afghanistan.—Beryl-bearing pegmatites are extensive in eastern Afghanistan, and some are 5 to 15 miles and occasionally 30 miles long. A Soviet-assisted survey in 1963–65 revealed four major pegmatite areas—Deh Bazar in Badakhshan Province, Sundurwar in Laghman Province, and Chawki-Sarkani and Darra-i-Pec in Konar Province. The Darra-i-Pec deposit appeared to be the most important. It forms a triangle with the Chawki-Sarkani and Sundurwar deposits and encompasses over 200 square miles of massive belts and veins of pegmatites. Afghanistan may have one of the largest reserves of beryl in the world.

The Darra-i-Pec beryl deposit, comparable to those in the largest beryl-producing countries, is about 1.73 square miles in area and a part of the 15-square-mile Dara-i-Pec field. The deposit contains two types of pegmatites. One, predominantly microcline and albite, has coarse crystals of hand-separable beryl; the other, predominantly albite and spodumene, contains beryllium, tantalum, and lithium mineralization requiring milling methods for their recovery. The thickness of the veins ranges between 67 and 130 inches in the first type of deposit and averages almost 45 feet in the second. The smaller deposit contains proven and indicated reserves of 1,632 short tons of beryllium oxide (13,255 tons of hand-separable beryl) and 246 tons of columbium pentoxide. Proven and indicated reserves in the larger deposit total 21,200 tons of mechanically separable beryllium oxide and 4,050 tons of columbium pentoxide.[4]

India.—Field reports show that beryl recoveries at mines are excellent and very high quality despite the somewhat unplanned and randomly executed procedures for mining. The "cottage industry" method of recovering beryl from pegmatites requires little or no capital investment; thus, the risk of economic disaster from expensive mechanization and over expansion at current prices and demand is minimized. Families work on a "split-profit" basis in the recovery of beryl. The annual output required to make a fair profit is not large.[5]

[4] Bureau of Mines. Mineral Trade Notes. V. 66, No. 6, June 1969, pp. 5–7.

[5] Bureau of Mines. Mineral Trade Notes. V. 66, No. 10, October 1969, pp. 9–10.

Table 6.—World production of beryl, by countries

(Short tons)

Country	1967	1968	1969 p
Argentina	296	654	e 570
Australia	62	17	---
Brazil	[1] 1,444	[1] 2,291	e 3,100
Congo (Kinshasa)	2	---	160
India	[2] 1,435	e 1,432	1,433
Kenya	19	8	3
Malagasy Republic	33	85	80
Mozambique	186	104	135
Portugal	15	140	30
Rhodesia, Southern	[3] 47	r 97	e 100
Rwanda	120	163	276
South Africa, Republic of	114	340	345
Uganda	r 346	398	316
U.S.S.R.e	1,323	1,322	1,378
United States (mine shipments)	W	168	W
Total [4]	r 5,442	7,219	7,926

e Estimate. p Preliminary. r Revised.
NA Not available. W Withheld to avoid disclosing individual company confidential data.
[1] Exports.
[2] Exports to United States as reported by Indian Department of Atomic Energy.
[3] U.S. imports.
[4] Totals are of listed figures only.

TECHNOLOGY

A new ring-rolling fabrication technique was used experimentally to make thinner, longer, and stronger hollow beryllium tubes. When the new method is used in conjunction with back extrusion, it is possible to convert a solid beryllium cylinder into a hollow tube two to four times larger in diameter and four to six times longer in length. The advantages over vacuum hot-pressed tubes are 50-percent higher yield strength, improved ductility in select directions, and greater utilization of beryllium.[6]

A new method for producing beryllium shapes, known as spark-sintering, combines electrical energy and mechanical pressure to convert powdered beryllium metal, as well as other materials, into shaped objects. Electric current passed through the powder, heats and sinters it rapidly. The properties of spark-sintered beryllium are practically the same as those for hot-pressed block produced by conventional methods.[7]

Experiments on pressed compacts using chromium-coated beryllium powders containing less than 0.3 percent chromium yielded consistently higher physical properties than those made of uncoated beryllium powders of similar particle size. In an evaluation of room-temperature properties, compacts made from chromium-coated beryllium powder averaging 13-micron particle size showed tensile strengths of 88,000 pounds per square inch and no elongation compared to 68,000 pounds per square inch and 3-percent elongation for compacts made from uncoated beryllium powder. The formation of a beryllide ($CrBe_{12}$) from using coated powder accounted for the increased strength. Generally, the addition of small quantities of elements, such as up to 2 percent chromium, to pressed beryllium powder compacts does not significantly affect the physical properties.[8]

A survey of beryllium technology and nuclear applications, which contains data on uses, fabrication methods, and the effects of neutron irradiation on beryllium, was published.[9]

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[6] Glenn, George, and Arthur F. Hayes. New Forging Techniques for Beryllium. Metal Progress, v. 95, No. 3, March 1969, pp. 131–139.

[7] Boesel, R. W., M. I. Jacobson, and I. S. Yoshioka. Spark Sintering Tames Exotic P/M Materials. Materials Engineering, v. 70, No. 4, October 1969, pp. 32–35.

[8] Morana, Simon J., and George J. Jagaciak. Thin Chromium Layer Raises Properties of Beryllium Compact. Metal Progress, v. 95, No. 4, April 1969, pp. 132, 134, 136.

[9] Pih, H. A Survey of Beryllium Technology and Nuclear Applications. No. ORNL-4421, June 1969, 72 pp. (Available from U.S. Dept. of Commerce, Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. 22151.)

Bismuth

By Donald E. Moulds[1]

Consumption of bismuth resumed an upward trend in 1969 despite a shortage in supply, a substantial increase in price, and a major change in end-use pattern. The availability of supply was highlighted by the lowest level of net imports since 1962, although this was balanced by a 43-percent increase over 1968 in domestic refinery production and shipment of over 500,000 pounds from Government stocks. Rising foreign demand created an attractive export market situation, and the domestic price was forced upward during the year from $4 to $6 per pound. At yearend domestic stocks of bismuth metal, excluding the Government stockpile, were about 8 percent below those existing at the beginning of the year.

Table 1.—Salient bismuth statistics

(Pounds)

	1965	1966	1967	1968	1969
United States:					
Consumption	2,931,673	3,199,321	2,513,652	2,347,768	2,531,959
Exports [1]	341,868	89,382	152,684	120,466	447,931
Imports, general	1,378,147	1,681,472	1,379,729	1,265,671	894,804
Price: New York, average ton lots	$3.43	$4.00	$4.00	$4.00	$4.63
Stocks Dec. 31: Consumer and dealer	506,300	651,800	659,600	621,500	597,901
World: Production	6,526,000	6,861,000	7,441,000	8,076,000	8,465,000

[1] Includes bismuth, bismuth alloys, and waste and scrap.

Legislation and Government Programs.— The General Services Administration, as authorized under Public Law 90-153 enacted November 30, 1967, continued disposal of surplus Government stocks of bismuth at the rate of 150,000 pounds each calendar quarter. Sales were conducted on an off-the-shelf basis at market prices at the time of offering. Purchasers had to agree that the bismuth was for domestic consumption and that they would not increase exports above the smallest quantity exported in any one of the immediately preceding three quarters. Sales amounted to 482,500 pounds during the year. The offering of 150,000 pounds was oversubscribed in each of the last three quarters. The reduction of inventories in 1969, reflecting shipments to industry, amounted to 529,197 pounds.

The Office of Emergency Preparedness announced on December 3 establishment of a bismuth stockpile objective of 2.1 million pounds, a reduction from the prior 2.4 million pounds. The total Government inventory at yearend in national and supplemental stocks was 2,876,986 pounds, and the surplus thus created amounted to 777,000 pounds. The sale of 477,000 pounds is authorized in 1970 under Public Law 90-193.

DOMESTIC PRODUCTION

Domestic refinery production from primary and secondary materials increased 43 percent over the 1968 strike-curtailed output. Shipments exceeded production and refinery stocks were reduced 23 percent. The Omaha plant of American Smelting

[1] Physical scientist, Division of Nonferrous Metals.

and Refining Company was the major bismuth producer. The East Chicago, Ind., plant of United States Smelting, Refining and Mining Co. was the only other primary producer. Secondary recovery of bismuth from alloy scrap amounted to about 4½ percent of domestic output and was accomplished at the Franklin Park, Ill., plant of United Refining & Smelting Co.

A new organization, Gulf Chemical and Metallurigical Corp., was announced by Fred H. Lenway & Co. and Southern California Chemical Co. The company will operate the old Texas City tin smelter for recovery of a wide range of products including bismuth from spent bismuth-molybdenum catalysts. The bismuth will be refined to metal at a plant in Los Nietos, Calif. Production was not reported in 1969.

CONSUMPTION AND USES

Consumption of bismuth metal, including direct use of bismuth-lead bullion, increased almost 8 percent above the 1968 low. All use categories exhibited growth, although the availability of metal had a retarding effect during the latter part of the year.

Consumption of fusible alloys increased almost 11 percent. The fusible alloys, manufactured to a wide range of melting points, have many applications in safety devices, temperature regulators, casting molds for plastics, forming tools, and fixtures. Low-melting alloy was especially in demand for a blade grinding and assembly fixture used in the production of jet engines.

Bismuth is also used as a metallurigical additive in iron and aluminum, an application that grew 15 percent in 1969. Of the total, 73 percent was used in malleable iron to improve castability and machinability, 24 percent was used in aluminum to improve machining and the remaining 3 percent was used in various alloys, including Babbitt and amalgam.

The largest use of bismuth is in the manufacture of pharmaceuticals which includes a wide variety of chemical compounds used as medicines, cosmetics, catalysts and laboratory reagents. From 1968 to 1969 consumption increased slightly over 3 percent but was far below the record 1.72 million pounds used in 1966.

Table 2.—Bismuth metal consumed in the United States, by uses

(Pounds)

Use	1968	1969
Fusible alloys [1]	675,416	748,393
Other alloys	454,519	523,710
Pharmaceuticals [2]	1,210,396	1,250,539
Experimental uses	215	252
Other uses	7,222	9,065
Total	2,347,768	2,531,959

[1] Includes 106,104 pounds of bismuth contained in bismuth-lead bullion used directly in the production of an end product in 1968 and 62,995 pounds in 1969.
[2] Includes industrial and laboratory chemicals.

A radical change in end use took place in 1969. The bismuth-molybdate catalyst for acrylic fiber production was reduced to an insignificant total, and the use of bismuth oxychloride for cosmetics expanded rapidly. Bismuth-molybdate catalyst, in which large amounts of bismuth were used in 1965–66, has been largely replaced by a less expensive antimony-depleted-uranium catalyst. The largest use of bismuth in 1969 was in the manufacture of bismuth nitrate for conversion to bismuth oxychloride. The bulk of the oxychloride is consumed in cosmetics—lipstick, cake powder, nail lacquers, hair spray, etc. The average size pearlescent lipstick, for example, contains about 0.0035 ounce of bismuth.

STOCKS

Consumer and dealer stocks of bismuth, amounting to 621,500 pounds at the end of 1968, were reduced to 502,000 pounds by midyear and then gradually increased to 598,000 pounds at yearend. Domestic producers shipments reflected heavy demand for domestic metal. Stocks at refineries were reduced 23 percent during the year.

PRICES

The delivered price of refined bismuth metal, in ton lots, was stable at $4 per pound from June 21, 1965, until advanced on August 1, 1969, by Cerro Sales Corp. to $5.25 per pound and by American Smelting and Refining Company to $5 per pound. The price was soon stabilized at $5.25. On November 1, the price was increased to $6 per pound.

The free-market price, as quoted by the London Metal Bulletin, held reasonably close to domestic producers, prices until July 1, at $4.70 to $4.90 per pound. The price then gradually increased to $4.90–$5 by the end of July and to $6.90–$7.10 by the end of October. The peak was reached in early December at $9.80 to $10 per pound c. i. f. U.K. ports, and at yearend was quoted at $8.90 to $9.10 per pound. Dealers' prices in the United States followed the free-market pattern.

FOREIGN TRADE

Exports of bismuth metal and alloys, largely to Europe, totaled 448,000 pounds gross weight and were valued at over $1.5 million, a record amount and almost four times the value of exports in 1968. Exports were destined for 17 countries. The United Kingdom and the Netherlands accounted for 53 percent and other Western European countries took 15 percent. Japan imported 20 percent of the U.S. bismuth and East Germany imported 22,200 pounds in 1969.

Table 3.—U.S. exports of bismuth[1]

Year	Gross weight pounds	Value
1966	89,382	$225,617
1967	152,684	395,695
1968	120,466	292,245
1969	447,931	1,515,363

[1] Includes bismuth, bismuth alloys, and waste and scrap.

General imports of metallic bismuth totaled 894,804 pounds, a 29-percent decrease from 1968 deliveries and the lowest level since 1962. Imports from Canada increased, which indicated the expanding output associated with molybdenum production. Receipts from Mexico were comparatively the same as in 1968. In 1968 the domestic market received almost over 37 percent of the Peruvian output compared with 21 percent in 1969. Asian exports were largely directed toward Europe.

Table 4.—U.S. general imports of metallic bismuth, by countries

Country	1968		1969	
	Pounds	Value (thousands)	Pounds	Value (thousands)
Canada	121,916	$479	142,013	$617
Japan	97,693	371	50,229	203
Korea, South	4,435	17	------	----
Mexico	383,367	1,316	382,630	1,473
Peru	658,260	2,535	319,932	1,419
Total	1,265,671	4,718	894,804	3,712

WORLD REVIEW

The demand for bismuth in the industralized areas of the world, and the resulting high prices and critical supply availability continued to induce expansion of production to the maximum consistent with efficient smelter recovery from bismuth containing ores. The byproduct relationship of bismuth to copper, lead, molybdenum, and tin ores determines production at the refinery rather than at the mine. In 1969 the world production of metal, excluding data withheld for the United States and based in part on preliminary reports and estimates, approximated 8.4 million pounds in comparison to the 6.4 million pounds produced in 1964 prior to the initiation of an upward trend in price. Peru continued to be the largest producer of bismuth-in-ore and was followed by Bolivia, Mexico, and the United States. Peru was also the leading producer of refined bismuth and was closely followed by Japan. The United States is also a large producer of metal from domestic ores, from imports of raw material, and from secondary materials. The United States, is the leading consumer of metal, followed by Japan, France, and other Western European countries, France in particular is the leading consumer of bismuth in pharmaceutical compounds, and the continuation of the French Government's subsidy on bismuth used in pharmaceuticals maintained a high demand. The principal bismuth metal producers and their plant locations are as follows:

Belgium	Société Géneral Métallurgie de Hoboken. Société des Mines et Fonderies de Zinc de la Vieille-Montagne.
Canada	Cadillac Moly Mines Ltd., Preissac, Quebec. Canadian Copper Refiners Ltd., Montreal, Quebec. Cominco Ltd., Trail, British Columbia. Gaspé Copper Mines Ltd., Murdochville, Quebec. Molybdenite Corporation of Canada Ltd., Val d'Or, Quebec. Preissac Molybdenite Mines Ltd., Preissac, Quebec.
France	Société des Mines & Usines de Salsigne, Combe-duSaut. Société Miniere et Metallurgique de Peñarroya, Noyelles-Godault.
Germany, West	Norddeutsche Affinerie, Hamburg. Unterharzer Berg- und Huttenwerke, G.m.b.H., Oker.
Italy	Monteponi e Montevecchio S.p.A., San Gavino Monreale, Sardinia.
Japan	Sumitomo Metal Mining Co., Ltd., Kuritomi. Mitsui Mining and Smelting Co., Ltd. Kamioka. Rasa Industries Ltd., Miyako. Mitsubishi Metal Mining Co., Ltd. Hosokura. Toho Zinc Co. Ltd., Chigirishima. Nippon Mining Co., Ltd., Saganoseki. Dowa Mining Co., Ltd., Kosaka. Furukawa Mining Co. Ltd., Ashio.
Korea, South	Korea Tungsten Mining Co. Ltd., Sangdong.
Mexico	Metalurgica Mexicana Peñoles, S.A., Monterrey. Asarco Mexicana, S.A., Monterrey.
Netherlands	NV Hollandse Metallurgische Industrie Billiton, Arnheim.
Peru	Cerro de Pasco Corp., Oroya.
Sweden	Bolidens Aktiebolag Rönnskär, Skelleftehamm.
United Kingdom	Mining and Chemical Products Ltd., Alperton.
Yugoslavia	Rudnici I Toplomice Olova I Cinka, Kosovska Mitrovica.

Table 5.—World production of bismuth by countries

(Thousand pounds)

Country [1]	1965	1966	1967	1968	1969 p
Australia (in concentrates)	---	1	r 26	388	448
Bolivia	599	991	1,107	1,268	1,476
Canada (metal) [2]	429	526	668	648	721
China, mainland (in ore) e	660	660	r 551	551	551
France (in ore)	135	129	r 123	128	e 132
Italy (metal) [3]	9	27	33	18	e 20
Japan (metal)	1,347	1,214	1,399	1,595	1,642
Korea, South (metal)	179	216	243	229	247
Mexico [2]	1,025	1,036	1,111	1,157	1,336
Mozambique	13	4	4	5	e 4
Peru [2]	1,781	1,674	r 1,785	1,757	1,518
Sweden e	77	77	66	44	33
U.S.S.R. (metal) e	77	77	88	99	110
United States	W	W	W	W	W
Yugoslavia (metal)	195	229	237	189	227
Total [4]	6,526	6,861	r 7,441	8,076	8,465

e Estimate. p Preliminary. r Revised. W Withheld to avoid disclosing individual company confidential data.

[1] In addition to countries listed, Argentina, Republic of South Africa, South-West Africa, Spain and Uganda also produce bismuth in small quantities, and it is believed to be produced in Brazil, Bulgaria, and East Germany but production data for the latter countries are not available.

[2] Bismuth content of refined metal and bullion plus recoverable content of concentrates exported.

[3] Production of Monteponi-Montevecchio Co., probably including production from purchased and toll materials.

[4] Total is of listed figures only.

Australia.—Production from existing mines and smelters was about 448,000 pounds. The entire output was exported to Japan for refining. New properties are being developed and refining facilities are under consideration.

Belgium.—The two large base-metal complexes, Société Géneral Métallurgie de

Hoboken, S.A., and Société des Mines et Fonderies de Zinc de la Vieille-Montagne, S.A., refine bismuth obtained from imported ores, intermediate smelter products, and secondary materials.

Bolivia.—Bolivia is one of the few areas where the bismuth content of ores runs as high as 40 percent. It is often found in association with copper and tin. The concentrates are exported to West Germany, the Netherlands, and Peru for refining. Corporacíon Minera de Bolivia, began construction of a bismuth smelting facility at Telemayu in October. The plant was being built by Poudreries Reunies of Belgium and was scheduled for production of crude metal, 95 percent bismuth, by March 1970. A proposed refinery will upgrade the metal to commercial grades.

Canada.—Approximately 60 percent of Canadian production is a coproduct of molybdenum produced by Molydenite Corporation of Canada Ltd.; Preissac Molybdenite Mines Ltd.; and Cadillac Moly-Mines Ltd. This bismuth, recovered as concentrates and processed to crude metal, is exported for refining. About 35 percent of the bismuth is produced from lead-zinc ores by Cominco Ltd., at Trail, British Columbia, and refined to metal. Another 5 percent is produced from copper-smelting flue dusts by Gaspé Copper Mines Ltd. as crude metal for export.

France.—Production as a byproduct of lead-zinc ores is smelted to bullion and refined in the United Kingdom. France is the world's largest importer of refined bismuth.

Japan.—Most of the domestic production is a byproduct of copper and lead ores. Additional refinery production is obtained from processing of imported base-metal concentrates.

Mexico.—Essentially all bismuth is produced in conjunction with smelting lead ores. Approximately one-half the output is refined to metal. The remainder is exported as bismuth-lead bullion for refining in the United States and United Kingdom.

Peru.—All bismuth produced is a byproduct of lead and copper ores. Of the 1.9-million-pound output about 600,000 pounds was exported as base-metal concentrates. The remainder, plus some 500,000 pounds in concentrate from Bolivia, was refined to commercial metal or alloy by Cerro de Pasco Corp.

Boron

By J. M. West [1]

Sales of boron minerals, continuing an uninterrupted rising trend that began in 1961, reached another new high in 1969. Markets were good, especially the export markets, and partly because of this, some products were reported in short domestic supply despite expansions at the major source, the Boron, Calif., operations of U.S. Borax & Chemical Corp. A new 95-percent anhydrous boric acid product captured a portion of the market for high B_2O_3 compounds because of its price and transportation economies in terms of boron content. A zinc borate compound was introduced for addition to plastics as a fire retardant. Boron fiber composites were increasingly used because of high strength to weight properties. Colemanite deposits were under development in the Death Valley area of California and sizable reserves were indicated.

Legislation and Government Programs.—In accordance with the Tax Reform Act of 1969, depletion rates were lowered from 15 to 14 percent on both domestic and foreign borax production, effective with taxable years beginning on or after October 9, 1969. No Government procurement programs for borates were in effect in 1969, and there were no Government stocks.

Table 1.—Salient boron minerals and compounds statistics in the United States

(Thousand short tons and thousand dollars)

	1965	1966	1967	1968	1969
Sold or used by producers:					
Quantity:					
Gross weight	807	866	r 892	r 963	1,020
Boron oxide	425	462	r 473	r 519	551
Value	$64,180	$68,209	r $69,819	r $76,535	$81,261
Imports for consumption:					
Quantity	6	12	27	19	25
Value	$279	$1,034	$1,201	$1,184	$1,668

r Revised.

DOMESTIC PRODUCTION

Domestic production of borate minerals rose; sales reported by producers were 6 percent higher than in 1968. Boron minerals were mined chiefly by open pit methods, with most of the output from Kern County, but some from Inyo County, Calif. In addition, a small tonnage was produced by underground methods in Inyo County, and production continued from brine solutions by two companies at Searles Lake, San Bernardino Country, Calif. The Boron mine of U.S. Borax & Chemical Corp., subsidiary of Rio Tinto-Zinc Corp. Ltd. since 1968, remained the world's foremost source of boron. The firm produced an upgraded crude sodium borate and various finished products at Boron, Calif., and processed borates in other plants at Wilmington, Calif., and Burlington, Iowa. Borates were shipped from Wilmington docks to many parts of the world.

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[1] Physical scientist, Bureau of Mines, San Francisco, Calif.

During the year, the company installed a new vacuum crystallizer system, several new thickeners, and an additional fusing line at its Boron works.[2]

Producers of borate and related products at Searles Lake were American Potash & Chemical Corp., a subsidiary of Kerr-McGee Corp., and Stauffer Chemical Co. Active with experimental solar evaporation studies in the same area was Searles Lake Chemical Corp., a subsidiary of Occidental Petroleum Corp., which together with another subsidiary, Garrett Research and Development Co., conducted evaluation tests at another site and produced small tonnages of borates and coproducts. Prototype ponds covering 400 acres were reported in use.

U.S. Borax & Chemical Corp. and Tenneco Corp. produced colemanite from mines near Furnace Creek, Calif. The products were used in nuclear shielding and as drill-hole stemming at test sites of the U.S. Atomic Energy Commission in Nevada. Tenneco continued to explore properties near Shoshone and Ryan, Calif., and apparently had discovered large tonnages of colemanite ore in both areas minable by open pit and underground methods.

CONSUMPTION AND USES

Glasses, enamels, soaps, chemical and agricultural products, and abrasives remained the major categories of boron consumption. Among the many products using boron were fertilizers, tanning compounds, fungicides, gasoline additives, fluxes, metal alloys, nuclear-shielding components, pesticides, and flameproofing compounds. Glass fiber consumed increasing amounts of boron, largely as a result of the popularity of glass-fiber textiles and the use of textile-grade fibers to reinforce tires. U.S. Borax & Chemical Corp. developed and began test-marketing a fire retardant additive for vinyl and polyester plastics. The advantages over other retardants were said to include less impairment of translucency and color, more resistance to formation of bubbles at elevated temperatures, and greater availability than traditional antimonial retardants. The compound, a zinc borate with 3.5 molecules of water of hydration, was given the trade name "Firebrake ZB."

To meet the growing demand for use of boron filaments in fiber composites, filament production capacity was tripled to 10,000 pounds a year at the Windsor Locks, Conn. plant of Hamilton Standard Division of United Aircraft Corp.

A copper master alloy containing 2 percent boron was introduced for removing impurities from metallic melts and for retarding grain growth.[3] An isotope-enriched boric acid was prepared for calibrating spectrometers and for use in nuclear reactors.[4] Boride evaporator bars were being tested for use in vacuum-metallizing. Development of processes for producing high-purity elemental boron and in utilization of boron composites in the aerospace industries continued. An estimated 25 to 30 tons of elemental boron was consumed in various specialized products in 1969.

Greater use of boron in metallurgical applications was foreseen. Research was conducted on substitution of borates for other fluxes in steelmaking, and efforts were underway to expand markets for borates in shielding for nuclear testing and for protective use with atomic waste products because of the radiation-absorption properties of boron. Continued overall growth in boron markets was predicted.[5]

[2] Commercial Fertilizer and Plant Industry. Part of $9 Million Expansion: New Crystallizer Line at U.S. Borax, Boron. V. 119, No. 3, September 1969, p. 23.

[3] American Metal Market. Kawecki Berylco Introduces New Boron Copper Alloy. V. 76, No. 129, July 10, 1969, p. 9.

[4] Technical News Bulletin. Enriched Boric Acid. V. 53, No. 7, July 1969, p. 162.

[5] Industrial Minerals (London). Sizeable Market for Borates Still Growing. No. 22, July 1969, pp. 10–20.

Thompson, R. The Boron Products Industry. 9th Commonwealth Min. and Metal Congress, London, Paper 12, 1969, 9 pp.

PRICES

Prices of virtually all borate products were higher than those in 1968, and an additional increase was posted at yearend on boric acid in all forms except a new special 95-percent anhydrous grade. The latter grade sold at a sharp discount from the price of the customary 99.9-percent grade. The price differential between U.S.P. and technical grades of boric acid sold in bags increased by $5 per ton. Elemental boron prices were quoted at yearend by American Metal Market as follows (per pound, in ton lots): 90 to 92 percent, $13; 97 to 99 percent, $18; and over 99 percent, $70. Boron fibers were priced about $250 per pound by one producer; however, prices were expected to decline with anticipated increased volume of production.

Table 2.—Borate prices at yearend, 1969

	Per short ton [1]
Borax, technical:	
Anhydrous, 99 percent:	
Bags	$102.50
Bulk	92.75
Granular, decahydrate, 99.5 percent:	
Bags	58.75
Bulk	50.25
Granular, pentahydrate, 99.5 percent:	
Bags	75.25
Bulk	66.75
Boric acid, technical: [2]	
Anhydrous, 99.9 percent, bags	397.00
Anhydrous, 95 percent, bulk	161.00
Crystals, 99.9 percent:	
Bags	240.00
Drums	273.00
Granular, 99.9 percent:	
Bags	125.00
Drums	158.00
Bulk	115.00
Sodium borate powder, U.S.P., bags	111.25

[1] Carlots, f.o.b. plant works.
[2] Boric acid U.S.P. $30 per ton higher than technical grade, in bags.

Source: Oil, Paint and Drug Reporter and industry sources.

FOREIGN TRADE

Exports of boric acid were lower in quantity but higher in value. The largest tonnages went to Japan, Canada, the Netherlands, and West Germany. Exports of re-

Table 3.—U.S. exports of boric acid and sodium borates in 1969

Destination	Boric acid (H_3BO_3 content)		Sodium borates (refined)	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Australia	2,119	$287	4,202	$389
Belgium-Luxembourg	39	4	801	62
Brazil	989	143	2,818	322
Canada	5,450	597	8,818	824
Chile	237	33	940	109
Colombia	259	39	1,227	128
Finland	9	1	247	19
France	11	5	6,880	661
Germany, West	4,836	476	1,818	158
Hong Kong	225	30	5,005	510
Indonesia	------	------	549	46
Israel	82	9	387	32
Italy	26	7	6,294	598
Japan	10,798	1,496	46,408	4,192
Korea, South	340	47	3,633	253
Mexico	1,426	211	9,211	913
Netherlands	5,422	808	68,929	7,131
New Zealand	707	90	3,793	553
Pakistan	256	34	778	52
Peru	160	22	483	45
Philippines	296	39	924	96
Singapore	29	4	534	50
South Africa, Republic of	357	50	341	30
Spain	121	24	1,255	138
Sweden	103	17	1,080	90
Switzerland	------	------	1,301	97
Taiwan	170	23	2,574	206
Thailand	------	------	955	94
United Kingdom	937	90	5,230	500
Venezuela	284	42	141	12
Vietnam, South	41	7	1,223	77
Yugoslavia	------	------	6,118	652
Other	723	112	2,301	218
Total	36,452	4,747	197,198	19,257

fined sodium borates increased in both quantity and value. In addition, large but unspecified quantities of unrefined sodium borates were exported, chiefly to Western Europe.

Colemanite, a calcium borate, was imported from Turkey in the amount of 24,303 short tons valued at $717,550. A small tonnage of boric acid was imported from Canada. Boron carbide, totaling 211 short tons valued at $883,464, was imported mainly from Canada and West Germany in 1969. Boron metal, waste, and scrap imports came mostly from West Germany and totaled 859 pounds valued at $61,124.

WORLD REVIEW

Argentina.—Boroquimica Limitada, a Borax (Holdings) Ltd. subsidiary, remained the principal producer of borate minerals in Argentina and operated its plant at Campo Quijano, Salta Province, at nearly its 25,000-ton-per-year capacity in 1969. The firm had conducted an exploration program for several years and was evaluating new reserves in the vicinity of the Tincalayu open pit mine, which it operated at the edge of the Salar del Hombre Muerto. Minerals occurring in the area include borax, kernite, ulexite, tincalconite ($Na_2O.2B_2O_3$) and several rare borates found in few other places. Production of borates in Argentina totaled 23,200 short tons during 1968; 8,140 tons of borates and perborates valued at $834,300 was exported, largely to Brazil and Chile.

Chile.—Mining of ulexite at the Ascotán mine in Antofagasta Province was discontinued in 1967, but small surface stocks remained to be sold. Boric acid continued to be produced in Chile as a byproduct of nitrate operations by Companía Salitrera Anglo-Lautaro at Coya Sur, also in Antofagasta Province. Boric acid capacity of the plant was reported at 2,500 tons per year. The Government reportedly sought assistance in developing ulexite ores in Tarapaca Province near the Bolivian border.

France.—Borax Français SA, a subsidiary of Borax (Holdings) Ltd., was expanding its plant at Coudekerque near Dunkirk to 25,000 tons of boric acid per year. Increased demand for boric acid in glass, ceramics, and nylon manufacture was cited for the expansion scheduled to be completed in late 1970. The plant would then account for about one-third of the production capacity of the Common Market countries, which was estimated to total 50,000 tons in 1969.

Italy.—Lardarello SpA scheduled doubling of boric acid capacity at its Volterra, Pisa, plant to 40,000 tons per year. New facilities were to include a 30,000-ton-per-year borax unit. The plant used Turkish colemanite as its raw material.

Netherlands.—Reported storage capacity of silos and warehouses of the Borax (Holdings) Ltd's Rotterdam terminal was about 50,000 tons of varied boron products. Trona Chemicals Co., a subsidiary of American Potash & Chemical Corp., shipped borax products to Rotterdam from the United States through the Dutch firm, Rotterdamse Silo Combinatie (ROSILCO NV), for distribution in Europe.[6]

Turkey.—Borates were produced in Turkey mainly in the following areas: Susurluk and Bigadic, Balikesir Province; Emet, Kutahya Province; M. Kemalpasa, Bursa Province, and Seyitgazi, Eskişehir Province. Production totaled 356,000 short tons in 1969, about 20 percent higher than in 1968. Exports of borates, according to the State Institute of Statistics, totaled 256,000 short tons in 1968 and were expected to go higher in 1969. France and Italy were the main destinations for crude borates; important quantities also went to the United States, the United Kingdom, Poland, East Germany, and Japan. Etibank, the State mining agency, continued to produce largely hand-cobbed colemanite from its open pit mine at Hisarcik.

Türk Boraks Madençilik, a subsidiary of Borax (Holdings) Ltd., was active in developing a mining concession at Killick, where large reserves had been outlined. Government plans remained unclear as to whether development of the recently discovered Kirka area deposits would be allowed to proceed under private ownership or whether the operations would be nationalized. Rasih ve Ihsan AS operated an underground colemanite mine on con-

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[6] Industrial Minerals (London). Rotterdam's Role in Bulk Mineral Distribution. No. 19, April 1969, pp. 33–35.

cessions near Bigadic. The company produces 25,000 to 30,000 tons of ore annually. In the same area, subsidiaries of the Ugine-Kuhlmann (France) and American Potash & Chemical Corp. (U.S.) joined in mining ulexite and colemanite ores, mainly for export to France. The combine received approval from the Turkish Government to develop a second property nearby.

Etibank's new plant at Bandirma operated with a capacity for about 22,000 short tons of borax and 6,600 tons of boric acid. Plans to build a colemanite beneficiation plant at Emet, possibly in 1970, with a capacity of 165,000 tons of concentrate, were studied. The plant would upgrade the ore from about 30 to 43 percent B_2O_3 content.

U.S.S.R.—Test shipments of borates during 1969 to Mexico and Japan from the U.S.S.R. and mainland China were reported.

TECHNOLOGY

Of over 80 minerals identified in the Kramer borate district of Kern County, Calif., nearly one-fourth were borates, including several that were first described in the Kramer deposit.[7] Discovery of a new boron mineral, named terrugite, was reported at the Loma Blanca borate mine in Jujuy Province, Argentina. The mineral occurred as white, cauliflower-shaped nodules in a spring deposit.[8]

Anhydrous boric acid was produced in a continuous production unit.[9] The process utilized sodium pentaborate directly reacted with sulfuric acid, followed by heating in a furnace. The products, separated by gravity into anhydrous boric acid (ABA) and salt cake, were then split by passing the mass through a horizontal blade to produce two marketable compounds. The ABA was reported to have a purity of 95 percent or more and to be strongly competitive with the purer but higher cost ABA produced by established processes in the borate industry.

With boron present in small fractions of a percent, increasing the manganese content of steel increased its hardenability and permitted reduction in carbon content without loss of product strength.[10] The development was reported to have fostered a new series of boron-treated steels combining cold formability with strength and toughness in heat-treated parts. A new additive for making boron steel was said to provide savings in cost up to 25 percent, and use of the additive was recommended to improve the hot workability of stainless steels.[11]

The effects of oxidation and thermal shock on boron nitride and composited materials at high temperatures were investigated at the Langley Research Center of NASA in Hampton, Va.[12] Tested for compatability, the boron nitride showed little or no reaction with refractory ceramics at temperatures up to 1,500° C or with refractory metals up to 1,000° C. Several new grades of boron nitride powders said to provide greater stability at temperatures above 500° C were placed on the market.[13] A cubic form of boron nitride was claimed by its developer, General Electric Co., to have superior abrasive qualities for metalworking. The product was rated second only to diamond in standard tests and gave significant cost reductions when used in either wet- or dry-grinding of hardened tool steels.[14]

Technology of boron fiber composites advanced significantly during the year. Metal matrix composites were produced by continuous casting by General Technologies Corp., Reston, Va., in a process for making preformed shapes of boron reinforced magnesium.[15] A composite tita-

[7] Morgan, Vincent, and Richard C. Erd. Minerals of the Kramer Borate District, California. Calif. Div. of Mines and Geol., Min. Inf. Serv., Part I, v. 22, No. 9, September 1969, pp. 143–153; Part II, v. 22, No. 10, October 1969, pp. 165–172.

[8] Aristarain, L. F., and C. S. Hurlbut, Jr. Terrugite, $4CaO.MgO.6B_2O_3.As_2O_5.18H_2O$, A New Mineral From Jujuy Argentina. Amer. Miner., v. 53, No. 11–12, November–December 1968, pp. 1815–1827.

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nium-boron tape was manufactured by a high-speed diffusion bonding process on a continuous basis by Solar Division, International Harvester Co., in San Diego for use in turbine blades.[16] Boron-aluminum composites for blades were tested successfully in a turbofan jet engine and promised significant increases in blade efficiency.[17] Airplane propeller blades of a similar composite were being considered.

Rudder sections were fabricated by McDonnell Douglas Corp. from a composite of epoxy resin and boron fibers for test installation in the F-4E fighter-bomber. Weight was reduced from 64 pounds for a comparable aluminum part to 42 pounds for the composite. The firm received a U.S. Air Force contract to produce 50 such units for experimental purposes. Bendix Corp. used boron composite parts instead of metal in landing-gear assemblies for aircraft, and this provided a 25- to 40-percent savings in weight. North American Rockwell Corp. was awarded a contract to construct a boron-epoxy wing for the Air Force's F-100 fighter plane. Northrup Corp. studied the use of composite parts in supersonic transport airframes. Production of boron filament tapes was described.[18] Characteristics of boron fiber composites were compared with those of graphite and other types of composites.[19] A prediction was made that within 10 years lowered costs would place these high-performance composites in range of many conventional applications.

A composite metal matrix system of considerable interest was one made of aluminum or aluminum alloys reinforced with boron filaments. It was found that cold-working improved panels made of such composites by increasing both the tensile strength of the material and the range over which response persists to elastic strain. The test panels, unidirectionally reinforced, were cross-rolled, and then hardness and tensile properties were measured in the direction parallel to the fibers.[20]

A new compound with the composition $2NiO.B_2O_3$ and stable from 1,303° to 1,480° C was discovered in studies of phase changes.[21] Reactions between boron nitride and molybdenum, tungsten, and rhenium were studied, and it was shown that activation energies were such that borides could either form almost simultaneously or in distinct steps.[22] Activity coefficients for boron in palladium were determined and deviations interpreted.[23]

Information was obtained on solubility and diffusion control of boron in silicon [24] and on electrical and crystalline properties of silicon implanted with boron atoms.[25] These properties are of interest because of boron's importance as a dopant in electronic semiconductors. Borate glasses were studied for ultraviolet absorption after vanadium additions [26] and in regard to lead diffusion.[27]

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Whittle, K. M. and G. L. Vick. Control of Boron Diffusion From a Pyrolitic Borosilicate Glass Source. J. Electrochem Soc., v. 116, No 5, May 1969, pp. 645–648.

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Bromine

By Keith S. Olson[1]

Production of bromine and bromine compounds by the Nation's primary producers continued to increase, owing to an increasing demand for ethylene dibromide and elemental bromine for use in gasoline additives, flame retardants, sanitizers, and many other industrial uses. Production of bromine and bromine compounds increased more than 8 percent in quantity and 1 percent in value. The lesser increase in value was attributed to a drop in price of ethylene dibromide. Over 85 percent of the domestic bromine output was in the form of bromine compounds, production of which increased almost 7 percent in quantity and less than 1 percent in value over that of 1968. Despite a threefold increase in imports of bromine compounds, imports comprised less than 1 percent of the total bromine products consumed in the United States.

[1] Industry economist, Bureau of Mines, Minneapolis, Minn.

DOMESTIC PRODUCTION

Production of bromine and bromine compounds increased to a record 392 million pounds valued at $88 million. The largest quantity increases occurred in the output of the two principal items, elemental bromine and ethylene dibromide. Production of elemental bromine increased 18 percent in quantity and 19 percent in value from that of 1968. Output of ethylene dibromide increased nearly 6 percent in quantity but decreased less than 1 percent in total value, owing to a 5-cent-per-pound price decrease, which took effect in August. Increases were also reported in the output of ammonium bromide, sodium bromide, potassium bromide, and ethyl bromide.

The Nation's eight primary bromine producers operated 12 plants in four States. Michigan retained its position as the leading bromine-producing State, followed by Arkansas (which replaced Texas as the second largest bromine producer), Texas, and California. The largest increase in production of bromine products occurred in Arkansas with increases in quantity and value of 52 and 36 percent, respectively. Chief reason for the increase was the addition of another bromine plant in mid-1969. Bromine production in Michigan increased nearly 6 percent in quantity, but decreased nearly 2 percent in value. Bromine production decreased in Texas and California. Domestic producers of bromine and bromine products were as follows:

State	Company	County	Plant	Production source
Arkansas	Arkansas Chemicals, Inc.	Union	Arkansas Chemicals	Well brines.
	Bromet Co.	Columbia	Magnolia	Do.
	The Dow Chemical Co.	do	do	Do.
	Great Lakes Chemical Corp.	Union	El Dorado	Do.
	Michigan Chemical Corp.	do	Michigan Chemical Corp.	Do.
California	American Potash & Chemical Corp.	San Bernardino	Trona	Searles Lake brines.
Michigan	The Dow Chemical Co.	Mason	Ludington	Well brines.
	Do	Midland	Midland	Do.
	Michigan Chemical Corp.	Manistee	East Lake	Do.
	Do	Gratiot	St. Louis	Do.
	Morton Chemical Co.	Manistee	Manistee	Do.
Texas	Ethyl-Dow Chemical Co.	Brazoria	Ethyl-Dow	Sea water.

Table 1.—Sales of bromine and bromine compounds by primary producers in the United States

(Thousand pounds and thousand dollars)

Year	Quantity		Value
	Gross weight	Bromine content	
1965	328,115	274,569	$77,259
1966	326,498	275,009	78,883
1967	349,757	292,072	85,391
1968	362,452	304,501	86,787
1969	391,883	335,242	87,990

Bromet Co., a joint venture of Ethyl Corp. (80 percent) and Great Lakes Chemical Corp. (20 percent), began production of ethylene dibromide at its new plant near Magnolia, Ark. in mid-1969. This plant was expected to supply Ethyl Corp. with its total requirements for ethylene dibromide. The Bromet plant replaced the Ethyl-Dow Chemical Co. plant at Freeport, Tex., which discontinued the production of ethylene dibromide in December. Major reason for replacing the Freeport plant was the lower cost of producing bromine from brines than from sea water.

Table 2.—Bromine and bromine compounds sold by primary producers in the United States

(Thousand pounds and thousand dollars)

Product	Quantity		Value
	Gross weight	Bromine content	
1968:			
Elemental bromine	51,997	51,997	$10,318
Ethyl bromide	569	415	246
Methyl bromide	19,014	16,008	8,001
Other, including ethylene dibromide, sodium bromide, ammonium bromide, and potassium bromide	293,694	238,220	70,041
Total [1]	362,452	304,501	86,787
1969:			
Elemental bromine	61,279	61,279	12,276
Ethyl bromide	1,725	1,265	677
Methyl bromide	18,726	15,762	6,902
Other, including ethylene dibromide, sodium bromide, ammonium bromide, and potassium bromide	314,530	259,982	70,972
Total [1]	391,883	335,242	87,990

[1] Total has been adjusted to avoid duplication of transferred or purchased material.

CONSUMPTION AND USES

Most bromine products were sold in the form of ethylene dibromide. Elemental bromine ranked second in production, followed by methyl bromide. Ethylene dibromide was used mainly as a lead scavenging agent in antiknock gasoline additives. Laws governing the lead content of gasoline, in an effort to combat air pollution, may seriously affect future bromine markets. Other uses for bromine and bromine compounds included fire extinguisher charges; flame retardants for plastics, textiles, and other materials; pharmaceuticals; photographic chemicals; hydraulic and gage fluids; agricultural chemicals; intermediates; sanitizers; and water treatment chemicals.

PRICES

Prices quoted at yearend for bromine and bromine compounds in the Oil, Paint and Drug Reporter were as follows:

	Cents per pound
Bromine, purified:	
Cases, carlots, ton lots, delivered east of Rocky Mountains	33
Zone I:[1]	
Returnable drums, carlots, ton lots, delivered	27
Tankcar lots, delivered	16.75
Tank truck lots, delivered	18.5
Ammonium bromide, National Formulary (N.F.), granular, drums, carlots, ton lots, freight equalized	46
Bromochloromethane:	
Drums, carlots, freight equalized	51.5
Tanks, same basis	50
Ethyl bromide, 98 percent drums, carlots, freight equalized	68
Ethylene dibromide:	
Drums, carlots, freight equalized	25
Tanks, same basis	20
Methyl bromide, service organization prices, 40- to 375-pound cylinders, large lots, freight allowed	57-64
Potassium bromate, 200-pound drums, carlots, freight allowed	55
Potassium bromide, N. F., granular, drums	40
Sodium bromide, N.F., granular, barrels, drums, freight equalized	40

[1] Prices in Zone II are 1 cent per pound higher. Prices in Zone III are 2 cents per pound higher.

Except for increases in the quoted prices for bromochloromethane and potassium bromate and a decrease in price for ethylene dibromide, the prices are unchanged from those quoted at the end of 1968.

FOREIGN TRADE

Data relating to exports of bromine, bromides, and bromates are not available.

Imports of bromine compounds in 1969 reported under existing tariff schedules (TSUS) consisted of 330 pounds of potassium bromide from West Germany valued at $2,914 and 58,201 pounds of ethylene dibromide valued at $6,054, compared with 2,116 pounds of ethylene dibromide and 16,571 pounds of potassium bromide imported in 1968. Despite the increase in imports, shipments of bromine products into this country are much less than those of several years ago. Increased output of ethylene dibromide by domestic producers has lessened the requirements for imported material. No transactions were reported in 1968 or 1969 for elemental bromine or sodium bromide. All other imports of bromine compounds are included in a blanket category and are not classified separately.

WORLD REVIEW

Germany, West.—Great Lakes Chemical Corp. and Chemische Fabrik Kalk G.m.b.H. of Cologne, have agreed to interchange technology, patents, and rights to manufacturing and marketing brominated flame retardants produced by both companies.[2]

Japan.—Bromine output in 1969 consisted of 7,118 metric tons of elemental bromine and 536 metric tons of potassium bromine compared with 6,330 metric tons of elemental bromine and 504 tons of potassium bromine produced in 1968.[3]

Spain.—Production of bromine by direct oxidation of the bromine content of sea water was initiated by Deritvados del Etilo S.A. at its new 1,000-ton-per-year operation at Villaricos (Almeria). Bromine produced at this operation was transported to the company's plant at Lissu de Vall, Barcelona, for use in the manufacture of fumigants, fire extinguishing agents, and flame retardant resins.[4]

United Kingdom.—Berk Ltd. announced plans for a bromine compounds plant at its main works in London to supplement the output of bromine products at its St.

[2] Oil, Paint and Drug Reporter. Great Lakes Chemical, CFK Sign a Bromine Data Accord. V. 196, No. 24, Dec. 15, 1969, p. 5.

[3] U.S. Embassy, Tokyo, Japan. State Department Airgram A-414, Apr. 14, 1970.

[4] European Chemical News (London). Spain Doubles Bromine Capacity. V. 15, No. 374, Apr. 4, 1969, p. 4.

Albans operation. The new plant was scheduled for completion in mid-1970 at a total cost of £200,000. Bromine extracted from sea water will be supplied to the new plant under contract by Associated Octel. About 75 percent of the output will be used in flame retardants, consisting of the company's Flammex brand which it has marketed for a number of years and Firemaster flame retardants, produced under license from Michigan Chemical Corp. and marketed in the United Kingdom under the Flammex label.[5]

Lunevale Products Co., Lancaster, was purchased by Great Lakes Chemical Corp. and will be operated as a wholly owned subsidiary of the latter. Purchase of the company will enable Great Lakes to serve most of the world with bromine products and other intermediates.[6]

TECHNOLOGY

A major chemical company began producing flame retardant unsaturated polyesters containing bromine for use in various resins with a large number of commercial applications. Reportedly, these polyesters are more fire resistant than those containing chlorine, as well as being competitively priced. The company also claims to have alleviated problems relating to lack of strength and wearability which have previously plagued bromine-based polyesters.[7]

A method of testing the relative soundness of aluminum and magnesium diecastings by submerging them in certain halogenated compounds was discussed. The compounds mentioned included tetrabromoethane, tribromoethane, methylene bromide, and ethylene dibromide.[8]

Much discussion has been raised concerning the possible relationship of leaded gasoline to the problem of air pollution. Ethyl Corp. has designed a series of engine improvements which reportedly will permit the use of leaded gasoline and substantially reduce the emission of nitrogen oxides, carbon monoxide, and hydrocarbons.[9]

The New Mexico State Bureau of Mines and Mineral Resources investigated the bromine content of halite and sylvite from the Saldo Formation in the Carlsbad potash district, southeastern New Mexico. Bromine content of the halite ranged from 25 to 105 parts per million, and that for sylvite ranged from 337 to 865 parts per million.[10]

Brines from 51 wells operated near Midland, Mich., by The Dow Chemical Co. were analyzed for several chemical components including bromine. The results were examined for trends and relationships among the various ions.[11]

A Canadian patent was granted in December 1969 for the use of lithium bromide in a synthetic polyamide composition to prevent the formation of voids when spun into large-diameter monofilms. This process was patented in the United States in 1967.[12]

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[5] Chemical Age. Interest in Bromine Based Flame Retardants. V. 99, No. 2621, Oct. 10, 1969, pp. 15, 20.

[6] Chemical Age. Great Lakes Chemical Acquire U K Lunevale As Bromine 'Springboard'. V. 99, No. 2625, Nov. 7, 1969, p. 8.

[7] Chemical Engineering. Fire-Retardant Unsaturated Polyesters Based on Bromine, Not Chlorine. V. 76, No. 6, Feb. 24, 1969, pp. 37–38.

[8] Foundry. Flotation Inspection of Aluminum and Magnesium Castings. V. 98, No. 2, Feb. 1970, pp. 136–137.

[9] Ethyl Corp. 1969 Report of Growth and Earnings, 28 pp.

[10] Adams, Samuel S. Bromine in the Saldo Formation, Carlsbad Potash District, New Mexico. New Mexico Bureau of Mines and Mineral Resources, Bull. 93, 1969, 122 pp.

[11] Environmental Science and Technology. Variation in the Composition of Brine From the Sylvania Formation Near Midland, Mich. V. 4, No. 4, April 1969, pp. 367–370.

[12] Hansen, J. E. (assigned to E. I. du Pont de Nemours & Co., Inc.). Use of Lithium Bromide or Lithium Iodide in a Synthetic Polyamide Composition. Canadian Pat. 829,974, Dec. 16, 1969.

Cadmium

By Donald E. Moulds [1]

The domestic demand for cadmium surged upward to a record level with an apparent consumption of more than 15 million pounds in 1969. Despite a record production, a 15-percent gain in shipments by domestic producers, and a 2.76-million-pound shipment from Government stocks, cadmium supplies were exceedingly tight until late in the fourth quarter. The rise in the domestic price initiated at the start of the year and continuing in four steps, ending on December 1 at $4.00 per pound, paralleled the upward trend in foreign market price. In 1969, as in 1964 when a like market situation existed, metal imports approximated exports. Total stocks of cadmium metal–producers', manufacturers', and distributors'—reached a low point in the first quarter and then trended upward to close the year substantially above stocks at the end of 1968. Producer stocks significantly improved in the fourth quarter as producer shipments dropped below production for the first time since the second quarter of 1968, and, as the balance of trade reversed to provide a net import of 210,000 pounds in contrast to the net export of 217,000 pounds in the prior three quarters.

Legislation and Government Programs.—The sale of 5 million pounds of Government surplus cadmium stocks under authorization of Public Law 88–319 enacted in 1964 was completed in the fourth quarter of 1969. The quantity remaining in the authorization as of December 31, 1968, was 2,635,792 pounds. Sale of the maximum quarterly amount of 600,000 pounds in the first quarter was completed by January 8, and the second quarter offering was quickly committed in April. An additional 600,000 pounds was released and awarded on June 6, with awards approximating 53 percent of the quantity sought by purchasers. The third quarter offering of 600,000 pounds was also oversubscribed, with awards in July approximating 18 percent of the total quantity in offers to purchase. The sale of 2.4 million pounds in the first three quarters thus left about 240,000 pounds for sale in the fourth quarter which was sold in October exclusively to producers, distributors, and consumers holding unsatisfied defense-rated orders. The Government price at storage depots continued at 12 cents per pound below the domestic quoted price at time of sale to compensate for conversion of stockpile material into balls and anodes for electroplating.

Government cadmium stocks as of December 31, 1969, totaled 10,186,116 pounds, indicating a drawdown of 2,755,471 pounds during the year. Acquisition cost of the yearend inventory was $18.3 million at an average of $1.79 per pound, whereas at current market value ($4.00 per pound) the inventory was worth $40.7 million.

The Office of Emergency Preparedness reexamined the stockpile objective during the year and revised the objective upward in May 1969, from 5.1 million pounds to 6 million pounds.

Legislation was introduced in October to authorize release of 4,180,000 pounds of cadmium, essentially all of the surplus remaining under the revised objective. The legislation was approved by the House of Representatives in late December and was awaiting Senate action at yearend.

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[1] Physical scientist, Division of Nonferrous Metals.

DOMESTIC PRODUCTION

Domestic production of cadmium, uninterrupted during the year, achieved a record total of 12.6 million pounds, a 19-percent increase compared with 1968. Producer shipments exceeded production by 332,000 pounds as stocks were severely reduced in the second quarter. Value of the shipments reached $40.6 million, a 43-percent increase compared with 1968.

Imported flue dust from Mexico contained 1.11 million pounds of cadmium for domestic recovery and refining. The cadmium in imported flue dust represented about 9 percent of total domestic output in comparison to 15 percent in 1968. The increased ratio of foreign zinc ores to domestic ores processed from which cadmium is obtained as a byproduct indicates a significantly higher foreign source component of domestic smelter output in 1969. Of the 10.8 million pounds of cadmium produced at zinc plants from the processing of zinc ore and other intermediate domestic smelter products, about 4 million pounds came from electrolytic plants and the remainder from retort and electrothermic plants. Imports of cadmium waste and scrap from the United Kingdom, Japan, and Canada also provided a small amount of secondary output.

Table 1.—Salient cadmium statistics

(Thousand pounds)

	1965	1966	1967	1968	1969
United States:					
Production [1]	9,671	10,460	8,699	10,651	12,646
Shipments by producers [2]	8,128	11,792	9,606	11,244	12,978
Value thousands	$19,153	$26,771	$24,665	$28,409	$40,636
Exports	73	379	691	530	1,085
Imports for consumption, metal	2,121	3,358	1,587	1,927	1,078
Consumption	10,431	14,780	r 11,578	13,328	15,088
Price: Average [3] per pound	$2.58	$2.42	$2.64	$2.65	$3.27
World: Production	26,228	28,643	29,069	32,354	37,587

r Revised.
[1] Primary and secondary cadmium metal. Includes equivalent metal content of cadmium sponge used directly in production of compounds.
[2] Includes metal consumed at producer plants.
[3] Average quoted price for cadmium sticks and bars in lots of 1 to 5 tons.

Table 2.—Cadmium sulfide [1] produced in the United States

(Thousand pounds)

Year	Sulfide [2]	
	Gross weight	Cadmium content
1965	4,666	1,575
1966	5,644	2,267
1967	4,327	1,536
1968	6,003	2,457
1969	6,345	2,439

[1] Cadmium oxide withheld to avoid disclosing individual company confidential data.
[2] Includes cadmium lithopone and cadmium sulfoselenide.

The cadmium metal content of various compounds produced—sulfide, lithopone, sulfoselenide—amounted to 2.44 million pounds, slightly below the 1968 record level of 2.46 million pounds. American Smelting and Refining Company, Blackwell Zinc Co., and Harshaw Chemical Co. produced cadmium oxide.

CONSUMPTION AND USES

Apparent consumption of cadmium—production, imports, Government shipments, exports, and known stock changes—was 15.09 million pounds of which 81.7 percent was from commercial sources and 18.3 percent from Government stocks. The total disappearance of cadmium metal in 1969 was 13 percent above the 1968 figure and well above the previous record of 14.78 million in 1966.

The Bureau of Mines does not sponsor an annual cadmium consumption survey, and data collected in 1960 and 1963 did not provide satisfactory information from

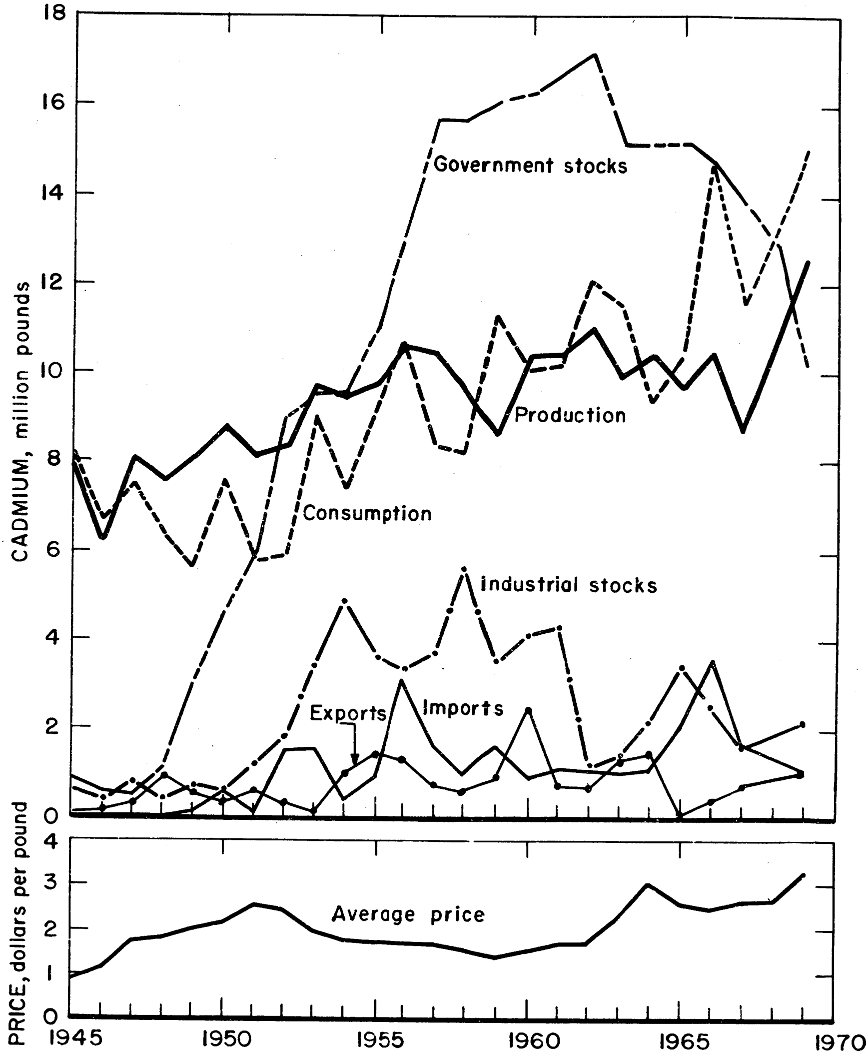

Figure 1.—Trends in production, consumption, yearend stocks, imports, exports, and average price of cadmium metal in the United States.

the large number of small individual consumers relying on various sources of supply. The National Materials Advisory Board of the National Research Council examined the trends in consumption of cadmium and published a report in November 1969.[2]

Electroplating, the largest single use of cadmium, is estimated to require about 50 percent of domestic supply, although ranging from 45 to as high as 60 percent depending on availability and price. The relative ease and universal acceptability of cadmium plating has provided a continu-

[2] National Materials Advisory Board, National Research Council. Trends in Usage of Cadmium. November 1969, 26 pp. (Publication AD-700-744, Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. 22151).

ing high demand level even though technological improvements in zinc plating and strong economical appeal of zinc are reducing the growth of cadmium usage in this field.

Cadmium compounds manufactured from metal comprise the second largest area of consumption, estimated at about 45 percent of total supply. In the compound area, consumption is approximately equally divided between pigments and thermoplastic stabilizers. The cadmium sulfide-base pigments cover a wide variation of yellow-red color and have a wide commercial application in plastics, paints, enamels, and printing inks. Polyvinyl chloride requires stabilization during processing and to prevent degradation by exposure to sunlight while in use. Cadmium salts in combination with barium salts and various acids have found wide economic acceptance in this use area. Cadmium oxide as the negative electrode of a nickel-cadmium battery and cadmium phosphorus in television tubes and fluorescent tubes are other significant compound applications.

Metallurgical applications of cadmium include use on a constituent of low-melting alloys, as a component of silver-cadmium and silver-copper-cadmium-nickel electrical contacts in switches and relays, in silver-base brazing alloys, and in copper-base alloys. Metallurgical uses are estimated to approximate 5 percent of total supply.

STOCKS

Total industry stocks of metal amounting to 1.1 million pounds at the start of the year were substantially reduced in the first 3 months of the year. In the second quarter stocks at compound producers improved while metal producers' and distributors' stocks continued downward. Improvement was evident in all stocks in the third quarter and especially at compound producers. The fourth quarter improvement at metal producers and distributors was countered, in part, by a stock drawdown at compound producers. The year-end stock of 1.4 million pounds was well below the 2.15-million-pound average for 1964–68.

Table 3.—Industry stocks, December 31

(Thousand pounds)

	1968		1969	
	Cadmium metal	Cadmium in compounds	Cadmium metal	Cadmium in compounds
Metal producers	623	W	708	W
Compound manufacturers	232	679	492	781
Distributors	r 244	r 69	206	44
Total	r 1,099	r 748	1,406	825

r Revised. W Withheld to avoid disclosing individual company confidential data; included with "Compound manufacturers."

PRICES

Record demand for cadmium was reflected by the advance in producer price from $2.65 per pound, (effective January 13, 1967) in four steps; January 2, to $2.80; March 3, to $3.00; June 16, to $3.50; and December 1, to $4.00. The sale price of stockpile metal for each quarterly offering was at the commercial quoted price at time of sale less 12 cents per pound to compensate for purchaser's cost of conversion to shapes and quality desired for use in electroplating. The free market price for cadmium was well above the producer price throughout the year, being quoted at $4.00 per pound in early June and at $4.60 to $4.75 per pound early in December. The foreign price for cadmium trended upward throughout the year. The French price advanced in six steps from $2.91 per pound (U.S. equivalent) in January to $4.99 per pound in the last half of December. The Italian price ranged from $3.00 per pound to $4.20 per pound. The London price for domestically produced cadmium, in contrast to imported cadmium quotations, advanced essentially in parallel with the U.S. price from $2.63 per pound in January to $3.94 per pound effective December 5.

Table 4.—Prices quoted for cadmium in the United States 1969

(Per pound)

	Producer to consumer		GSA	
	1-ton lots	Less than 1-ton lots	1-ton lots	Less than 1-ton lots
January 1	$2.80	$2.85	$2.68	$2.73
March 3	3.00	3.05	2.88	2.93
June 16	$3.00-3.50	$3.05-3.55	3.38	3.43
July 1	3.50	3.55	3.38	3.43
Dec. 1 to Dec. 31	4.00	4.05	----	----

FOREIGN TRADE

The worldwide demand and favorable foreign market for cadmium was reflected in the 105-percent increase in exports and 44-percent decrease in imports. The resulting net exporter status of the United States was last recorded in 1964 when exports reached 1.4 million pounds in relation to imports of 1.1 million pounds. Shipments to foreign countries reached a peak of 404,000 pounds in the second quarter and a low of 139,000 in the fourth quarter. The Netherlands received almost 50 percent; United Kingdom, 19 percent; France, 13 percent; West Germany, 3 percent, and Canada, 3 percent. The remaining 12 percent was divided among 12 countries.

Table 5.—U.S. exports of cadmium metal and cadmium in alloys, dross, flue dust, residues, and scrap

(Thousand pounds and thousand dollars)

Year	Quantity	Value
1967	691	$1,669
1968	530	1,400
1969	1,085	3,254

Cadmium metal was imported from nine countries, Canada was again the leading source with 37 percent, followed by Australia 17 percent, Peru 16 percent, and Japan 14 percent. Imports of cadmium in flue dust from Mexico were well below both the 1968 total and the 1.35-million-pound average for 1964–68.

Table 6.—U.S. imports [1] of cadmium metal and cadmium in flue dust, by countries

(Thousand pounds and thousand dollars)

Country	1968		1969	
	Quantity	Value	Quantity	Value
Cadmium metal:				
Angola	11	$26	-----	-----
Australia	297	686	186	$429
Belgium-Luxembourg	11	27	1	3
Canada	508	1,309	398	1,290
Congo (Kinshasa)	11	26	-----	-----
Cyprus	8	19	-----	-----
Germany, West	-----	-----	43	169
Japan	668	1,555	148	474
Mexico	152	359	43	183
Peru	212	477	173	389
Poland and Danzig	9	21	-----	-----
South Africa, Republic of	40	97	72	211
United Kingdom	-----	-----	14	18
Total	1,927	4,602	1,078	3,166
Flue dust (cadmium content):				
Mexico	1,605	1,796	1,115	1,495
Grand total	3,532	6,398	2,193	4,661

[1] In 1969, general imports and imports for consumption were the same; in 1968, general imports were 1,920,000 pounds ($4,587,000), and imports for consumption 1,927,000 pounds ($4,602,000), the difference was reflected in Japan.

The import duty on cadmium metal was reduced from 3 cents per pound to 2 cents per pound effective January 1, 1969, in accord with the "Kennedy round" trade agreements. Import of flue dust continued duty free.

WORLD REVIEW

World cadmium production during 1965–69 grew 10 percent annually. The increase in 1969 was especially evident in North America and in the major zinc concentrate importing countries of West Germany and Japan. Many of the major zinc-producing areas with large exports of concentrate are credited only with cadmium produced at indigenous smelters, and the importing country is credited with the cadmium recovered. For example in 1969 Peru produced 371,000 pounds as metal and exported 365,000 pounds in zinc concentrates to various countries. Mexico likewise produced 462,000 pounds as metal and exported 3,019,000 pounds in zinc concentrates and flue dust for refining. The free world production of cadmium in terms of slab zinc output averaged 7.03 pounds per ton of slab zinc in comparison to 6.66 pounds achieved in 1968, indicating the increased attention to recovery of this byproduct under current market incentives.

Apparent consumption of cadmium in the United States in 1969 was equivalent to 40 percent of the world production in comparison to 41 percent in 1968. The large shipment from Government stocks however, reduced the United States requirements from current world production from 39 percent in 1968 to 33 percent in 1969.

Table 7.—World smelter production of cadmium, by countries [1] [2]

(Thousand pounds)

Country	1965	1966	1967	1968	1969 p
North America:					
Canada	948	1,704	2,058	2,078	2,100
Mexico	152	243	370	446	462
United States [3]	9,671	10,460	8,699	10,651	12,646
South America: Peru	473	442	332	378	371
Europe:					
Austria	46	47	42	43	[3] 42
Belgium	1,620	1,282	1,446	1,898	e 1,874
France	944	988	1,098	1,226	e 1,213
Germany, West	723	785	880	754	1,746
Italy	602	540	481	551	e 529
Netherlands e	198	220	236	220	220
Norway	172	159	185	192	e 198
Poland e	970	948	915	915	925
Spain	137	132	148	154	176
U.S.S.R. e	4,189	4,519	4,850	4,850	5,070
United Kingdom [3]	485	405	460	456	518
Yugoslavia e	90	90	330	331	330
Africa:					
Congo (Kinshasa)	278	329	580	705	1,316
South-West Africa [4]	73	291	366	370	e 375
Zambia	40	27	22	25	e 26
Asia:					
Japan	3,262	3,872	4,186	4,839	6,096
Korea, North e	------	------	230	231	230
Oceania: Australia	1,155	1,160	1,155	1,040	1,124
Total [5]	r 26,228	r 28,643	r 29,069	32,354	37,587

e Estimate. p Preliminary. r Revised.
[1] Data derived in part from bulletins of World Metal Statistics (London) and annual issues of Metal Statistics (Metallgesellschaft).
[2] No estimates included for Bulgaria and East Germany due to lack of information.
[3] Including secondary.
[4] Output of Tsumeb Corp. Ltd., for fiscal years ending June 30.
[5] Total is of listed figures only.

A source of cadmium on which data are not available, is mainland China, long known as a metal supplier with some Western trade via offerings at the semiannual Canton Fair. In 1969, however, Chinese Minerals and Metals Trade Corp. was reported to have purchased 25 tons of cadmium from a West German merchant.

Calcium and Calcium Compounds

By Arnold M. Lansche[1]

Production of natural and synthetic solid forms of calcium chloride decreased about 3 percent in 1969, whereas output of the brine and calcium-magnesium chloride brine increased approximately 7 percent. Most of the output of calcium chloride and calcium-magnesium chloride came from naturally occurring deposits in Michigan. California produced a small quantity. Imports of calcium metal rose sharply, but calcium chloride imports were down.

DOMESTIC PRODUCTION

Chas. Pfizer and Co., Canaan, Conn., produced calcium metal in 1969. Production of all forms of natural and synthetic (byproduct of Solvay process) solid calcium chloride, calcium chloride brine, and calcium-magnesium chloride brine, excluding that used to produce granular forms, was as follows, in short tons:

Year	$CaCl_2$, solid and flake, 75 percent chlorine equivalent	$CaCl_2$ and Ca, $MgCl_2$ brine, 40 percent chloride
1967	710,000	509,500
1968	762,000	566,000
1969	738,000	603,000

Producers of natural calcium chloride brine, calcium-chloride-bearing brines, and synthetic calcium-chloride brine produced as a byproduct of soda ash manufacture were as follows:

Natural Compounds	
Leslie Salt Co.	Amboy, Calif.
National Chloride Company of America	Do.
Michigan Chemical Corp	St. Louis, Mich.
Wilkinson Chemical Corp	Mayville, Mich.
Morton Chemical Co., Div of Morton-Norwich, Inc.	Manistee, Mich.
The Dow Chemical Co.	Ludington and Midland, Mich.
Wyandotte Chemicals Corp	Wyandotte, Mich.
Synthetic Compounds	
Industrial Chemicals Division, Allied Chemical Corp.	Syracuse, N.Y.
PPG Industries, Inc	Barberton, Ohio
Hooker Chemical Corp.	Tacoma, Wash.
Reichhold Chemicals, Inc	Do.

Production of all forms of natural calcium and calcium magnesium chlorides (solid, flake, and liquid), calculated as 75 percent chloride equivalent, averaged 617,000 tons annually for the period 1965–69. The average annual value for the period was $12.8 million ($20.82 per ton).

CONSUMPTION AND USES

Calcium metal and calcium alloys were added to molten metals to remove oxygen, halogens, sulfur, and phosphorus. Calcium also was used as a reducing agent and dehydrating agent in organic chemistry, to remove sulfur from some hydrocarbons, and to separate nitrogen from argon. Calcium hydride, a manufactured compound, was utilized as a source of hydrogen. Organocalcium compounds were used in lubricants, corrosion inhibitors, detergents, etc.

[1] Physical scientist, Bureau of Mines, Bartlesville, Okla.

Calcium chloride and mixtures of calcium chloride and sodium chloride were used for highway deicing; other uses included dust control, concrete treatment, synthetic rubber, paper, oilfield drilling, brine refrigeration, and tireweighting.

PRICES AND SPECIFICATIONS

Calcium metal prices remained unchanged during 1969. Price quotations for calcium chloride increased except for the granulated U.S.P. variety, which remained unchanged.

Table 1.—Price quotations for calcium metal in 1969[1]

(Per pound)

	Less than 100 pounds	100 to 1,999 pounds	2,000 to 5,999 pounds [2]	6,000 pounds and over
Commercial grade:				
Full crowns [3]	$2.00	$1.25	$0.95	----
Broken crowns (5-inch and down)	2.10	1.50	1.05	----
6-mesh nodules	2.50	1.70	1.15	----
Turnings	3.00	2.80	2.50	----
Ingots or waffles	2.80	1.70	1.30	----
80 percent Ca-20 percent Mg (ingots or waffles)	2.80	1.30	1.30	----
Redistilled grade:				
Broken crowns (8-inch and down)	3.75	2.60	1.70	$1.50
6-mesh nodules	4.00	2.80	1.80	1.60
⅛-inch nodules	5.00	3.80	2.50	2.50

[1] Prices are f.o.b. Canaan, Conn.
[2] 2,000 pounds and over for commercial grade.
[3] Calcium produced in the aluminothermic reduction process forms a crown, which is a cylindrical deposit of crystalline calcium conforming in shape to the interior of the vacuum retort.

Table 2.—Price quotations for calcium chloride in 1969

Grade	Jan. 6	Dec. 29
Concentrated flake or pellet 94-97 percent [1] per short ton	$46.50	$48.25
Concentrated flake, 77-80 percent [1] do	38.00	39.50
Powdered, 77 percent minimum [1] do	43.23	46.00
Liquor, 40 percent [2] do	15.50	16.00
Granulated U.S.P. [3] per pound	.29	.29

[1] Paper bags, carlots at works, freight equalized.
[2] Tank cars, freight equalized.
[3] 225-pound drums, freight equalized.

Source: Oil, Paint and Drug Reporter. V. 195,No. 1, Jan. 6, 1969; v. 196 No. 26, Dec. 29, 1969.

FOREIGN TRADE

The quantity of calcium metal imported increased 158 percent over that of 1968. The average value of imported metal in 1969 was about 87 cents per pound. Canada supplied all of the imported calcium metal.

Calcium chloride imports decreased 34 percent in quantity and 33 percent in value. Canada supplied 11.5 million pounds; Belgium-Luxembourg, 4.3 million pounds; West Germany, 1.4 million pounds; and the United Kingdom, 1.3 million pounds.

In 1969, other calcium compounds imported included 48.6 million pounds of crude calcium borate valued at $717,550 from Turkey; 35.8 million pounds of calcium carbide valued at $1.2 million and 32.4 million pounds of calcium cyanide valued at $1.3 million from Canada; 29.1 million pounds of dicalcium phosphate valued at $610,000 from Belgium-Luxembourg, Canada, and West Germany; and 4.3 million pounds of calcium carbonate valued at $170,000 from the United Kingdom, Japan, Norway, Sweden, and West Germany. Smaller quantities of other calcium compounds, such as the acetate, hypochlorite, and tungstate, were also imported.

Table 3.—U.S. imports for consumption of calcium and calcium chloride

Year	Calcium		Calcium chloride	
	Pounds	Value	Short tons	Value
1967	423,631	$370,407	4,385	$157,570
1968	137,251	120,416	14,069	522,680
1969	354,370	307,437	9,226	349,998

WORLD REVIEW

Spain.—Solvay et Cie. planned to expand the flake calcium chloride plant at its Torrelavega factory.

Switzerland.—Construction of a 30,000-ton-per-year capacity plant for production of calcium chloride was planned for the Zarzach works of Soudiére Suisse, a subsidiary of Solvay et Cie.

Carbon Black

By Carl W. Kelley [1]

Shipments of carbon black increased 4.3 percent in 1969, a leveling off from the 1968 reinvigorated demand which followed resumption of work after strikes at rubber plants. Carbon black production rose to a new peak.

Use of carbon black by the rubber industry outweighed by far all other uses. In 1969, 94 percent of the carbon black shipments were used in rubber products, with 60 percent of that volume used by tire manufacturers. Almost nine out of every 10 tires produced are used on passenger cars, and in 1969 passenger car tire production totaled 180,616,000, approximately a 2-percent increase over the 177,408,000 tires produced in 1968.

According to preliminary reports, the carbon black industry operated at 81 percent of capacity in 1969. Over the past 5 years, daily capacity has risen from 8,040,300 pounds to 10,038,639 pounds, a net increase of 24.9 percent.

Yearend inventories were lower than those of a year earlier as channel black shipments exceeded production by 14.4 million pounds. Although overall production of carbon black in 1969 topped that of the preceding year by more than 151 million pounds, channel black output dropped 10.5 million pounds, thus continuing a downward trend that began in the late 1940's.

The average value of carbon black at the plant in 1969 was 7.26 cents per pound, a decrease of 0.06 cent from 1968 levels.

The volume of natural gas used for manufacturing carbon black continued to decline in 1969. The use of natural gas in carbon black manufacture was lower in Louisiana, Texas, and the other States. Cost of natural gas increased in Louisiana, Texas, and the other States as indicated in table 5.

The amount of liquid hydrocarbons needed to produce furnace blacks in 1969 was higher by 40 million gallons or 8 percent.

Further improvement in carbon black yields was noted in 1969. Each 1,000 cubic feet of natural gas consumed yielded on the average 6.28 pounds of carbon black as compared with 5.79 pounds per thousand cubic feet in 1968. The yields of carbon black from liquid hydrocarbons, as shown in table 6, were 4.78 pounds per gallon in 1969 as compared with 4.86 in the preceding year.

[1] Chemist, Division of Fossil Fuels.

Table 1.—Salient statistics of carbon black produced from natural gas and liquid hydrocarbons in the United States

(Thousand pounds)

	1965	1966	1967	1968	1969
Production:					
Channel process	147,909	153,117	149,420	142,948	132,471
Furnace process	2,205,867	2,418,435	2,334,420	2,668,858	2,830,790
Total	2,353,776	2,571,552	2,483,840	2,811,806	2,963,261
Shipment:					
Domestic sales	2,072,500	2,277,595	2,216,145	2,588,402	2,777,949
Exports	274,608	297,281	236,035	263,122	196,203
Total	2,347,108	2,574,876	2,452,180	r 2,851,524	2,974,152
Losses	135	1,236	559	359	5,259
Stocks of producers, December 31	237,704	233,145	264,247	224,170	208,020
Value:					
Production thousand dollars	$166,111	$184,308	$178,158	$205,849	$215,120
Average per pound cents	7.06	7.17	7.17	7.32	7.26

r Revised.

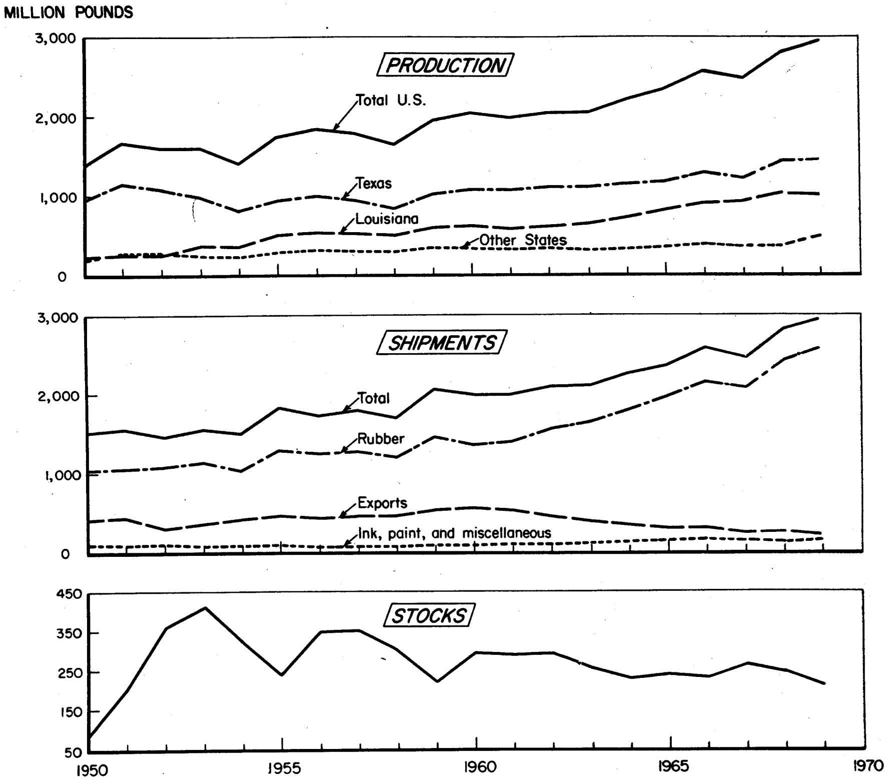

Figure 1.—Production by States, shipments by use, and exports, and stocks of carbon black.

PRODUCTION AND CAPACITY

Production by States.—Production of carbon black totaled 2,963.2 million pounds, an increase of 151 million or 5 percent above the levels of 1968. Texas produced almost half of the total and Louisiana supplied about 35 percent of the total. Over the past 5 years (1965–70) Louisiana's share has ranged from 34.8 percent of the total to 37.2 percent, and Texas remained at about 50 percent over the same period. Output in the carbon black producing States of Arkansas, Kansas, New Mexico, and Oklahoma, in the aggregate has varied over the past 5 years from 12.6 percent of the total to 16 percent.

Production by Grades and Types.—Although carbon blacks are produced by both channel and the furnace process, the latter accounted for 96 percent of the 1969 total. There are seven major grades of carbon blacks produced by the furnace process, plus thermal blacks. In the furnace category, High Abrasion Furnace (HAF) grade, constituted the largest single item produced in 1969 and accounted for 27 percent of total furnace blacks. During the past decade the output of the HAF grade has varied from a low of 25 percent of furnace blacks produced to a high of 32 percent. Production of furnace black, excluding thermal, increased from 1,933 million pounds to 2,505 million pounds between 1965 and 1970. HAF increased from 595 million pounds annually in 1965 to 760 million pounds in 1969, a difference of nearly 28 percent. Second in importance today is the Intermediate Abrasion Furnace (ISAF) grade, which supplied 22 percent of the furnace black. Over the same interval of 1965–69, output of ISAF grade increased from 504 million pounds to 616 million pounds or 22 percent. Trends in the production of blacks by grades are included in table 3.

Production of channel process carbon black aggregated 132.5 million pounds or 7.3 percent less than in 1968. Channel blacks are used in inks, pigments, and in mechanical goods, in natural rubber off-the-road tires, in other types of truck tires and many other nontire applications.

Number and Capacity of Plants.—Expansion of capacities at existing facilities in 1969 were primarily responsible for the increase in daily output of nearly 897,000 pounds or 9.8 percent, as indicated in table 4. Facilities in Louisiana enlarged their output potential some 385,000 pounds or 12 percent to 3,568,055 pounds daily. Although individual totals cannot be revealed because of company confidentiality the capacity of the plants consolidated under "Other States" increased 517,000 pounds per day or 37 percent.

Materials Used and Yields.—In 1969, a total of 524.4 million gallons of liquid hydrocarbons were consumed in the manufacture of 2,507.4 million pounds of carbon black. This amount was 40 million gallons greater than that consumed in 1968. Yields in 1969 averaged 4.78 pounds per gallon compared with 4.86 pounds in the preceding year. Yields improved for natural gas. In 1969, while the amount of gas used was nearly 7 billion cubic feet smaller than in 1968, yields of black were greater; 6.28 pounds compared with 5.79 pounds in 1968.

CONSUMPTION AND USES

In 1969, domestic sales of carbon black increased by 190 million pounds or 7.32 percent. Exports dropped 25.4 percent below the 1968 levels. Domestic sales to the rubber industry, which accounted for 94.2 percent of all the carbon black shipped, were higher by 171 million pounds or 7.0 percent.

Sales gains were made also in the blacks used in ink manufacture, rising nearly 8 percent to 73 million pounds. Manufacturers used both the furnace blacks and the channel blacks in their operations. The oil furnace type known as "Short-Ink" was used in the manufacture of inks for printing newspapers. Blacks produced by the channel process known as "Long-Ink" were used in lithographic or halftone printing inks.

The plastics industry expanded its use of carbon black by about 23 percent in 1969.

Carbon black sales to the paper industry had been declining since 1963, and reached a low of 4.7 million pounds in 1968 but rallied to 5.7 million pounds in 1969, a gain of 20 percent. Since 1963, sales to the paper industry have declined 36 percent. Some of this decline can be attributed to technological developments in the paper industry coupled with the development of new products lowering the use of carbon black. Still another consideration, however, is the change in consumer preference from somber tones to brighter colors.

STOCKS

Inventories of carbon black were reduced 16 million pounds in 1969 with a decline of 14 million pounds in channel black and 2 million pounds in the furnace-type blacks. The reduction in channel black stocks reduced the level of that type by almost 44 percent. Stocks of the HAF type declined 6.9 million pounds; GPF and thermal types increased 5.3 and 5.0 million pounds, respectively. The SRF and the HMF types, which are furnace blacks generally produced from gas, declined 5.6 million pounds.

FOREIGN TRADE

Foreign countries have been gradually becoming more self-sufficient in carbon black, and a very impressive part of this growth represented expansion programs of U.S. carbon black manufacturers and their affiliates as well as investments by foreign companies. This has taken place in spite of the rising demand for rubber products and tires, leading to the increase in demand for carbon black. In 1969, exports fell to 196,203,000 pounds or 25.4 percent below those of the preceding year. However, 29 percent of exports were blacks made by the channel process, slightly higher than the 27 percent exported in 1968. Some channel black is made in West Germany and in Japan but output is insufficient to satisfy demand.

Europe continued to be the best customer accounting for 52 out of every 100 pounds of carbon black exported. France, the United Kingdom, Italy, and West Germany aggregate the largest users of carbon black and received 38.9 percent of carbon black exported from the United States. In the Western Hemisphere, Canada was the largest user of blacks from the United States. Other exports by countries are given in table 9.

Imports of carbon blacks into the United States are usually limited to specialty blacks and 1969 followed this pattern. Approximtely 6.1 million pounds of carbon black derived from acetylene were imported from Canada and another 664,000 pounds of the same type black came from East Germany. Belgium-Luxembourg and West Germany supplied the United States a total of about 50,000 pounds of lamp black. West Germany also supplied 30,000 pounds of bone black.

WORLD REVIEW

Carbon black capacity is being expanded in Europe, Japan, Canada, Mexico and the Republic of South Africa to meet increasing demand by tire producers. Two carbon black units have recently come on stream in Mexico, Hungary's first carbon black plant is under construction, and a U.S. affiliate is considering building a carbon black plant in Portugal.

Japanese production for 1969 was 574,331,000 pounds. Its production of carbon black increased 135 percent from 1964 to 1969. in 1969, sizable gains were shown in France, West Germany, Spain, the Netherlands, and the United Kingdom. Increased production was also indicated in Rumania, Yugoslavia, and Italy.

Despite these expansions, Western Europe has virtually no facilities for producing carbon black either by the channel or the thermal process. Hence, the United States continues to be the principal source of supply for these blacks.

No data are available on the magnitude of carbon black facilities in the Soviet Union. However, it is not unreasonable to assume that the large supplies of natural gas readily available in that nation offer inducement to make carbon blacks by the channel process.

TECHNOLOGY

Carbon black, a petrochemical, is an extremely fine soot, primarily carbon (90 to 99 percent) and containing some oxygen and hydrogen; oil furnace blacks may also contain small amounts of sulfur. The furnace process, which accounts for 96 out of every 100 pounds produced, breaks down into three different processes: oil furnace, gas furnace, and thermal. Brief description of the four processes, including the channel process, are as follows:

Channel Black.—Made by the oldest process, is a product of incomplete combustion of natural gas. Small flames are impinged on cool surfaces or channels where carbon black is deposited and then scraped off as the channel moves back and forth over a scraper. The properties of channel blacks are varied by changes in burner tip design, distances from tip to channel, and the amount of air made available for combustion. The process is extraordinarily inefficient, chemically. For rubber reinforcing grades, the yield is only 5 percent; for finer particle size high color blacks, the yield shrinks to 1 percent. Low yields and rising gas prices have spurred the industry to develop other methods to make blacks.

Gas Furnace.—This is based on partial combustion of natural gas in refractory-lined furnaces. Carbon black is removed by flocculation and high-voltage electric precipitators. Yields of the gas furnace blacks range from 10 to 30 percent and are lowest for the smaller particle size grades. Properties of gas furnace blacks can be modified to a degree by changing the ratio of air to gas. The grades SRF, HMF, and FF are generally produced from gas. (The full name of each grade is given in the footnoes to table 3.)

Thermal.—Unlike channel and furnace blacks, thermal blacks are produced by cracking a hydrocarbon; that is, separating the carbon from the hydrogen and not by the combustion of a hydrocarbon. Thermal furnaces are built from a checkerboard brickwork pattern. Two refractory-lined furnaces or generators are used. One generator is heating, using hydrogen as a fuel, while the other generator is being charged with natural gas, which decomposes to produce thermal black and hydrogen. The hydrogen is collected and used as fuel for the generator being heated. Yields of carbon black are primarily in the large particle sizes and range from 40 to 50 percent.

Oil Furnace.—In this process, the liquid hydrocarbons are used and the blacks are produced in furnaces. Natural gas is generally burned to furnish the heat of combustion and atomized oil is introduced into the combustion zone to be burned to various grades of carbon black. Yields range from 35 percent to 65 percent depending on the grade of black produced. Oil furnace grades are GPF, FEF, HAF, ISAF, and SAF. (The full name of each grade is given in the footnotes to table 3.)

A most desirable feedstock for furnace black plants is an oil having 0° to 4° API gravity, low in sulfur, and high in aromatics and olefins, which comes from near the "bottom of the refinery barrel" and is similar in many respects to residual fuel oil. The rising cost of natural gas has been a factor in the shift to a greater use of liquid feedstocks and a decline in the use of natural gas as a source of carbon. At the same time, it should be recognized that oil furnace processing has become very flexible. Oil furnace blacks supplemented channel blacks in most high-performance applications, notably passenger car tire treads. Over the past two decades, carbon black technology has centered on the oil furnace black process.

During the latter part of 1969, a process was unveiled for making carbon black feedstock from tar produced from low-temperature carbonization of coal. The tar is a product of the char oil energy development project, which aims at converting coal to synthetic crude oil, pipeline gas, and fuel char. Performance of the tar in a pilot-scale carbon black reactor is practically identical to that of the standard feedstock. Also, rubber samples compounded with the low-temperature carbonization carbon black are substantially the same, in elasticity modules, tensile strength, and abrasion resistance, as those made with carbon black from standard feedstock.

Under development is a new type of carbon black with high structure. It has special advantages for use in manufacturing tires because it has improved tread cracking resistance and lower heat buildup. Its high structure gives a tread performance better than that obtained from blends of HAF and ISAF.

Also under development is a high jet carbon black (one containing more carbon) that is dispersed in plasticizers for use in the manufacture of polyvinyl chloride and cable insulation.

A new and intriguing use of carbon black is in prevention of frost damage to crops. Farmers spread it over the ground and the darkened soil absorbs more heat during the day. Then, at night, when the temperature dips, the soil remains warm longer.

The basic raw materials for carbon black are natural gas and oils; hence, most carbon black producing plants have been located near a fuel and raw material supply in southern Louisiana and in the Texas Panhandle. The carbon black is transported from there to the rubber plants. Recently, however, the carbon black industry has begun to change its policy by building new facilities near the largest customers, the rubber manufactures, not near its fuel supply.

Table 2.—Carbon black produced from natural gas and liquid hydrocarbons in the United States, by States

(Thousand pounds)

State	1965	1966	1967	1968	1969	Change from 1968 (percent)
Louisiana	820,552	899,178	923,286	1,031,349	1,045,902	+ 1.41
Texas	1,172,693	1,296,292	1,214,349	1,426,307	1,442,033	+ 1.10
Other States	360,531	376,082	346,205	354,150	475,326	+34.22
Total	2,353,776	2,571,552	2,483,840	2,811,806	2,963,261	+ 5.39

Table 3.—Production and shipments of carbon black in the United States in 1969, by months and grades of furnaces

(Thousand pounds)

Month	SRF [1]	HMF [2]	GPF [3]	FEF [4]	HAF [5]	SAF [6]	ISAF [7]	Thermal	Total (furnace)	Channel	Total
PRODUCTION [8]											
January	26,985	730	31,824	31,938	66,113	1,974	46,720	26,481	232,765	12,151	244,916
February	24,512	817	32,663	27,688	49,517	1,344	50,073	25,905	212,519	10,453	222,972
March	26,394	1,760	37,859	28,846	68,332	683	55,995	29,453	249,322	11,287	260,609
April	25,233	743	32,274	30,386	56,429	2,048	49,708	30,291	227,112	10,918	238,030
May	26,719	1,616	34,688	28,562	64,972	2,070	50,718	31,061	240,406	11,875	252,281
June	24,587	1,130	35,441	28,101	53,803	859	53,818	28,215	225,954	10,939	236,893
July	20,500	301	32,671	28,344	59,154	3,282	52,336	28,859	225,447	11,297	236,744
August	21,533	849	40,090	26,851	59,642	2,515	53,395	26,892	231,767	10,615	242,382
September	21,682	875	44,795	26,555	65,578	1,605	47,335	25,595	234,020	10,611	244,631
October	25,887	377	40,895	33,347	71,022	1,426	52,163	23,626	248,743	10,876	259,619
November	25,177	738	42,657	28,285	69,826	1,738	51,123	23,971	243,515	10,392	253,907
December	25,304	1,119	45,496	31,745	75,427	1,614	53,058	25,457	259,220	11,057	270,277
Total	294,513	11,055	451,353	350,648	759,815	21,158	616,442	325,806	2,830,790	132,471	2,963,261
SHIPMENTS (Including exports) [9]											
January	25,198	897	31,799	30,957	61,878	841	52,045	26,283	229,898	9,498	239,396
February	22,573	903	30,782	28,903	57,509	1,650	51,780	21,934	216,034	8,383	224,417
March	26,468	910	34,747	27,661	61,354	1,471	51,165	28,667	232,443	8,534	240,977
April	25,121	1,009	35,302	28,814	59,007	1,598	49,768	28,945	229,564	14,130	243,694
May	25,932	1,062	35,846	29,539	62,002	1,848	52,049	31,219	239,497	15,856	255,353
June	21,970	891	33,916	27,345	57,899	1,610	52,784	26,529	222,944	16,533	239,477
July	24,891	972	34,594	27,433	64,042	1,811	53,081	24,247	231,071	11,874	242,945
August	23,583	1,209	40,186	27,146	59,823	2,215	51,393	24,432	229,987	11,359	241,346
September	25,774	1,023	43,168	30,085	68,690	985	53,868	26,630	250,223	13,376	263,599
October	27,177	930	42,592	33,603	74,131	2,598	52,436	27,528	260,995	13,028	274,023
November	27,510	840	41,718	29,390	69,372	1,297	49,633	26,769	246,529	10,414	256,943
December	23,533	791	41,377	27,565	70,973	2,092	49,349	27,653	243,333	13,908	257,241
Total	299,730	11,437	446,027	348,441	766,680	20,016	619,351	320,836	2,832,518	146,893	2,979,411

[1] Semireinforcing furnace.
[2] High-modulus furnace.
[3] General-purpose furnace.
[4] Fast-extrusion furnace.
[5] High-abrasion furnace.
[6] Superabrasion furnace.
[7] Intermediate-abrasion furnace.
[8] Compiled from reports of a survey firm and producing companies. Figures adjusted to agree with annual reports of individual producers.
[9] Includes losses.

Table 4.—Number and capacity of carbon black plants operated in the United States

State	County or Parish	Number of plants 1968 Channel	Number of plants 1968 Furnace	Number of plants 1969 Channel	Number of plants 1969 Furnace	Total daily capacity (pounds) 1968	Total daily capacity (pounds) 1969
Texas	Aransas	--	1	--	1		
	Carson	1	--	1	--		
	Ector	1	--	1	--		
	Gaines	1	--	1	--		
	Gray	--	1	--	1		
	Harris	--	1	--	1		
	Howard	--	2	--	2	4,554,941	4,550,078
	Hutchinson	1	4	1	4		
	Montgomery	--	1	--	1		
	Moore	--	1	--	1		
	Orange	--	1	--	1		
	Terry	--	1	--	1		
	Wheeler	--	1	--	1		
Total Texas		4	14	4	14	4,554,941	4,550,078
Louisiana	Avoyelles	--	1	--	1		
	Calcasieu	--	1	--	1		
	Evangeline	--	1	--	1	3,183,068	3,568,055
	Ouachita	1	2	--	2		
	St. Mary	--	3	--	3		
	West Baton Rouge	--	--	--	1		
Total Louisiana		1	8	--	9	3,183,068	3,568,055
Arkansas	Union	--	1	--	1		
California	Contra Costa	--	--	--	1		
	Kern	--	2	--	2		
	Mojave (District)	--	--	--	1		
Kansas	Grant	--	1	--	1	1,403,849	1,920,506
New Mexico	Lea	1	1	1	1		
Ohio	Washington	--	--	--	1		
Oklahoma	Kay	--	1	--	1		
West Virginia	Pleasants	--	1	--	1		
Total Other States		1	7	1	10	1,403,849	1,920,506
Total United States		6	r 29	5	33	9,141,858	10,038,639

r Revised.

Table 5.—Carbon black and the feedstocks used in its production, by States

		Louisiana	Texas	Other States [1]	Total
1968					
Carbon black production:					
Total	thousand pounds	1,031,349	1,426,307	354,150	2,811,806
Value	thousand dollars	$70,403	$111,091	$24,355	$205,849
Average value	cents per pound	r 6.86	7.79	6.88	7.32
Natural gas used: [2]					
Total	million cubic feet	29,146	59,527	16,300	104,973
Value	thousand dollars	$4,896	$7,367	$2,128	$14,391
Average value	cents per thousand cubic feet	16.80	12.38	r 13.06	13.71
Carbon black produced [3]	thousand pounds	326,019	85,049	44,147	455,215
Liquid hydrocarbons used:					
Total	thousand gallons	144,003	282,004	58,397	484,404
Value	thousand dollars	$10,462	$20,056	$3,914	$34,432
Average value	cents per gallon	r 7.27	7.11	6.70	7.11
Carbon black produced	thousand pounds	705,330	1,341,258	310,003	2,356,591
1969					
Carbon black production:					
Total	thousand pounds	1,045,902	1,442,033	475,326	2,963,261
Value	thousand dollars	$70,768	$110,816	$33,536	$215,120
Average value	cents per pound	6.77	7.68	7.06	7.26
Natural gas used: [2]					
Total	million cubic feet	27,834	55,199	15,218	98,251
Value	thousand dollars	$4,891	$7,549	$2,184	$14,624
Average value	cents per thousand cubic feet	17.57	13.68	14.35	14.88
Carbon black produced [3]	thousand pounds	326,168	64,592	65,099	455,859
Liquid hydrocarbons used:					
Total	thousand gallons	152,891	292,293	79,186	524,370
Value	thousand dollars	$10,813	$21,195	$5,921	$37,929
Average value	cents per gallon	7.07	7.25	8.50	7.23
Carbon black produced	thousand pounds	719,734	1,377,441	410,227	2,507,402

r Revised.
[1] Arkansas, California, Kansas, New Mexico, Ohio, Oklahoma, and West Virginia.
[2] Includes natural gas used to enrich liquid hydrocarbons.
[3] Produced from natural gas used as feedstock.

Table 6.—Natural gas and liquid hydrocarbons used in manufacturing carbon black in the United States and average yield

	1965	1966	1967	1968	1969
Natural gas used [1] ----- million cubic feet--	115,574	114,936	108,961	104,973	98,251
Average yield of carbon black per thousand cubic feet [2] ----- pounds--	6.36	5.75	5.54	r 5.79	6.28
Average value of natural gas used per thousand cubic feet ----- cents--	14.59	14.45	14.02	13.71	14.88
Liquid hydrocarbons used ----- thousand gallons--	389,173	433,700	421,286	484,404	524,370
Average yield of carbon black per gallon --- pounds--	4.52	4.72	4.79	4.86	4.78
Average value of liquid hydrocarbons used per gallon cents--	6.86	7.09	7.07	7.11	7.23
Number of producers reporting-----	9	9	9	8	9
Number of plants-----	34	34	35	r 35	38

r Revised.
[1] Includes natural gas used to enrich liquid hydrocarbons.
[2] Average yield based on natural gas used as feedstock, excluding natural gas used to enrich liquid hydrocarbons.

Table 7.—Sales of carbon black for domestic consumption in the United States, by uses

(Thousand pounds)

Use	1965	1966	1967	1968	1969	Change from 1968 (percent)
Ink-----	54,333	63,682	63,963	67,721	73,077	+ 7.91
Paint-----	10,896	11,959	12,553	13,435	17,711	+31.83
Paper-----	7,649	6,108	5,658	4,710	5,668	+20.34
Plastics-----	20,183	21,945	20,907	26,863	(1)	-------
Rubber-----	1,945,459	2,131,169	2,072,543	r 2,445,550	2,616,166	+ 6.98
Miscellaneous [2]-----	33,980	42,732	40,521	30,123	65,327	XX
Total-----	2,072,500	2,277,595	2,216,145	r 2,588,402	2,777,949	+ 7.32

r Revised. XX Not applicable.
[1] Included in "Miscellaneous."
[2] Chemical, food, and plastics (1969) combined with "Miscellaneous" to avoid disclosing individual company confidential data.

Table 8.—Producers' stock of channel- and furnace-type blacks in the United States, December 31

(Thousand pounds)

Year	Furnace									Channel	Total
	SRF [1]	HMF [1]	GPF [1]	FEF [1]	HAF [1]	SAF [1]	ISAF [1]	Thermal	Total		
1965-----	34,828	7,291	20,385	23,275	48,644	4,277	35,506	22,835	197,041	40,663	237,704
1966-----	35,479	5,570	15,709	21,411	53,344	4,925	43,801	9,615	189,854	43,291	233,145
1967-----	43,747	4,916	13,669	20,029	58,688	6,284	37,951	26,943	212,227	52,020	264,247
1968-----	29,695	2,900	14,756	20,047	55,590	3,592	41,621	23,074	191,275	32,895	224,170
1969 r-----	24,478	2,518	20,082	22,254	48,725	4,734	38,712	28,044	189,547	18,473	208,020

r Revised.
[1] For explanation, see footnotes to table 3.

Table 9.—U.S. exports of carbon black, by countries

(Thousand pounds and thousand dollars)

Country	1967		1968		1969	
	Quantity	Value	Quantity	Value	Quantity	Value
North America:						
Canada	27,591	$2,309	29,189	$2,455	26,454	$2,394
Guatemala	1,423	125	3,042	250	1,132	98
Mexico	1,792	203	4,780	556	4,089	415
Other	1,534	135	3,085	279	1,037	98
Total	32,340	2,772	40,096	3,540	32,712	3,005
South America:						
Argentina	1,373	213	2,419	300	1,914	273
Brazil	3,190	301	4,800	465	2,865	301
Chile	4,473	426	627	79	455	50
Colombia	1,074	117	466	97	475	78
Peru	6,317	550	8,731	792	338	35
Venezuela	690	77	1,409	133	2,376	228
Other	802	76	844	88	393	57
Total	17,919	1,760	19,296	1,954	8,816	1,022
Europe:						
Belgium-Luxembourg	5,366	467	5,804	530	3,448	326
Denmark	1,110	173	2,135	322	1,105	154
Finland	595	58	1,044	156	314	39
France	35,584	3,624	36,523	3,822	33,236	3,625
Germany, West	24,174	2,063	23,871	2,258	15,041	1,647
Italy	17,186	2,048	22,425	2,695	10,934	1,384
Netherlands	3,185	349	3,793	479	2,470	320
Norway	959	85	1,145	101	934	72
Portugal	1,941	193	709	83	1,668	148
Spain	3,492	438	5,047	602	3,684	445
Sweden	3,335	261	6,075	515	2,380	217
Switzerland	2,140	205	2,504	210	1,511	150
U.S.S.R.	9	13	66	65	7,345	863
United Kingdom	19,748	2,839	24,597	3,675	17,117	2,782
Yugoslavia	511	63	436	43	72	12
Other	3,416	360	789	87	568	73
Total	122,751	13,239	136,963	15,643	101,827	12,257
Africa:						
Ghana	-----	-----	35	3	818	72
South Africa, Republic of	9,338	851	7,736	786	4,660	463
Other	813	77	1,427	122	498	57
Total	10,151	928	9,198	911	5,976	592
Asia:						
India	6,510	661	3,505	376	5,554	587
Indonesia	805	60	1,766	148	759	65
Iran	364	39	1,150	112	139	12
Israel	1,102	112	1,287	117	555	55
Japan	10,296	1,824	12,093	2,234	8,109	2,117
Korea, South	7,972	706	11,026	1,041	13,779	1,375
Pakistan	536	45	206	17	1,794	173
Philippines	7,340	644	8,737	770	3,614	333
Thailand	4,050	339	2,310	198	958	82
Turkey	2,216	199	935	96	428	47
Other	2,495	282	2,912	394	2,477	312
Total	43,686	4,911	45,927	5,503	38,166	5,158
Oceania:						
Australia	6,472	554	8,348	773	5,384	559
New Zealand	2,716	246	3,294	302	3,322	322
Total	9,188	800	11,642	1,075	8,706	881
Grand total	236,035	24,410	263,122	28,626	196,203	22,915

Table 10.—U.S. exports of carbon black in 1969, by months

(Thousand pounds and thousand dollars)

Month	Channel		Furnace		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
January	733	$179	4,039	$313	4,772	$492
February	571	140	3,806	308	4,377	448
March	1,068	241	10,537	791	11,605	1,032
April	7,525	1,316	15,420	1,237	22,945	2,553
May	9,209	1,551	18,246	1,486	27,455	3,037
June	7,201	1,305	15,761	1,307	22,962	2,612
July	8,039	1,418	11,312	1,083	19,351	2,501
August	5,339	1,104	12,470	1,102	17,809	2,206
September	4,922	867	11,721	1,062	16,643	1,929
October	4,989	1,000	13,817	1,184	18,806	2,184
November	4,013	988	10,043	889	14,056	1,877
December	4,732	1,094	10,690	950	15,422	2,044
Total	58,341	11,203	137,862	11,712	196,203	22,915

Table 11.—World production of carbon black by countries [1]

(Thousand pounds)

Country	1967	1968	1969 [p]
Argentina	45,166	48,444	52,911
Brazil	67,681	99,207	95,901
France	261,906	260,473	[e] 295,416
Germany, West	297,246	392,406	474,220
India	[e] 55,115	[e] 55,115	[e] 55,115
Italy	199,748	205,711	230,949
Japan	388,742	482,051	574,531
Korea, South	NA	NA	1,001
Netherlands	164,243	169,975	[e] 176,148
Rumania	115,682	120,973	124,390
Spain	[r] 27,558	[e] 55,115	[e] 66,138
Taiwan	1,091	[e] 1,100	[e] 1,100
United Kingdom	360,452	405,867	436,511
United States	2,483,840	2,811,806	2,963,261
Venezuela	16,204	16,204	16,001
Yugoslavia	27,388	19,760	[e] 22,046
Total [2]	[r] 4,512,062	5,144,207	5,585,639

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.
[1] Australia, Belgium, Canada, mainland China, Colombia, Mexico, Republic of South Africa, and Sweden produce carbon black, but production data are not available.
[2] Totals are of listed figures only.

Cement

By Robert A. Whitman [1]

Finished portland cement shipments topped the 400-million-barrel mark in 1969, with a total of 418,284,000 barrels shipped. Until midyear it had appeared that total cement shipments would rise above the coveted mark with more momentum than was apparent by yearend.

Although the industry's level of activity proved to be at an alltime high, the degree of achievement was not as high as had earlier been expected. Price increases instituted early in 1969 had been somewhat eroded by the time vigorous summertime construction activity began, and the total f.o.b. mill value of all portland cement shipments for 1969 was about 4 percent above the $1.3 billion mark established in 1968.

Two new white-cement plants and three new gray-cement plants went on stream in 1969. The new gray plants at Lyons, Colo., near Miami, Fla., and at Greencastle, Ind., added nearly 9 million barrels of new capacity. Several remodeling and updating projects came into operation as well. Enough production capacity from outdated or inefficient plans was permanently closed down so that the net gain in U.S. capacity was about 9 to 10 million barrels. Sales increases did not keep pace with these capacity increases. However, much of the new capacity was located in areas which will soon need such facilities.

In the face of these factors, the industry made its costliest wage and fringe benefit settlement ever during 1969, and prices were expected to rise in 1970 commensurate with the increase in labor costs.

Imports for consumption of hydraulic cement increased in 1969 by more than 30 percent over those of 1968. Total cement imports at yearend were running nearly 10 million barrels per year, or about 2.3 percent of domestic shipments, having risen from 1.8 percent in 1968.

There were no equipment or raw material shortages in 1969. In addition to ever-larger kilns, the trend in new and modernized plants continued toward more extensive automation and air pollution control equipment. In fact, demands for improved air pollution controls by governments frequently have been stringent enough to become important factors in

[1] Physical scientist.

Table 1.—Salient cement statistics

	1965	1966	1967	1968	1969
United States:					
Production [1] thousand 376-pound barrels	381,578	393,824	377,885	403,349	407,944
Capacity used at portland cement mills [1] percent	76.8	77.3	72.7	77.6	78.7
Shipments from mills [1] thousand 376-pound barrels	384,402	389,856	381,824	405,863	418,284
Value [1] [2] thousands	$1,221,454	$1,226,806	$1,210,736	$1,294,533	$1,354,033
Average value [1] per barrel	$3.18	$3.15	$3.17	$3.19	$3.23
Stocks Dec. 31 at mills: [1] thousand 376-pound barrels	32,942	40,698	41,529	41,977	37,920
Exports do	748	1,069	980	942	589
Imports for consumption thousand 376-pound barrels	5,505	7,066	5,913	7,289	9,687
Consumption, apparent [3] thousand 376-pound barrels	389,159	395,853	386,757	412,210	427,382
World: Production do	2,543,258	2,722,068	2,812,729	3,009,950	3,168,951

[1] Excludes Puerto Rico; includes portland, masonry, and slag cements.
[2] Value received, f.o.b. mill, excluding cost of containers.
[3] Quantity shipped plus imports minus exports.

management decisions with respect to modernization or discontinuance of some of the older cement plants.

The United States continued to be the only major cement-producing nation in the world that still used the 376-pound barrel as the chief unit of measure. During 1969, Canadian companies abandoned their own 350-pound barrel and adopted the 2,000-pound short ton as their standard unit of cement measure.

The fast-moving swing to the cement terminal at a point some distance from the manufacturing plant, as a means of expanding the distribution radius of the plant, leveled off by 1969. Four new terminals were opened, while five were closed, and those opened generally were in special situations where the markets were exceptionally vigorous. It has been estimated that 25 percent of all cement shipments now originate from distribution terminals.

Legislation and Government Programs.—The two most important housing measures enacted by Congress in 1969 were both passed too late in December to affect activity during the year. The Housing and Urban Development (HUD) Act of 1969 (Public Law 91–152) had four important new provisions: (1) It established a replacement requirement for slum dwellings razed as part of an urban development project, by requiring that an equivalent number of new or rehabilitated housing units be provided to replace those dwellings demolished or removed by an urban renewal project. (2) Authorized a Federal subsidy for the operating costs of the public housing program. (3) Provided for financing of mobile homes. (4) Enabled HUD to override local building codes or labor union restrictions in the development of experimental housing. Of these four, the first and the last should be of the most direct benefits to the building industry and therefore to the cement industry. The Mortgage Credit Act (Public Law 91–151) was designed to fight inflation and thus will affect the cement industry indirectly. Probably the Government program most promising for the industry was the initiation of Operation Breakthrough by HUD. This should provide for a vast increase in the use of cement for housing. The program is discussed further in the section on consumption and uses.

DOMESTIC PRODUCTION

PORTLAND CEMENT

The portland cement industry probably increased its net total production capability by about 2 to 2.5 percent in 1969. This increase, coincidentally, just about matched the rated 9 million barrel production capacity for the three new gray-cement plants that went on stream during the year. Probably the total amount of new capacity installed was around 22 million tons, however over half of the new production capacity resulted from modernization and replacement of old and obsolescent equipment. Thus over half of this total expansion was cancelled by the closing of old equipment, no longer economical. The installation of dust-collecting facilities had a high priority. These included at least 12 electrostatic precipitators and several bag houses or bag-type collectors. Although four new distribution terminals were installed in widely scattered parts of the country, at least five terminals were closed down, mostly in the eastern part of the United States. The following tabulation, with plants grouped according to estimated annual capacity, shows the trend toward larger size plants in the United States, including Puerto Rico:

Million barrels	Yearend 1967		Yearend 1968		Yearend 1969	
	Number of plants	Percent of total capacity	Number of plants	Percent of total capacity	Number of plants	Percent of total capacity
Less than 1	[1] 11	1.5	[r] [2] 7	0.9	[2] 8	1.0
1 to 2	[2] 59	17.3	[2] 58	17.1	[2] 55	16.4
2 to 3	52	24.5	53	25.1	53	25.3
3 to 4	40	26.6	[r] 36	23.9	36	24.1
4 to 5	12	10.0	13	10.9	12	10.0
5 and over	14	20.1	16	22.1	17	23.2
Total	188	100.0	183	100.0	181	100.0

[r] Revised.
[1] 2 plants received clinker from other sources.
[2] 1 plant received clinker from other sources.

All three of the new gray-cement plants which went on stream during the year were highly automated. Maule Industries, Inc., had a new 2.4-million-barrel plant erected at its quarry near Pennsuco, Fla. A new dry-process, single-kiln plant was completed for the Dewey Rocky Mountain Cement Co. at Lyons, Colo. Between 75 and 80 men were employed. Operation of the 2.3-million-barrel plant, from raw material mix right through the kiln, was controlled by computer. A roaster dryer was used to eliminate kerogens from the raw material. Lone Star Cement Corp. replaced an older, four-kiln operation at Greencastle, Ind., with a new one-kiln plant with a capacity of 4 million barrels per year.[2] The new plant has a full, direct, digital-control, real-time, computer system, which incorporated on-line X-ray analysis.

The Nevada Cement Co. doubled the production capacity of its plant at Fernley, Nev., in an expansion project; total cost was estimated at $2 million. The Idaho Portland Cement Co., which had its plant in Spokane, Wash., merged with the Oregon Portland Cement Co. to form a company with a total capacity of 5.2 million barrels per year. Idaho Portland continued to operate as a division of Oregon Portland Cement, but retained the Idaho Portland Cement Co. identification on its product. Calaveras Cement Co. in San Francisco announced plans to convey limestone to its cement plant at San Andreas through a 17.6-mile underground transmission line. The pulverized limestone would be in liquid suspension. Water necessary to create the limestone slurry was to be furnished to the quarry by an underground pipeline connected with the water source 3.7 miles north of the quarry.

An expansion program to double the capacity of the Midlothian, Texas cement plant of Gifford-Hill & Co., Inc., was announced. The expansion of the wet-process plant situated about 25 miles south of Dallas was to increase its capacity from 1.5 million barrels annually to about 3 million barrels per year.

Kaiser Cement & Gypsum Corp. of Oakland, Calif., purchased a site at Seattle, Wash., to locate an integrated plant for cement production. The company had, in 1969, about $4 million invested in silos and cement-handling and docking facilities in an industrial area along the Duwamish River. This installation was planned as part of the new plant.

Lehigh Portland Cement Co. started a $9 million expansion program to enlarge the capacity of its Union Bridge, Md., cement plant. The program, involving the addition of a fourth kiln and related grinding equipment, was to increase the 1969 capacity to almost 5 million barrels.

Arizona Portland Cement Co. announced a $12 million expansion and modernization project for the Rillito Plant located about 20 miles northwest of Tucson. This was planned to increase production from 3 to 4.2 million barrels per year. Approximately $1 million was to be used for additional equipment to reduce air pollution, and it was projected that the plant's air pollution control would eliminate any visible dust. Giant Portland Cement Co. announced plans to modernize its marl-processing operation at Harleyville, S.C. with new equipment. The project was planned to allow for a future increase of 30 percent in the plant's production of portland cement. Construction was started by the Peerless Division of American Cement Corp. of a new 4-million-barrel plant to be located on the Rouge River near Detroit. The new plant, with access to the Great Lakes, would have facilities for shipping package and bulk cement by rail, truck, and ship. It would replace the oldest of three plants currently operated by the corporation's division in the Detroit area. Universal-Atlas Cement Division of United States Steel Corp. began construction of a Chicago-area plant to produce calcium-aluminate cements. These cements were to be used in refractory applications.

TRANSPORTATION

Two new 7,000-barrel cement barges were ordered during the year by Dewey Portland Cement Co. to haul cement products from the Davenport, Iowa, plant to the St. Paul, Minn., distribution terminal. These two barges represented a new design in that they were compartmentalized and

[2] Herod, Buren C. At Greencastle-Lone Star Even Brighter. Pit & Quarry, v. 62, No. 7, January 1970, pp. 126–139.

able to carry three types of cement at one time. They were equipped with self-contained unloading systems. In another phase of this expansion program new docks were constructed at the St. Paul terminal, and new storage silos raised the total storage capacity from 11,500 to 26,000 barrels. New storage silos of 7,000-barrel capacity were constructed at the Davenport terminal together with a 2,000-barrel-per-hour loading system.

Kaiser Cement & Gypsum Corp. ordered a new cement carrier of 5,000 deadweight tons for its subsidiary, the Ryukyu Cement Co. The vessel, to cost about $1.6 million, was to be built by C. Itoh & Co. of Japan.

American Cement Corp. purchased 3.15 acres with a 580-foot frontage along the Buffalo ship canal as a site for a distribution terminal for cement brought down the Great Lakes.

CONSUMPTION AND USES

Consumption of portland cement, if measured by shipments, exceeded the all-time high reached in 1968 by about 3 percent. Slowing down of private construction through high interest rates combined with the stretch-out of public construction created a more even demand throughout the year. No monthly shipment records were set, but over 40 million barrels were shipped in each of the 5 months of June through October.

According to the Construction Review of the Business and Defense Services Administration, U.S. Department of Commerce, the value of new construction in place, measured in constant dollars, declined throughout 1969. The total for 1969 was slightly under that for 1968. The review showed that 2 percent less cement was going to highway contractors than in 1964, while nearly 2 percent more was going to ready-mixed concrete producers. Concrete pavers, who have done very well with the interstate highway program, will now have to develop their techniques to bid competitively for urban street renewal, sidewalks, parking areas, and rehabilitation of secondary roads throughout the country.

The use of cement to modify or to create soil-cement mixtures grew rapidly. The principal objective of cement modification or the creation of a soil cement was to reduce the ability of the soil to retain moisture rather than to increase its strength. The use of soil cement was very successful in Florida, which has an extremely shallow water table. A paper entiled "Cement Modification of Clay Soils" by A. P Christensen [3] presented comparisons between cement-soil and lime-soil modifications using 11 different clay soil samples. Results indicated that 3 to 5 percent of either lime or cement was effective in reducing the water-retention properties of clay soils. As a result, soil shrinkage or swelling was considerably reduced. However, soils modified with cement generally showed greater compressive and triaxial strengths than those modified with lime.

The use of cement in concrete block should expand as more concrete-block production facilities are automated. A plant was opened at Stanton Harcourt, Oxfordshire, England, early in 1969, capable of producing 30,000 blocks per shift with a crew of seven men.[4] A fully automated factory-type plant was opened at Germantown, Tenn. in January, capable of producing 4.7 million units annually with a work force of six men.[5] The use of conrete for building should be greatly increased as more architects and engineers utilize the versatility of concrete to create buildings with beauty rather than simply utility.[6] Designing for beauty was extended to bridges as well as buildings. The 439-foot-long bridge passing over Adams Avenue on Interstate Highway 805 in San Diego, Calif., is a good example.[7]

In order to initiate a program for Operation Break-through, sponsored by the Department of Housing and Urban Development, the Portland Cement Association formed a consortium of precast concrete

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[3] Christensen, A. P. Cement Modification of Clay Soils. Portland Cement Association, RD002.015 1969.

[4] Cement, Lime, and Gravel. Concrete Block Production on Factory Lines. V. 44, No. 11, November 1969, pp. 323–326.

[5] Papineau, Don Fischer. Limes New Block Plant. Modern Concrete, v. 33, No. 7, November 1969, pp. 42–46, 68.

[6] Engineering News Record. Prefab Beams Update, Decorate Buildings. V. 182, No. 8, Feb. 20, 1969, pp. 44–48.

[7] Engineering News Record. Curved Bridge Takes Fancy Formwork. V. 182, No. 13, Mar. 27, 1969, pp. 34–35.

producers, which included the National Gypsum Co., Buffalo, N.Y.; American Standard, Inc., New York City; Wiremold Co., Hartford, Conn.; Ferendino, Grafton, and Pancoast, Miami, Fla.; and the National Urban League, Washington, D.C. The consortium submitted a proposal covering the design, testing, and construction of prototype concrete housing which could be mass-produced. There were 135 precast concrete manufacturers represented from across the country. Included were members of Flexicore Manufacturers Association, Spancrete Manufacturers Association, Span-Deck Manufacturers Association, Spiroll Producers Association, Dynaspan Producers Association, and Prestressed Concrete Institute.

PRICES

The average mill value of a barrel of cement (all classes) was about $3.23 in 1969. The poor profit position of the cement industry continued throughout 1969. Although the 20-city average, as provided by Engineering News-Record, started at $4.10 per barrel for bulk cement in carload lots in January and increased to $4.18 per barrel in September, by November and December it was down to an average of $4.02 per barrel. A very large wage increase in the industry coupled with the price drop toward yearend tended to depress annual profits.

Engineering News-Record provides f.o.b. base prices per barrel for portland cement by carload lots in 20 cities across the United States. The annual average for bulk cement was $4.07 per barrel, as compared with $4.09 in 1968. December 1969 price quotations (with the 1968 figures in parentheses for comparison) were as follows: Bulk, $4.02 ($4.09) per barrel, ranging from a high of $5 at Cleveland ($4.95 at Pittsburgh) to a low of $3.75 at Birmingham and Philadelphia ($3.60 at Detroit). For cement in paper bags during 1969 the 20-city average over the year was $5.18. For December the prices ranged from a high of $6.40 per barrel in New Orleans ($6.88 in New Orleans) to a low of $4.30 in Birmingham ($4.30 in Birmingham). The high of $6.88 per barrel for cement in sacks lasted only through May, at which time it dropped to $6.40. The low of $4.30 per barrel persisted throughout the year. For mortar cement in carload lots the average for the year was $4.53 per barrel. The high remained at $6.40 in New Orleans for all of 1969 (as it had ended in 1968) and the low dropped to $3.20 in New York ($3.90 in New York).

FOREIGN TRADE

Exports of cement from the United States in 1969 dropped 37 percent from those of the previous year to a total of only 589,000 barrels of 376 pounds each. The total dollar value of these exports was just under $3.2 million. Over 40 countries received U.S. exports of cement, but of these, four—Canada, the Leeward and Windward Islands, the French West Indies, and the Bahamas, took over 75 percent of the volume.

The importation of cement for consumption into the United States in 1969 increased by 2.4 million barrels to an all-time high of 9.7 million barrels with a value of over $24 million. This represented 2.3 percent of the total domestic shipments for 1969. The Bahamas, Canada, and Norway provided 85 percent of the imports. The Bahamas (41 percent) forged to the leadership position during 1969, edging out Canada (28 percent), long the leader. Norway (16.9 percent) and Colombia (5 percent) have slowly lost ground to others in recent years. Of the 10 other countries from which the United States received cement, only shipments from Japan and the United Kingdom increased appreciably over those in 1968.

A new tariff reduction became effective January 1, 1969. The duty on white, nonstaining cement was reduced from 2.5 cents per hundred pounds to 2 cents per hundred pounds, while the duty on hydraulic cement and clinker was reduced from 1.5 to 1.3 cents per hundred pounds.

WORLD REVIEW

Algeria.—An automated cement plant with a rated capacity of 500,000 metric tons per year was to be constructed for Algeria by the French firm, Five Lille Cail, according to a contract signed October 1, 1969. The cost of the plant was estimated at 138 million dinars.

Czechoslovakia.—Construction of a large, modern, cement plant with an expected capacity of over 1 million tons per year of portland and high-quality cement was completed near the city of Brno. This plant will increase the country's annual productive capacity of 6,500,000 tons by about 15 percent.

Ethiopia.—About one-third of the total production of the Eritrea Cement Share Co. of Ethiopia was being exported in the early part of 1969. The cement, almost the only industrial export of Ethiopia, was being sent to Saudi Arabia and Yemen. The main plant of the company, located on the Red Sea just outside Massawa, was built with the technical advice of and a commercial loan from the Krupp Co. of West Germany. The plant commenced production in 1965 with an annual output of about 65,000 tons of cement.

Germany, West.—A cement plant owned by Klockner Humbolt Deutz, A.G., at Cologne, was scheduled to install a Honeywell DDP-516 real-time computer system. The system was to include analysis of data on the mix obtained from an on-line X-ray fluorescent spectrometer.

Ghana.—The cement industry of Ghana in 1969 operated two plants using imported clinker. The first plant was built at Tema in 1964 with an annual capacity of 200,000 tons. The second plant, which came on stream at the end of 1968 has an annual production capacity of 500,000 long tons. Plans were being made for the exploration of limestone deposits in the southwestern corner of the country to furnish clinker locally.

Indonesia.—It was reported that the Indonesian Government had placed orders with the Industrial Development Corp. of India for six small-scale cement plants modeled on the shaft-kiln, small-scale, cement plant near Dalmiapuram, India.

Morocco.—The capacity of the Meknes Cement Plant in Morocco was raised from 150,000 to 400,000 metric tons per year by the addition of a second kiln late in 1969. This plant is operated by a private company, Societe des Ciments Artificiels de Meknes, which is associated with Ciments Lafarge Group of France.

Philippines.—The Philippine Board of Investments included cement manufacturing in its list of overcrowded industries. This means that the cement industry will not receive incentive tax preference.

Qatar.—The Qatar National Cement Co., Ltd., of the Sheikdom of Qatar produced portland and sulfate-resistant cements in excess of the plant's designed capacity of 100,000 metric tons per year. This cement plant, Qatar's first major industrial venture outside of oil recovery, is located in the west side of the country at Umm Bab. Limestone was furnished from a quarry adjacent to the cement works. Clay came from a deposit some 20 kilometers from the plant.

Thailand.—The Siam Cement Co. built a third plant at Thung Song, Nakorn Srithamarha Province in southern Thailand. The rated capacity of this plant, which began production at the beginning of 1969, is 500,000 tons per year. The total production capacity of the Siam Cement Co. is estimated at 2,300,000 tons.

Turkey.—Cement production in Turkey increased during 1969 by approximately 500,000 metric tons to about 4,700,000 tons. Hastas Holding Co. started construction in August 1969 on two cement plants in Ceyhan. One was to produce cement and the other to manufacture cement products. The new cement production facility, with a capacity of over 6 million barrels, should increase the country's production capacity by over 20 percent.

United Kingdom.—The Cement Makers Federation announced that cementmakers would change to the use of metric weights and decimal currency simultaneously on January 1, 1971. The Federation hopes to avoid the confusion which might result from the use of both systems of weights and currencies concurrently.

A new cement plant with a rated capacity of 315,000 tons per year (1,800,000 barrels) was opened during 1969 by the Associated Portland Manufacturers, Ltd., at Cookstown, west of Belfast in Northern Ireland. The plant uses the semidry process of cement manufacture and gets its limestone near the plant. The shale comes from about 8 miles away, near Dungannon. Although automatic control of the Lepol semidry process kiln plant was difficult, the control of several variables, such as primary and secondary air volumes and temperatures, kiln and grate temperatures, pressure balance between sections of the grate, and kiln hood pressure, coupled with weight control of nodule input, made it possible to level off the factors affecting the equilibrium of the process. Dust collectors and precipitators throughout the plant helped to eliminate or minimize air pollution. The final electrostatic precipitators in the stack were stainless steel with a total area of 23,000 square feet.

TECHNOLOGY

A nondestructive device for in-place testing of the compressive strength of concrete was being used on a trial basis in several parts of the United States. Metal probes in sets of three were driven into the actual concrete in place through metal templates by the use of precisely measured charges of powder. The depth of penetration could be calibrated to give direct readings on the compressive strength of the concrete. The findings of this probe method were compared with those of conventional destructive core tests in the laboratory and were said to show a high degree of correlation. One advantage of probe-testing is the ability to make rechecks on questionable findings. This is not possible with cylinder or core-testing because the cylinders are destroyed in the test.

Another nondestructive testing device, marketed in the Netherlands, is based largely on the correlation existing between the speed of ultrasonic sound waves and the compressive strength of concrete.[8]

A concrete-plastic combination with strength, durability, and water resistance said to exceed those of ordinary concrete was developed jointly by the Atomic Energy Commission and the Interior Department's Bureau of Reclamation. Ordinary hardened concrete was vacuum-soaked in a liquid monomer (the unpolymerized form of a chemical compound) such as methyl methacrylate. This plastic was then hardened or polymerized by exposure to radiation from cobalt-60 for several hours. It could also be polymerized by a combination of heat and radiation or heat and a chemical catalyst. This polymer gave the concrete tensile and compressive strength 4 times greater than that of ordinary concrete. Its abrasion and cavitation resistance was 4 or 5 times greater than regular concrete. Water permeability was reduced to a negligible level. The weight of the polymerized concrete was increased by less than 7 percent. Colored dyes could also be injected at the same time to produce an attractive and permanent finish requiring little maintenance.

Concrete reinforced with short, randomly oriented, steel fibers was reported to have outstanding fatigue resistance and significantly improved load-bearing capacity. This concrete, called Wirand, contains about 7 percent (by weight) of steel wires, in lengths about 100 times the diameter which ranges from 6 to 10 mils. The concrete also exhibited good spall resistance.

Construction of a 3-mile-long conveyor system to haul both shale and limestone from separate quarries to the Davenport, Calif., cement plant operated by Pacific Cement & Aggregates of San Francisco was started during 1969. Target date for completion was March 1970. The new system transported ore at the rate of 100 tons per hour and carried the raw material from an altitude of 750 feet at the quarries to the oceanside plant site. It required only 100 horsepower in total operating energy. The bulk of the conveyor system was to be completely enclosed in prestressed concrete housings designed to provide a minimum of contrast with the area's natural surroundings. The new conveyor system replaced a narrow-gage railroad hauling from older quarries.

A major technological advance in concrete construction could be expected from the use of an advanced method of post-tensioning of concrete structures. Some of the patent rights to the system were sold by E. I. du Pont de Nemours & Co., Inc.; these covered technical data concerning plastic-covered lubricated wire (PLW) and an anchoring system to be used primarily

[8] South African Mining Journal. Non-destructive Concrete Tester. V. 80, No. 3991, Aug. 1, 1969, p. 263.

in the construction industry. The use of the PLW would permit post-tensioning of wire embedded in concrete structures, thereby prestressing the concrete. This was in line with the trend for prestressing and precasting of reinforced cement noticed in recent years.

Three notable papers on dust control in the cement industry were presented during the year. The first, by E. Burke,[9] director of research, Associated Portland Cement Manufacturers, Ltd, was given at the Clean Air Conference organized by the National Society for Clean Air and held at Eastbourne, England, during October 1969. The paper discussed briefly portland cement manufacture, processes used, various points in the plant where dust issues were noted and the methods used to avoid this nuisance. The difficulties encountered in making dust collecting equipment work efficiently were touched upon, and methods of dust measurement were described. In addition, reference was made to the implications of Britain's Clean Air Act, the requirements of the chief alkali inspector, and the cost of dust removal.

The second paper was "Dust Control Techniques for a Portland Cement Plant," by Thomas L. McCubbin, application engineer, the Pangborn Corp., Hagerstown, Md.[10] The third paper pointed out the many cost, legislative, and technical problems involved in air pollution control in the cement industry.[11]

The use of acidproof concrete to replace acid brick in the lining of a continuous pickling-line tank at the Yorkville, Ohio, plant of Wheeling-Pittsburgh Steel Corp. was recorded. The bricks in the tank (80 feet long by 8 feet wide by 6 feet deep) were becoming worn because of the continual washing by the 6 percent hydrochloric acid used to remove oxide scale from hot-rolled steel. Since the acid-proof cement could be poured, cast, or applied with pressure applicators, the tank was emptied on Saturday, and a crew immediately began applying the acidproof concrete. This provided a surface resistant to water, oil, electricity, most solvents, all acids except hydrofluoric, and temperatures up to 2,000° F. Only 1 day was required for the concrete to set, so by Monday the tank was back in operation. This saved several days of downtime as well as several days' labor in bricklaying.

Increased emphasis was placed during 1969 on reducing production and maintenance expenses. The wear and tear caused by friction is extremely high under the high heat and abrasive dust conditions of a cement plant; one plant reported success with the installation of a systematic lubrication system supplemented by centralized lubrication.

The reduction in the cost of carrying large inventories by standardizing cement specifications and thus reducing the numbers of grades of cement carried was proposed. Bureau of Public Roads studies indicated that there were 216 different coarse aggregate gradations for paving in the United States. In some cement plants, 20 to 25 identifiable types of tested cement in separate silos were not uncommon, which caused a multiplication of costs for the plant and its customers.

In another area, a major section of the Nation's precast, prestressed concrete industry formed a consortium of companies to mass-produce standarized concrete building components to be marketed nationwide. The nonprofit corporation, formed by 41 participating precast, prestressed concrete producers with 67 plants throughout the country, was to provide a program capable of delivering building components (a complete package of floors, roofs, exterior and interior walls, and structural systems) for multiunit housing and industrial and institutional facilities.

High-magnesia portland cements prepared in the laboratory from low-grade Indian limestones and containing as much as 15 percent magnesium oxide (MgO) could be made volume-stable by mixing the cements with suitable quantitites of an active silicate material such as pulverized fuel ash. These mixtures passed ASTM autoclave expansion tests and also possessed adequate strengths to satisfy the Indian Government's standards. Pulverized fuel ash from power stations at Delhi, Bokara, and Durgapur and powdered burnt clays were found to be very suitable additives. Granulated blast furnace slag

[9] Burke, E. Dust Control in the Cement Industry. Cement, Lime, and Gravel, v. 44, No. 11, November 1969, pp. 317–322.

[10] McCubbin, Thomas L. Dust Control Techniques for a Portland Cement Plant. Minerals Processing, v. 10, No. 5, May 1969, pp. 24–25, 35.

[11] Hailstone, R. E. Air Pollution Control in the Cement Industry. Minerals Processing. V. 10, No. 5, May 1969, pp. 11–15.

from the Rourkella Steel Plant was found to be unsatisfactory for the purpose of controlling the volume expansion of high-magnesia cements. This research could point the way for the use of both lower grade limestone and fly ash.

The National Bureau of Standards published the results of a study on the effects of varying compositions on the shrinkage of cement.[12]

An article from England noted many of the problems in the use of the electron probe for analyzing cement clinker and the areas of sulfate attack on concrete.[13]

Another article reported that evolved-water analysis, a thermal-analysis method, could be used to identify hydrates formed during the hydration of portland cement. The technique could be used quantitatively and was not subject to some of the disadvantages of differential thermal analysis or thermogravimetric analysis.[14]

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[12] Blaine, R. L., H. T. Arni, and D. N. Evans. Interrelations Between Cement and Concrete Properties, Part 4. NBS Bldg. Sci. Ser. 15, March 1969.

[13] Fletcher, K. E. Electron Probe Analysis of Silicate Building Materials. Chem. and Ind. (London), No. 38, Sept. 20, 1969, pp. 1325–1328.

[14] Forrester, J. A. Some Applications of Evolved Gas Analysis to the Study of Portland Cement. Chem. and Ind. (London), No. 36, Sept. 6, 1969, pp. 1244–1246.

Table 2.—Finished portland cement produced, shipped, and in stock in the United States,[1] by districts

District	Active plants		Production (thousand 376-pound barrels)		Shipments from mills 1968			Shipments from mills 1969			Stocks at mills Dec. 31 (thousand 376-pound barrels)	
	1968	1969	1968	1969	Thousand 376-pound barrels	Value: Total (thousands)	Value: Average per barrel	Thousand 376-pound barrels	Value: Total (thousands)	Value: Average per barrel	1968	1969
New York, Maine	11	11	28,696	27,555	29,090	$75,006	$2.58	29,423	$77,234	$2.62	3,472	2,374
Eastern Pennsylvania	17	17	32,145	31,453	31,270	86,569	2.77	32,940	89,096	2.70	3,704	2,387
Western Pennsylvania	5	5	11,784	11,651	11,748	36,608	3.12	11,953	37,845	3.17	1,844	1,688
Maryland, West Virginia	4	4	10,591	11,293	10,151	30,330	2.99	12,172	35,417	2.91	972	756
Ohio	9	9	14,891	14,698	15,222	49,814	3.27	15,100	50,071	3.32	1,766	1,824
Michigan	9	9	31,195	30,565	31,375	99,158	3.16	30,373	98,425	3.24	4,043	4,320
Indiana, Kentucky, Wisconsin	7	8	19,148	18,723	18,265	59,341	3.25	17,946	56,824	3.17	2,309	2,318
Illinois	4	4	9,719	8,872	9,372	32,475	3.47	8,720	29,996	3.44	1,829	1,765
Tennessee	6	6	8,584	8,813	8,488	27,691	3.26	9,159	29,403	3.21	943	799
Virginia, North Carolina, South Carolina	6	5	12,515	11,864	12,584	39,537	3.14	12,071	38,210	3.17	930	817
Georgia, Florida	6	6	13,163	14,520	13,883	45,254	3.26	15,108	51,260	3.40	753	776
Alabama	8	8	13,291	13,686	15,514	48,147	3.10	16,527	51,251	3.10	1,386	929
Louisiana, Mississippi	6	5	8,394	7,593	8,719	28,487	3.27	7,801	25,911	3.32	500	674
Minnesota, South Dakota, Nebraska	4	4	7,195	7,033	6,885	23,907	3.47	7,284	25,397	3.49	1,330	1,060
Iowa	5	5	13,544	13,633	13,900	47,275	3.40	14,084	47,265	3.36	1,343	1,157
Missouri	8	8	19,806	20,860	20,081	71,206	3.55	21,325	74,368	3.49	2,656	2,165
Kansas	6	6	9,887	9,737	9,680	29,898	3.09	9,764	29,365	3.01	1,585	1,483
Oklahoma, Arkansas	5	5	12,587	12,881	12,237	35,995	2.94	12,859	38,671	3.01	1,378	1,260
Texas	20	19	34,161	35,823	34,499	107,532	3.12	36,037	117,989	3.27	2,722	2,740
Wyoming, Montana, Idaho	4	4	3,818	4,680	3,881	13,669	3.52	5,099	17,727	3.48	735	696
Colorado, Arizona, Utah, New Mexico	7	7	12,099	12,037	12,105	42,141	3.48	12,408	44,868	3.62	1,281	899
Washington	5	5	6,327	6,323	6,328	23,030	3.64	6,356	22,724	3.58	925	1,004
Oregon, Nevada	3	3	3,617	3,497	3,812	13,657	3.58	3,689	14,127	3.83	201	305
Northern California	6	6	18,426	19,527	18,967	61,682	3.25	19,309	64,974	3.36	1,446	1,648
Southern California	8	8	28,650	31,238	28,628	90,279	3.15	31,301	105,638	3.37	1,780	1,928
Hawaii	2	2	1,752	2,102	1,841	9,254	5.03	2,075	10,544	5.08	130	133
Puerto Rico	2	2	8,924	8,945	8,923	27,577	3.09	8,943	27,920	3.12	152	154
Total	183	181	394,909	399,602	397,448	1,255,519	3.16	409,826	1,312,520	3.20	42,115	38,059

[1] Includes Puerto Rico.

Table 3.—Portland cement produced and shipped by plants in the United States,[1] by types

Type and year	Active plants	Production (thousand 376-pound barrels)	Shipments: Thousand 376-pound barrels	Shipments: Value: Total (thousands)	Shipments: Value: Average per barrel
General use and moderate heat (types I and II):					
1965	181	[2] 348,665	352,431	$1,095,639	$3.11
1966	[3] 183	[2] 359,493	358,446	1,102,940	3.08
1967	[4] 186	[2] 346,577	352,254	1,091,956	3.10
1968	[3] 180	[2] 370,358	373,668	1,164,594	3.12
1969	178	[2] 373,317	384,654	1,216,626	3.16
High-early-strength (type III):					
1965	153	[5] 13,388	12,757	44,621	3.50
1966	149	[5] 14,550	12,955	44,828	3.46
1967	145	[5] 12,899	12,188	42,453	3.48
1968	145	[5] 13,519	12,980	44,853	3.46
1969	144	[5] 14,606	13,485	47,065	3.49
Sulfate-resisting (type V):					
1965	19	512	425	1,648	3.88
1966	18	540	482	1,796	3.73
1967	18	870	560	2,023	3.61
1968	21	1,630	1,437	4,957	3.45
1969	20	2,476	2,033	7,452	3.67
Oil-well:					
1965	13	1,645	1,613	5,571	3.45
1966	14	2,172	2,006	6,954	3.47
1967	14	2,518	2,413	9,251	3.83
1968	14	2,502	2,596	9,512	3.66
1969	18	[6] 2,429	2,892	11,079	3.83
White:					
1965	5	[6] 2,241	2,128	14,517	6.82
1966	5	[6] 2,208	2,060	14,675	7.12
1967	6	[6] 2,244	2,092	13,928	6.66
1968	6	[6] 2,242	2,200	15,159	6.89
1969	7	[6] 2,127	1,928	12,945	6.71
Portland-slag and portland pozzolan:					
1965	6	[7] 967	913	2,878	3.15
1966	[3] 5	[7] 956	562	1,732	3.08
1967	[3] 6	[7] 818	780	2,610	3.35
1968	5	[7] 444	454	1,607	3.54
1969	5	[7] 390	386	1,187	3.08
Miscellaneous: [8]					
1965	34	[9] 4,004	3,819	12,989	3.40
1966	39	[9] 4,713	4,183	14,336	3.43
1967	32	[9] 3,473	3,730	13,384	3.59
1968	43	[9] 4,214	4,113	14,837	3.61
1969	42	[9] 4,257	4,448	16,166	3.63
Grand total:					
1965	[10] 181	371,422	374,086	1,177,863	3.15
1966	[4 10] 184	384,632	380,694	1,187,261	3.12
1967	[10 11] 188	369,399	374,017	1,175,605	3.14
1968	[4 10] 183	394,909	397,448	1,255,519	3.16
1969	180	399,602	409,826	1,312,520	3.20

[1] Includes Puerto Rico.
[2] Includes air-entrained portland cement as follows (in thousand 376-pound barrels): 1965—46,118; 1966—46,022; 1967—43,801; 1968—40,608; 1969—39,750.
[3] Includes 1 plant which received clinker from another source.
[4] Includes 2 plants which received clinker from other sources.
[5] Includes air-entrained portland cement as follows (in thousand 376-pound barrels): 1965—2,677; 1966—2,611; 1967—2,213; 1968—2,049; 1969—2,644.
[6] Includes a small quantity of air-entrained portland cement.
[7] Includes air-entrained portland cement as follows (in thousand 376-pound barrels): 1965—none; 1966—392; 1967—167; 1968—60; 1969—67.
[8] Includes hydroplastic, plastic, and waterproofed cements.
[9] Includes air-entrained portland cement as follows (in thousand 376-pound barrels): 1965—775; 1966—853; 1967—434; 1968—523; 1969—283.
[10] Includes number of plants making air-entrained portland cement as follows: 1965—132; 1966—129; 1967—132; 1968—125; 1969—125.
[11] Includes 3 plants which received clinker from other sources.

Table 4.—Destinations of shipments of all types of finished portland and high-early-strength cement from mills in the United States, by States

(Thousand 376-pound barrels)

Destination	Finished portland 1968	Finished portland 1969	High-early-strength 1968	High-early-strength 1969
Alabama	6,178	6,043	82	76
Alaska [1]	W	W	W	W
Arizona	4,440	5,177	W	W
Arkansas	4,437	3,845	13	10
Northern California	17,783	17,733	36	72
Southern California	26,848	28,782	226	121
Colorado	4,936	4,817	17	17
Connecticut [1]	4,313	4,425	329	378
Delaware [1]	1,010	939	44	35
District of Columbia [1]	1,427	1,048	16	4
Florida	16,292	18,703	975	1,201
Georgia	9,734	10,880	237	207
Hawaii	1,885	2,584	------	------
Idaho	1,730	2,534	60	75
Illinois	20,885	19,581	566	606
Indiana	10,213	9,510	373	367
Iowa	8,096	8,865	97	83
Kansas	5,729	5,656	57	65
Kentucky	7,250	5,804	131	138
Louisiana	12,545	11,699	122	41
Maine	1,017	1,069	59	77
Maryland	6,438	7,230	318	399
Massachusetts [1]	6,547	6,952	478	493
Michigan	16,158	16,459	920	898
Minnesota	8,764	9,150	395	332
Mississippi	4,371	4,427	12	22
Missouri	9,709	9,577	229	267
Montana	1,483	2,077	16	13
Nebraska	4,370	4,525	153	163
Nevada	1,350	1,683	5	9
New Hampshire [1]	1,037	992	73	68
New Jersey [1]	10,319	10,963	466	513
New Mexico	2,851	2,273	121	149
New York	17,691	17,626	1,005	1,145
North Carolina [1]	7,383	8,526	301	254
North Dakota [1]	922	1,216	48	22
Ohio	20,013	20,242	487	499
Oklahoma	6,045	7,282	53	49
Oregon	3,622	3,645	100	98
Eastern Pennsylvania	11,164	12,460	449	483
Western Pennsylvania	7,301	7,357	218	267
Rhode Island [1]	1,091	1,031	123	138
South Carolina	4,041	4,297	182	211
South Dakota	1,543	1,341	67	54
Tennessee	7,230	7,231	206	226
Texas	28,356	30,051	1,498	1,547
Utah	2,053	2,441	49	65
Vermont [1]	723	692	61	59
Virginia	8,921	9,117	403	367
Washington	6,686	6,125	652	621
West Virginia	2,597	2,501	34	12
Wisconsin	8,967	9,611	349	375
Wyoming	978	915	5	2
Total United States	387,472	399,709	12,916	13,393
Other countries	[2] 9,976	10,117	[3] 64	92
Total shipped from cement plants	397,448	409,826	12,980	13,485

W Withheld to avoid disclosing individual company confidential data; included with "Other countries."
[1] Noncement producer.
[2] Direct shipments by producers to foreign countries, the State of Alaska, and to Puerto Rico, including distribution from Puerto Rican mills.
[3] Direct shipments by producers to other countries and the States of Alaska and Arizona.

Table 5.—Portland-cement-manufacturing capacity of the United States,[1] by districts

District	Capacity Dec. 31 (thousand 376-pound barrels)[2]		Percent utilized	
	1968	1969	1968	1969
New York, Maine	34,192	34,303	83.9	80.3
Eastern Pennsylvania	37,392	37,703	86.0	83.4
Western Pennsylvania	13,847	13,990	85.1	83.2
Maryland, West Virginia	12,650	12,650	83.7	89.2
Ohio	19,744	19,792	75.4	74.2
Michigan	39,162	39,162	79.7	78.0
Indiana, Kentucky, Wisconsin	23,193	25,190	82.6	74.3
Illinois	11,600	11,600	83.8	76.4
Tennessee	10,156	10,156	84.5	86.7
Virginia, North Carolina, South Carolina	16,900	15,200	74.1	78.0
Georgia, Florida	18,856	18,856	69.8	75.5
Alabama	16,611	16,680	80.8	82.0
Louisiana, Mississippi	11,200	9,200	74.9	82.5
Minnesota, South Dakota, Nebraska	9,099	9,206	79.1	76.4
Iowa	15,462	15,462	87.6	88.1
Missouri	29,296	29,370	67.6	71.0
Kansas	12,855	13,005	76.9	74.8
Oklahoma, Arkansas	15,500	15,700	81.2	82.0
Texas	47,793	45,311	71.5	79.0
Wyoming, Montana, Idaho	5,100	5,300	74.9	88.3
Colorado, Arizona, Utah, New Mexico	16,800	16,900	72.0	71.2
Washington	8,200	8,200	77.2	77.1
Oregon, Nevada	5,700	6,600	63.5	52.9
Northern California	21,700	21,700	84.9	89.9
Southern California	42,600	42,600	67.3	73.3
Hawaii	2,700	2,700	64.9	77.8
Puerto Rico	10,750	10,750	83.0	83.2
Total	509,058	507,286	77.6	78.7

[1] Includes Puerto Rico.
[2] These capacities are estimates and/or approximations only, based upon the best information available from the companies operating each plant, but should not be taken as absolute values.

Table 6.—Capacity of finished portland cement plants in the United States,[1] by processes

Process	Capacity, Dec. 31[2] Thousand 376-pound barrels		Capacity, Dec. 31[2] Percent of total		Percent of capacity utilized		Percent of total finished cement produced	
	1968	1969	1968	1969	1968	1969	1968	1969
Wet	314,432	305,309	61.8	60.2	76.2	79.1	60.7	61.4
Dry	194,626	201,977	38.2	39.8	79.8	78.3	39.3	38.6
Total	509,058	507,286	100.0	100.0	77.6	78.7	100.0	100.0

[1] Includes Puerto Rico.
[2] These capacities are estimates and/or approximations only, based upon the best information available from the companies operating each plant, but should not be taken as absolute values.

Table 7.—Portland cement clinker produced and in stock at mills in the United States,[1] by process

Process	Number of plants[2]		Thousand 376-pound barrels Production		Thousand 376-pound barrels Stocks, Dec. 31	
	1968	1969	1968	1969	1968	1969
Wet	115	113	243,391	245,235	11,654	10,396
Dry	68	68	154,630	157,040	10,880	12,306
Total	183	181	398,021	402,275	22,534	22,702

[1] Includes Puerto Rico.
[2] 2 plants received clinker from other sources.

Table 8.—Production and percentage of total output of portland cement in the United States,[1] by raw materials used

(Quantities in thousand 376-pound barrels)

Year	Cement rock and pure limestone		Limestone and clay or shale [2]		Blast-furnace slag and limestone	
	Quantity	Percent	Quantity	Percent	Quantity	Percent
1965	84,360	22.7	266,148	71.7	20,914	5.6
1966	86,095	22.4	277,597	72.2	20,940	5.4
1967	72,231	19.5	281,704	76.3	15,464	4.2
1968	77,556	19.6	304,861	77.2	12,492	3.2
1969	68,699	17.2	318,462	79.7	12,441	3.1

[1] Includes Puerto Rico.
[2] Includes output of plants using marl and clay: 2 plants in 1965, 1966, and 1967; 1 plant in 1968 and 1969. Also includes output of plants using oystershell and clay; 11 plants in 1965, 1966, 1967, and 1969; 12 plants in 1968.

Table 9.—Raw materials used in producing portland cement in the United States [1]

(Thousand short tons)

Raw materials	1967	1968	1969
Cement rock	21,544	23,842	23,315
Limestone (including oystershell)	80,013	83,751	84,202
Marl	716	701	716
Clay and shale [2]	11,574	12,489	12,190
Blast-furnace slag	1,058	1,086	959
Gypsum	3,264	r 3,465	3,569
Sand and sandstone (including silica and quartz)	1,467	1,807	1,979
Iron materials [3]	658	652	783
Miscellaneous [4]	225	r 343	369
Total	120,519	r 128,136	128,082

r Revised.
[1] Includes Puerto Rico.
[2] Includes fuller's earth, diaspore, and kaolin.
[3] Includes iron ore, pyrite cinders and ore, and mill scale.
[4] Includes fluorspar, pumicite, calcium chloride, soda ash, borax, staurolite, fly ash, bauxite, diatomite, air-entraining compounds, and grinding aids.

Table 10.—Finished portland cement produced and fuel consumed by the portland-cement industry in the United States,[1] by processes

Year and process	Finished cement produced			Fuel consumed		
	Plants	Thousand 376-pound barrels	Percent of total	Coal (thousand short tons)	Oil (thousand 42-gallon barrels)	Natural gas (thousand cubic feet)
1968:						
Wet	114	239,572	60.7	5,551	4,987	140,436,474
Dry	69	155,337	39.3	3,957	775	62,484,980
Total	183	394,909	100.0	[2] 9,508	5,762	202,921,454
1969:						
Wet	113	245,344	61.4	5,553	5,093	139,337,469
Dry	68	154,258	38.6	3,630	981	61,957,351
Total	181	399,602	100.0	[3] 9,183	6,074	201,294,820

[1] Includes Puerto Rico.
[2] Comprises 180,631 tons of anthracite and 9,327,170 tons of bituminous coal.
[3] Comprises 212,522 tons of anthracite and 8,970,260 tons of bituminous coal.

Table 11.—Portland cement produced in the United States,[1] by kinds of fuel

Year and fuel	Finished cement produced: Plants	Finished cement produced: Thousand 376-pound barrels	Finished cement produced: Percent of total	Fuel consumed: Coal (thousand short tons)	Fuel consumed: Oil (thousand 42-gallon barrels)	Fuel consumed: Natural gas (thousand cubic feet)
1968:						
Coal	60	[2] 132,741	33.6	6,381	-----	-----------
Oil	7	[2] 16,948	4.3	-----	3,320	-----------
Natural gas	48	[2] 91,956	23.3	-----	-----	107,305,858
Coal and oil	18	41,373	10.5	1,772	1,140	-----------
Coal and natural gas	24	48,013	12.1	1,187	-----	32,585,007
Oil and natural gas	19	48,172	12.2	-----	1,162	47,883,961
Coal, oil, and natural gas	7	15,706	4.0	168	140	15,146,628
Total	183	394,909	100.0	[3] 9,508	5,762	202,921,454
1969:						
Coal	60	[2] 129,950	32.5	6,191	-----	-----------
Oil	8	[2] 18,677	4.7	-----	3,338	-----------
Natural gas	48	[2] 101,714	25.5	-----	-----	111,505,526
Coal and oil	18	42,805	10.7	1,770	1,255	-----------
Coal and natural gas	21	44,309	11.1	986	-----	31,949,593
Oil and natural gas	18	42,894	10.7	-----	1,338	42,504,578
Coal, oil, and natural gas	8	19,253	4.8	236	143	15,335,123
Total	181	399,602	100.0	[4] 9,183	6,074	201,294,820

[1] Includes Puerto Rico.
[2] Average consumption of fuel per barrel of cement produced as follows: 1968—coal, 96.1 pounds; oil, 0.19589 barrels; natural gas, 1,167 cubic feet; 1969—coal, 95.3 pounds; oil, 0.1783 barrels; natural gas, 1,096 cubic feet.
[3] Comprises 180,631 tons of anthracite and 9,327,170 tons of bituminous coal.
[4] Comprises 212,522 tons of anthracite and 8,970,260 tons of bituminous coal.

Table 12.—Electric energy used at portland cement plants in the United States,[1] by processes

Year and process	Electric energy used: Generated at portland cement plants: Active plants	Generated: Million kilowatt-hours	Purchased: Active plants	Purchased: Million kilowatt-hours	Total: Million kilowatt-hours	Total: Percent	Finished cement produced (thousand 376-pound barrels)	Average electric energy used per barrel of cement produced (kilowatt-hours)
1968:								
Wet	11	337	109	5,284	5,621	58.7	239,572	23.4
Dry	15	873	68	3,075	3,948	41.3	155,337	25.4
Total	26	1,210	177	8,359	9,569	100.0	394,909	24.2
Percent of total electric energy used	--	12.6	---	87.4	100.0	----	-------	----
1969:								
Wet	9	265	109	5,508	5,773	59.3	245,344	23.5
Dry	13	782	68	3,180	3,962	40.7	154,258	25.7
Total	22	1,047	177	8,688	9,735	100.0	399,602	24.4
Percent of total electric energy used	--	10.8	---	89.2	100.0	----	-------	----

[1] Includes Puerto Rico.

Table 13.—Shipments of portland cement from mills in the United States,[1] in bulk and in containers, by types of carriers

Year and type of carrier	In bulk		In paper bags [2]		Total shipments	
	Thousand 376-pound barrels	Percent	Thousand 376-pound barrels	Percent	Thousand 376-pound barrels	Percent
1968:						
Truck	252,565	70.4	31,722	82.3	284,287	71.5
Railroad	94,654	26.4	6,538	17.0	101,192	25.5
Boat	11,650	3.2	267	.7	11,917	3.0
Used at the plant	50	-----	2	-----	52	-----
Total	358,919	100.0	38,529	100.0	397,448	100.0
Percent of total	90.3	-----	9.7	-----	100.0	-----
1969:						
Truck	271,886	73.4	33,501	84.9	305,387	74.5
Railroad	85,520	23.1	5,848	14.8	91,368	22.3
Boat	12,932	3.5	97	.3	13,029	3.2
Used at the plant	37	-----	5	-----	42	-----
Total	370,375	100.0	39,451	100.0	409,826	100.0
Percent of total	90.4	-----	9.6	-----	100.0	-----

[1] Includes Puerto Rico.
[2] Cloth bags and other containers included with paper bags to avoid disclosing indiviudal company confidential data.

Table 14.—Cement shipments by types of customers in 1969

(Quantities in thousand 376-pound barrels)

District	Number of plants in district	Building material dealers		Concrete product manufacturers		Ready-mixed concrete		Highway contractors		Other contractors		Federal, State, and other government agencies		Miscellaneous including own use		Total
		Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	
New York, Maine	11	5.3	1,581	12.3	3,613	62.8	18,481	2.6	751	2.2	646	0.1	14	14.7	4,337	29,423
Eastern Pennsylvania	17	9.6	3,163	24.5	8,053	58.1	19,146	5.9	1,954	.6	197	.2	70	1.1	357	32,940
Western Pennsylvania	5	7.4	880	12.1	1,448	65.9	7,880	10.1	1,212	.4	44	2.6	305	1.5	184	11,953
Maryland, West Virginia	4	4.4	534	20.5	2,498	61.1	7,438	8.6	1,044	5.0	606	---	4	.4	48	12,172
Ohio	9	7.2	1,083	16.8	2,548	59.8	9,024	13.1	1,980	1.7	257	---	---	1.4	208	15,100
Michigan	9	8.5	2,596	15.9	4,828	60.4	18,342	12.9	3,915	.8	250	.2	46	1.3	396	30,373
Indiana, Kentucky, Wisconsin	8	5.0	892	13.6	2,435	64.5	11,576	14.4	2,589	1.5	271	.1	23	.9	160	17,946
Illinois	4	8.7	758	9.3	810	73.8	6,431	6.4	557	1.7	151	---	---	.1	13	8,720
Tennessee	6	6.7	618	18.7	1,708	65.2	5,971	3.7	342	2.9	261	1.2	108	1.6	151	9,159
Virginia, North Carolina, South Carolina	5	8.5	1,026	17.4	2,106	61.0	7,364	10.9	1,310	.9	111	1.1	129	.2	25	12,071
Georgia, Florida	6	14.3	2,163	17.9	2,709	50.0	7,557	9.1	1,366	6.8	1,030	.4	54	1.5	229	15,108
Alabama	8	5.8	958	14.7	2,427	62.1	10,265	12.4	2,045	2.9	472	1.1	190	1.0	170	16,527
Louisiana, Mississippi	5	9.7	754	13.7	1,073	48.0	3,745	14.1	1,104	10.6	824	.1	7	3.8	294	7,801
Minnesota, South Dakota, Nebraska	4	8.2	594	8.8	640	55.6	4,049	24.7	1,801	1.7	126	---	1	1.0	73	7,284
Iowa	5	4.3	609	15.5	2,184	68.0	9,580	8.7	1,218	3.2	452	.1	16	.2	25	14,084
Missouri	8	3.3	706	8.9	1,899	70.3	14,999	13.0	2,766	3.3	695	.2	41	1.0	219	21,325
Kansas	6	7.2	707	20.0	1,948	52.8	5,154	8.4	818	6.5	638	.6	60	4.5	439	9,764
Oklahoma, Arkansas	5	9.1	1,171	5.9	767	54.7	7,029	22.2	2,852	6.1	782	.1	8	1.9	250	12,859
Texas	19	5.7	2,061	8.6	3,110	56.5	20,341	8.0	2,896	7.1	2,552	.3	120	13.8	4,957	36,037
Wyoming, Montana, Idaho	4	4.3	221	6.5	333	43.3	2,207	13.9	706	26.0	1,326	---	---	6.0	306	5,099
Colorado, Arizona, Utah, New Mexico	7	7.9	983	10.7	1,322	64.4	7,998	6.8	842	3.9	484	.3	33	6.0	746	12,408
Washington	5	4.6	290	8.8	557	61.4	3,906	8.3	529	6.4	404	8.3	527	2.2	143	6,356
Oregon, Nevada	3	5.2	192	7.0	257	71.6	2,640	6.9	254	9.3	342	---	2	---	2	3,689
Northern California	6	6.3	1,219	8.4	1,618	65.8	12,717	10.4	2,007	7.6	1,462	.2	35	1.3	251	19,309
Southern California	8	8.3	2,588	11.3	3,536	61.0	19,095	7.8	2,445	5.3	1,651	3.7	1,154	2.6	832	31,301
Hawaii	2	3.9	81	15.1	313	77.9	1,617	---	---	2.5	52	.5	11	.1	1	2,075
Puerto Rico	2	56.7	5,066	4.6	415	26.8	2,398	---	---	.7	65	.1	4	11.1	995	8,943
Total	181	8.2	33,494	13.5	55,155	60.3	246,950	9.6	39,303	3.9	16,151	.7	2,962	3.8	15,811	409,826

Table 15.—Prepared masonry cement produced and shipped in the United States, by districts

District	Active plants		Production (thousand 280-pound barrels)		Shipments from mills					
					1968			1969		
	1968	1969	1968	1969	Thousand 280-pound barrels	Value (thousands)	Average per barrel	Thousand 280-pound barrels	Value (thousands)	Average per barrel
New York, Maine	8	8	988	905	930	$2,172	$2.34	939	$2,335	$2.49
Eastern Pennsylvania	11	10	2,217	1,920	2,026	5,363	2.65	1,963	5,232	2.67
Western Pennsylvania	5	5	1,116	1,094	1,125	3,344	2.97	1,122	3,272	2.92
Maryland, West Virginia	5	4	937	947	882	2,314	2.62	930	2,468	2.66
Ohio	6	6	1,019	1,158	1,063	3,155	2.97	1,123	3,527	3.14
Michigan	5	4	2,128	1,903	2,006	5,527	2.76	1,904	5,473	2.87
Indiana, Kentucky, Wisconsin	6	5	3,213	3,015	3,209	8,491	2.65	2,983	8,009	2.68
Illinois	3	3	634	642	602	2,097	3.48	603	2,137	3.54
Tennessee	4	4	1,386	1,366	1,370	3,836	2.80	1,331	3,587	2.69
Virginia, North Carolina, South Carolina	6	5	2,072	2,222	2,087	6,312	3.02	2,182	7,238	3.32
Georgia, Florida	3	4	1,011	1,195	1,006	2,839	2.82	1,192	3,378	2.83
Alabama	9	9	2,348	2,395	2,523	7,309	2.90	2,600	8,520	3.28
Louisiana, Mississippi	5	4	402	297	474	1,238	2.61	380	1,018	2.68
Minnesota, South Dakota, Nebraska	4	4	279	188	250	865	3.46	227	740	3.25
Iowa	4	4	615	569	624	1,986	3.18	606	1,912	3.15
Missouri	5	6	354	416	405	1,312	3.24	427	1,319	3.09
Kansas	7	7	360	432	383	1,177	3.07	348	1,023	2.94
Oklahoma, Arkansas	5	5	548	621	568	1,712	3.01	582	1,789	3.07
Texas	13	12	997	1,137	1,059	3,371	3.18	1,110	3,873	3.49
Wyoming, Montana, Idaho	3	4	47	34	38	121	3.18	39	127	3.25
Colorado, Arizona, Utah, New Mexico	5	5	467	601	480	1,538	3.20	602	1,912	3.18
Washington	4	4	63	42	56	175	3.13	58	204	3.53
Oregon, Nevada	---	---	---	---	1	5	5.00	2	13	[1] 5.30
Total	126	122	23,201	23,099	23,167	66,259	2.86	23,253	69,106	2.97

[1] Computed prior to rounding.

Table 16.—Shipments of prepared masonry cement from mills in the United States, by States

(Thousand 280-pound barrels)

Destination	1968	1969
Alabama	648	597
Alaska [1]	W	W
Arizona	W	W
Arkansas	359	343
Colorado	198	223
Connecticut [1]	144	145
Delaware [1]	57	59
District of Columbia [1]	249	257
Florida	1,438	1,703
Georgia	1,393	1,367
Idaho	11	13
Illinois	795	805
Indiana	845	805
Iowa	195	188
Kansas	185	172
Kentucky	632	634
Louisiana	480	440
Maine	84	80
Maryland	686	687
Massachusetts [1]	312	315
Michigan	1,433	1,380
Minnesota	455	451
Mississippi	393	407
Missouri	235	229
Montana	15	14
Nebraska	79	74
Nevada	W	W
New Hampshire [1]	78	92
New Jersey	623	600
New Mexico	78	73
New York	898	872
North Carolina	1,558	1,544
North Dakota [1]	48	50
Ohio	1,581	1,632
Oklahoma	290	304
Oregon	2	2
Eastern Pennsylvania	460	466
Western Pennsylvania	646	638
Rhode Island [1]	29	28
South Carolina	934	916
South Dakota	50	45
Tennessee	1,189	1,087
Texas	1,000	1,039
Utah	6	5
Vermont [1]	45	43
Virginia	1,296	1,317
Washington	61	60
West Virginia	246	233
Wisconsin	486	469
Wyoming	14	15
Total United States	22,939	22,918
Other countries [2]	228	335
Total shipped from cement plants	23,167	23,253

W Withheld to avoid disclosing individual company confidential data; included with "Other countries."
[1] Noncement producer.
[2] Direct shipments by producers to other countries and to Alaska, Arizona, and Nevada.

Table 17.—Average mill value in bulk, of cement in the United States [1]

(Per barrel)

Year	Portland cement [2]	Natural slag, and hydraulic-lime cements [2]	Prepared masonry cement [3] [4]	All classes of cement [5]
1965	$3.15	$3.68	$2.84	$3.18
1966	3.12	3.74	2.83	3.15
1967	3.14	3.87	2.86	3.17
1968	3.16	3.86	2.86	3.19
1969	3.20	3.84	2.97	3.23

[1] Includes Puerto Rico.
[2] 376-pound barrels.
[3] Includes masonry cements made at portland, natural, and slag cement plants.
[4] 280-pound barrels.
[5] Includes masonry cement converted to 376-pound barrels.

Table 18.—U.S. exports of hydraulic cement by countries

(Thousand 376-pound barrels and thousand dollars)

Destination	1967 Quantity	1967 Value	1968 Quantity	1968 Value	1969 Quantity	1969 Value
Australia	9	$73	9	$56	5	$215
Bahamas	45	233	44	217	32	220
Belgium-Luxembourg	1	20	7	55	5	53
Bolivia	4	34	4	42	2	14
Brazil	1	11	(1)	4	3	43
Canada	349	1,426	222	1,117	200	980
Chile	2	28	3	40	5	79
Dominican Republic	6	25	3	17	1	21
Ecuador	1	9	1	13	3	25
France	5	21	1	10	1	13
French West Indies	210	509	349	660	79	146
Germany, West	1	31	4	80	4	84
Guatemala	(1)	11	(1)	1	1	5
Guyana	(1)	3	2	5	10	20
Indonesia	6	60	16	149	10	91
Iran	5	40	1	5	(1)	1
Italy	3	23	2	16	1	5
Jamaica	5	28	5	28	5	42
Japan	8	155	11	197	11	228
Leeward and Windward Islands	104	273	130	271	130	266
Liberia	5	22	1	4	(1)	(1)
Mexico	37	260	17	197	24	190
Mozambique	---	---	(1)	1	2	11
Netherlands	1	8	2	10	2	12
Netherlands Antilles	29	75	42	87	12	27
Nicaragua	3	17	10	67	4	33
Nigeria	67	463	(1)	4	(1)	4
Norway	4	16	3	12	3	13
Pakistan	1	5	(1)	1	---	---
Panama	3	20	1	16	1	20
Peru	15	103	6	42	1	15
Philippines	8	52	3	29	1	12
Spain	7	49	3	14	3	15
Surinam	(1)	1	(1)	1	1	6
Sweden	1	16	1	22	2	19
Taiwan	2	26	1	20	---	---
Trinidad and Tobago	4	83	(1)	2	(1)	1
United Kingdom	2	8	5	23	2	9
Venezuela	2	13	2	27	5	47
Vietnam, South	2	10	(1)	1	(1)	4
Western Africa, n.e.c	3	28	4	38	(1)	2
Other	19	164	27	283	18	198
Total	980	4,452	942	3,884	589	3,189

1 Less than ½ unit.

Table 19.—U.S. imports for consumption of cement

(Thousand 376-pound barrels and thousand dollars)

Year	Roman, portland, and other hydraulic cement		Hydraulic cement clinker		White nonstaining portland cement		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1967	5,591	$13,058	135	$757	187	$883	5,913	$14,698
1968	r 6,922	r 16,103	152	242	215	1,033	r 7,289	r 17,378
1969	8,612	21,333	608	1,641	467	1,402	9,687	24,376

r Revised.

Table 20.—U.S. imports for consumption of hydraulic cement in 1969, by countries and customs districts [1]

(Thousand 376-pound barrels and thousand dollars)

	Quantity	Value
Country:		
Bahamas	3,943	$9,826
Belgium-Luxembourg	37	165
Canada	2,699	7,256
Colombia	508	990
Denmark	9	49
France	4	25
Germany, West	17	179
Japan	409	1,155
Mexico	4	16
Norway	1,637	3,207
United Kingdom	339	1,318
Venezuela	67	105
Yugoslavia	14	85
Total	9,687	24,376
Customs district:		
Anchorage	251	1,057
Baltimore	15	31
Bridgeport	463	769
Buffalo	1,414	2,973
Chicago	39	340
Detroit	34	83
Galveston	2	12
Customs district—Continued:		
Great Falls	19	$69
Honolulu	384	1,054
Houston	5	29
Laredo	3	15
Los Angeles	13	59
Miami	2,028	4,879
Milwaukee	(2)	(2)
Mobile	(2)	(2)
New Orleans	1	5
New York	1,237	2,601
Norfolk	671	1,697
Ogdensburg	328	1,189
Pembina	144	557
Philadelphia	26	209
Portland, Maine	17	66
Portland, Oreg	6	43
St. Albans	170	649
San Juan	601	1,219
Savannah	6	36
Seattle	345	957
Tampa	1,465	3,778
Total	9,687	24,376

[1] In 1968 Minerals Yearbook, Bahamas quantity should read 2,995—$7,168; Norfolk customs district should read quantity 363—$909. Grand total quantity should read 7,289—$17,378.
[2] Less than ½ unit.

Table 21.—World production of hydraulic cement, by countries

(Thousand 376-pound barrels)

Country [1]	1967	1968	1969 p
North America:			
Bahamas	e r 3,997	e 4,161	4,764
Canada (sold or used by producers)	42,503	43,411	45,421
Costa Rica	651	774	926
Dominican Republic	1,817	1,922	2,291
El Salvador	838	902	832
Guatemala	1,313	1,055	e 1,143
Haiti	234	240	e 234
Honduras	651	756	774
Jamaica	1,963	2,397	2,438
Mexico	32,798	35,898	39,772
Nicaragua	563	598	639
Panama	1,072	967	1,021
Trinidad and Tobago	1,113	e 1,172	1,424
United States (including Puerto Rico)	385,629	412,040	416,652
South America:			
Argentina	20,809	24,676	25,550
Bolivia	363	416	469
Brazil	37,533	42,667	45,603
Chile	7,237	7,331	8,415
Colombia	12,388	13,871	14,111
Ecuador	e 2,285	2,543	2,696
Paraguay	82	141	217
Peru	r 6,376	6,434	6,635
Uruguay	2,438	3,018	2,737
Venezuela	13,173	14,287	12,189
Europe:			
Albania e	r 1,289	1,289	1,289
Austria	26,651	26,681	26,710
Belgium	34,105	33,402	36,736
Bulgaria	19,678	20,604	20,815
Czechoslovakia	37,856	38,049	e 38,383
Denmark	12,892	12,130	14,568
Finland	8,872	8,649	10,308
France	142,984	150,016	161,402
Germany:			
East	42,087	44,249	e 44,536
West	r 185,826	195,917	205,147
Greece	20,217	23,440	28,304
Hungary	15,564	16,414	15,048
Iceland	680	721	545
Ireland	7,606	7,923	7,460
Italy	153,954	173,081	e 185,176

See footnotes at end of table.

Table 21.—World production of hydraulic cement, by countries—Continued

(Thousand 376-pound barrels)

Country [1]	1967	1968	1969 p
Europe—Continued			
Luxembourg	1,072	1,119	1,213
Netherlands	19,625	20,135	19,315
Norway	12,611	13,460	14,533
Poland	65,269	67,976	69,324
Portugal	10,671	10,905	11,931
Rumania	37,141	41,172	44,038
Spain (includes Canary Islands)	r 78,975	88,486	93,830
Sweden	r 22,866	22,924	23,194
Switzerland	24,471	25,321	26,370
U.S.S.R.	r 496,981	512,820	526,228
United Kingdom	r 103,025	104,736	102,081
Yugoslavia	19,414	22,063	23,229
Africa:			
Algeria	r 4,284	5,075	e 5,567
Angola	1,635	1,826	2,244
Congo (Kinshasa)	1,709	1,721	e 1,729
Ethiopia	879	1,020	973
Ghana	NA	1,348	2,391
Ivory Coast	1,500	1,934	2,274
Kenya	2,807	3,194	3,827
Liberia	---	e 586	e 586
Libya [2]	---	---	e 293
Malgasy Republic	352	398	440
Malawi	r 258	328	492
Morocco	5,028	5,837	5,426
Mozambique e	1,453	1,688	1,817
Niger	129	135	147
Nigeria	4,594	3,364	3,264
Senegal	r 1,008	1,102	e 996
South Africa, Republic of	r 23,510	25,843	29,224
Sudan	779	850	1,026
Tanzania	r 861	914	990
Tunisia	2,766	e 2,754	e 2,203
Uganda	815	914	996
United Arab Republic	r 16,138	18,436	21,172
Zambia	1,758	1,641	1,219
Asia:			
Afghanistan [3]	762	e 1,037	e 1,055
Burma	r 762	938	1,172
Cambodia e	352	352	352
Ceylon	r 1,125	1,301	1,658
China, mainland e	46,880	52,740	58,600
Cyprus	1,096	1,412	1,424
Hong Kong	1,260	1,518	1,670
India	68,562	69,968	77,704
Indonesia	e 2,051	2,408	3,164
Iran e 3	8,175	8,204	13,724
Iraq e	8,204	8,204	8,204
Israel	4,717	e 7,032	e 7,618
Japan	251,939	281,333	301,122
Jordan	1,881	2,233	2,994
Korea:			
North e	15,236	15,822	16,408
South	14,298	20,932	28,509
Lebanon	5,954	5,309	7,343
Malaysia e	4,893	5,274	5,274
Mongolia e	293	440	703
Pakistan	11,943	14,281	15,816
Philippines	12,376	15,025	17,287
Qatar	---	---	e 293
Ryukyu Islands	879	r 1,465	r 1,758
Saudi Arabia	1,893	4 2,994	e 3,223
Singapore	2,760	3,323	3,651
Syrian Arab Republic e	3,516	3,575	3,604
Taiwan	20,434	23,399	23,956
Thailand	10,179	13,859	14,082
Turkey	24,899	27,735	33,959
Vietnam:			
North e	r 4,395	2,930	2,930
South	1,061	850	1,447
Oceania:			
Australia	r 22,438	23,018	25,257
Fiji Islands	275	299	322
New Zealand	4,770	4,471	4,706
Total e 5	r 2,812,729	3,009,950	3,168,951

e Estimate. p Preliminary. r Revised. NA Not available.

[1] Cape Verde Islands, Cuba, and Southern Rhodesia produce cement but production data are not available.

[2] Production apparently started in 1969 rather than in 1967 as previously reported.

[3] Year ended March 20 of year following that stated.

[4] For the period Mar. 30, 1968, to Mar. 18, 1969.

[5] Totals are of listed figures only.

Chromium

By John L. Morning [1]

Increased prices for metallurgical-grade chromite and chromium alloys and a strong demand for chromium alloys, owing to increased production of alloy and stainless steels, marked the year. Chromite imports for consumption failed to meet requirements and the industrial inventory of chromite was drawn down. Government stockpile deliveries of chromite accounted for 27 percent of the metallurgical industry's demand.

Table 1.—Salient chromite statistics
(Thousand short tons)

	1965	1966	1967	1968	1969
United States:					
Exports	7	19	8	13	49
Reexports	95	173	157	126	150
Imports for consumption	1,518	1,864	1,240	1,084	1,106
Consumption	1,584	1,461	1,355	1,316	1,411
Stocks Dec. 31: Consumer	1,111	1,306	1,197	912	675
World: Production	5,301	4,843	5,041	5,336	5,635

Legislation and Government Programs.—On May 13, 1969, the Office of Emergency Preparedness (OEP) revised chromium conventional war stockpile objectives and subobjectives. The accompanying table indicates the new objectives and status of chromium Government stockpiles at yearend. The new lower objective for refractory-grade chromite allowed the transfer of 200,000 tons of chemical-grade chromite, back to the chemical-grade stockpile account. The material had been assigned to fill the former refractory-grade objective.

General Services Administration's (GSA) stockpile sales of metallurgical-grade chromite, under Public Law 89–415 May 11, 1966, total 865,192 tons, of which 29,389 tons were delivered in 1966, 71,177 tons in 1967, 134,574 tons in 1968, and 242,430 tons in 1969, leaving a balance for future delivery of 387,622 tons. Repeated GSA stockpile offerings for chemical-grade chromite, under Public Law 89–247 October 9, 1965, failed to generate interest in the earlier years, but in December 5,600 tons were sold for metallurgical use.

[1] Physical scientist, Division of Ferrous Metals.

Table 2.—U.S. defense materials inventories and objectives
(Thousand short tons)

Type of material	Objective	Inventory by program, Dec. 31, 1969			
		National stockpile	Defense Production Administration	Supplemental stockpile	Total
Chromite, chemical: Stockpile grade	260	560	---	684	1,244
Chromite, refractory:					
Stockpile grade	400	1,047	---	180	1,227
Nonstockpile grade	-----	(1)	---	---	(1)
Chromite, metallurgical:					
Stockpile grade	3,117	[2] 2,644	---	323	2,967
Nonstockpile grade	-----		901	---	901
Ferrochromium high-carbon:					
Stockpile grade	127	126	---	276	402
Nonstockpile grade	-----	1	---	---	1
Ferrochromium, low-carbon:					
Stockpile grade	54	107	---	191	298
Nonstockpile grade	-----	20	---	---	20
Ferrochromium-silicon:					
Stockpile grade	39	25	---	31	56
Nonstockpile grade	-----	(1)	---	2	3
Chromium metal, electrolytic: Stockpile grade	6	1	---	3	4
Chromium metal, aluminothermic: Stockpile grade	-----	-----	---	4	4

[1] Less than ½ unit.
[2] Includes 591,126 short dry tons nonstockpile-grade material.

DOMESTIC PRODUCTION

Domestic mine production of chromite ceased in 1961 when the last Government Defense Production Act contract was concluded. However, the United States in 1969 continued to be the free world's leading chromite consumer in producing chromium alloys, refractories, and chemicals. The principal producers of these products were as follows:

Company	Plant
Metallurgical industry:	
Airco Alloys and Carbide Division, Air Reduction Co. Inc	Calvert City, Ky.
	Niagara Falls, N.Y.
	Charleston, S.C.
Chromium Mining and Smelting Corp	Woodstock, Tenn.
Foote Mineral Co	Vancoram, Ohio
	Graham, W. Va.
Interlake Steel Corp	Beverly, Ohio
Ohio Ferro-Alloys Corp	Brilliant, Ohio
	Takoma, Wash.
Shieldalloy Corp	Newfield, N.J.
Union Carbide Corp	Niagara Falls, N.Y.
	Marietta, Ohio
	Alloy, W. Va.
Refractory industry:	
A. P. Green Refractory Co	Mexico, Mo.
The Babcock & Wilcox Co	Augusta, Ga.
Basic, Inc	Maple Grove, Ohio
Corhart Refractories Co. Inc	Buckhannon, W. Va.
	Louisville, Ky.
E. J. Lavino & Co. (Division of IMC)	Newark Calif.
	Plymouth Meeting, Pa.
General Refractories Co	Baltimore, Md.
	Lehi, Utah
H. K. Porter Co., Inc	Pascagoula, Miss.
Harbison-Walker Refractories Co. (Div. of Dresser Industries, Inc.)	Hammond, Ind.
	Baltimore, Md.
Kaiser Aluminum & Chemical Corp	Moss Landing, Calif.
	Columbiana, Ohio
North American Refractories Co	Womelsdorf, Pa.
Ohio Fire Brick Co	Jackson, Ohio
Chemical industry:	
Allied Chemical Corp	Baltimore, Md.
Diamond Shamrock Corp	Kearny, N.J.
	Painsville, Ohio
Imperial Color & Chemical Department, Hercules, Inc	Glenns Falls, N.Y.
PPG Industries, Inc	Corpus Christi, Tex.

CONSUMPTION AND USES

Domestic consumption of 1,411,000 tons of chromite ore and concentrate containing about 439,000 tons of chromium was 7 percent higher than in 1968. Most of the increase occurred in the metallurgical industry and was due to the strong demand for chromium alloys in the steel industry. Of the total chromite consumed, the metallurgical industry used 64 percent, the refractory industry 21 percent, and the chemical industry 15 percent.

The metallurgical industry consumed 898,000 tons of chromite containing 302,000 tons of chromium in producing 433,000 tons of chromium ferroalloys and chromium metal. Of the 898,000 tons consumed, 780,000 tons averaging 50.6 percent chromic oxide (Cr_2O_3) was classified by consumers as metallurgical-grade ore; 69,000 tons averaging 44.0 percent (Cr_2O_3) was classified as chemical-grade ore, and 49,000 tons averaging 33.0 percent (Cr_2O_3) was classified as refractory-grade ore. More than 90 percent of the metallurgical-grade ore had a chromium-to-iron ratio of 3:1 and over; 9.4 percent had a ratio between 2:1 and 3:1, and less than 1.0 percent had a ratio of less than 2:1.

Producers of chromite-bearing refractories consumed 302,000 tons of ore containing 70,000 tons of chromium. The chemical industry consumed 211,000 tons of chromite containing 65,000 tons of chromium in producing 149,000 tons of chemicals (sodium bichromate equivalent).

Air Reduction Co., Inc., announced that

negotiations were held with Puerto Rican authorities for the construction of a ferroalloy plant to produce chromium, manganese, or silicon alloys. A two-furnace plant with a minimum capacity of 40,000 kilowatts was planned.

Union Carbide Corp. placed in operation a 30,000-kilowatt furnace for production of charge chromium at its Marietta, Ohio, facility. The new furnace was reported to have 2½ times the production capacity of the unit replaced. Air pollution abatement equipment was an important part of the installation.

Diamond Shamrock Corp. announced plans to construct a chromium chemical plant at Wilmington, N.C., to produce a full line of chromium products. Construction was scheduled to begin early in 1970 with completion early in 1971. The new plant will have greater capacity than the two older and less efficient plants it is replacing.

Table 3.—Consumption of chromite and tenor of ore used by primary consumer groups in the United States

(Thousand short tons)

Year	Metallurgical industry		Refractory industry		Chemical industry		Total	
	Gross weight	Average Cr_2O_3 (percent)	Gross weight	Average Cr_2O_3 (percent)	Gross weight	Average Cr_2O_3 (percent)	Gross weight	Average Cr_2O_3 (percent)
1965	907	49.8	460	34.7	217	45.0	1,584	44.8
1966	828	49.6	439	34.6	194	44.9	1,461	44.5
1967	866	49.7	310	34.0	179	45.2	1,355	45.5
1968	804	49.7	311	34.1	202	45.1	1,316	45.4
1969	898	49.1	302	35.0	211	45.1	1,411	45.5

Table 4.—Production, shipments, and stocks of chromium ferroalloys and chromium metal in 1969

(Short tons)

Alloy	Production		Shipments	Producer stocks Dec. 31
	Gross weight	Chromium content		
Low-carbon ferrochromium	95,297	67,744	103,291	5,115
High-carbon ferrochromium	205,951	139,021	210,357	25,575
Ferrochromium silicon	114,329	50,815	112,104	12,600
Other [1]	17,895	13,787	18,987	1,393
Total	433,472	271,367	444,739	44,683

[1] Includes chromium briquets, chromium metal, exothermic chromium additives, and other miscellaneous chromium alloys.

Table 5.—Consumption, by end uses, and stocks of chromium ferroalloys and metal in the United States in 1969

(Short tons)

	Ferrochromium				Ferrochromium silicon		Other chromium alloys [1]		Total	
	Low carbon		High carbon							
	Gross weight	Contained weight	Gross weight	Contained weight	Gross weight	Contained weight	Gross weight	Contained weight	Gross weight	Contained weight
Steel:										
Carbon	1,833	1,265	7,616	4,497	W	W	913	453	10,362	6,215
Stainless and heat resisting	123,240	84,805	72,185	48,317	66,759	26,793	1,255	627	263,439	160,542
Alloy (excludes stainless and heat resisting)	16,268	11,208	44,034	29,648	6,941	3,040	2,673	1,121	69,916	45,017
Tool	784	564	2,879	1,939	1,113	465	29	29	4,805	2,997
Cast irons	1,299	823	6,950	4,496	105	44	454	180	8,808	5,543
Superalloys	10,145	7,118	926	617	724	306	2,116	2,057	13,911	10,093
Alloys (exclude alloy steels and superalloys):										
Cutting and wear resistant materials	55	37	629	417	-------	-------	130	120	814	574
Welding and alloy hard-facing rods and materials	552	368	778	511	-------	-------	318	309	1,648	1,188
Nonferrous alloys	406	278	W	W	-------	-------	1,374	706	1,780	984
Other alloys [2]	1,160	797	104	67	15	7	141	139	1,420	1,010
Miscellaneous and unspecified	3,525	2,393	5,146	3,007	1,442	641	169	147	10,282	6,188
Total	159,267	109,656	141,247	93,516	77,099	31,296	9,572	5,888	387,185	240,356
Consumer stocks Dec. 31, 1969	17,839	NA	13,285	NA	5,119	NA	3,444	NA	39,687	NA

NA Not available. W Withheld to avoid disclosing individual company confidential data, included in "Miscellaneous and unspecified."

[1] Includes chromium metal.

[2] Includes magnetic alloys.

STOCKS

Chromite stocks in the three consuming industries once again decreased, thereby continuing the trend of the past 3 years. Although the refractory and chemical industries inventory dropped 24 percent and 31 percent, respectively, compared with 1968, stocks appear more than adequate. The metallurgical industry chromite inventory at yearend dropped to a 3-month supply based on 1969 consumption and reflects the continuation of economic sanctions against Southern Rhodesia. Producers' stocks of chromium alloys decreased more than 11,000 tons compared with 1968, but was offset by almost a similar quantity in inventory buildup in hands of consume. Stocks of chromium chemicals (sodium bichromate equivalent) at producers' plants increased from 8,150 tons in 1968 to 8,279 tons in 1969.

Table 6.—Consumers' stocks of chromite, Dec. 31

(Thousand short tons)

Industry	1965	1966	1967	1968	1969
Metallurgical	443	463	459	r 396	297
Refractory	526	578	486	r 309	235
Chemical	142	265	252	207	143
Total	1,111	1,306	1,197	r 912	675

r Revised.

PRICES

The price of metallurgical-grade chromite rose for the third successive year as United Nations economic sanctions against Southern Rhodesia remained in effect. Rhodesia was one of the principal suppliers of domestic requirements prior to 1967. Russian and Turkish chromite moved upward for 1970 delivery about $10 per long ton.

Along with increased chromite prices, chromium alloy prices were increased quarterly during the year. Prices were also increased for delivery in the first quarter of 1970. Selected chromium alloy prices published by Metals Week were as follows:

	Jan. 1, 1969	Dec. 31, 1969
	Cents per pound chromium	
High-carbon ferrochromium	20.1	21.7
Low-carbon ferrochromium (0.025 percent carbon)	26.1	28.6
Charge chromium	16.4	18.0
Blocking chromium (10–14 percent silicon)	19.0	20.6
	Cents per pound product	
Ferrochromium silicon (40–43 grade)	12.5	14.35
Electrolytic chromium metal	96.0	101.0
Aluminothermic chromium metal	99.0	99.0

Table 7.—Price quotations for various grades of foreign chromite in 1969

Source	Cr_2O_3 (percent)	Chromium-iron ratio	Price per long ton, Jan. 1 [1]	Price per long ton, Dec. 31 [1]
South Africa, Republic of (Transvaal)	44	------	$19.00–$21.50	$19.00–$21.50
Turkey	48	3:1	37.50– 38.50	47.50– 58.50
U.S.S.R.	48	4:1	40.00– 42.00	50.00– 52.00
U.S.S.R.	54–56	4:1	45.20– 49.20	55.20– 59.20

[1] Dry basis, subject to penalties if guarantees are not met, f.o.b. cars Atlantic ports.

Source: Metals Week.

FOREIGN TRADE

Exports of chromite ore and concentrate jumped nearly fourfold compared with 1968. Since there has been no domestic production of chromite since 1961, this material must be imported chromite that has been ground, blended, or otherwise processed for value added. Mexico, Canada, and Sweden received the majority of shipments. Reexports of chromite returned to the level of 1967 and were all to Canada and Mexico.

Ferrochromium exports to 15 countries totaled 24,573 tons valued at nearly $5.7 million. West Germany, the United Kingdom, and Canada were the leading recipients accounting for 83 percent of the total.

Chromium and chromium alloys (wrought or unwrought) and waste and scrap exports totaled 150 tons valued at $245,000. The majority of the shipments were to Canada, Italy, and France.

Exports of nonpigment-grade chromium chemicals totaled 590 tons valued at $499,000. Canada, Mexico, and Denmark received most of the shipments. Exports of pigment-grade chromium chemicals totaled 148 tons valued at $189,000. Of the 19 countries receiving shipments, Canada accounted for 72 percent of the total.

Table 8.—U.S. exports and reexports of chromite ore and concentrates

(Thousand short tons and thousand dollars)

Year	Exports		Reexports	
	Quantity	Value	Quantity	Value
1967	8	$328	157	$5,422
1968	13	517	126	5,351
1969	49	1,915	150	5,806

Exports of sodium chromate and bichromate totaled 5,116 tons valued at nearly $1.3 million. Other than Canada (77 percent), most of the remaining shipments were to Latin American countries.

Imports of chromite ore were about the same as in 1968, but were less than domestic consumption as stocks in the three consuming industries decreased. Metallurgical-grade over (46 percent Cr_2O_3) comprised 48 percent of total imports; chemical-grade ore (40–46 percent Cr_2O_3) 27 percent, and refractory-grade ore (under 40 percent Cr_2O_3) 25 percent.

Imports of unwrought chromium, other than alloys, and waste and scrap totaled 1,533 tons valued at $2.1 million. Japan and the United Kingdom were the principal suppliers. Chromium carbide received from the United Kingdom and West Germany totaled 79 tons valued at $185,000.

Imports of chromium-containing pigments were as follows: Chrome green, 79 tons; chrome yellow, 3,560 tons; chromium oxide green, 747 tons; hydrated oxide green, 220 tons; molybdenum orange, 64 tons; strontium chromate, 22 tons; and zinc yellow, 1,266 tons. Total value of these products was $2.6 million. Japan was the leading supplier, accounting for 65 percent of total value.

Imports of sodium bichromate and chromate totaled 6,469 tons, valued at $1.1 million. The U.S.S.R., Italy, Japan, and the Republic of South Africa were the leading suppliers. Potassium chromate and dichromate imports totaled 105 tons valued at $13,000.

Table 9.—U.S. imports for consumption of ferrochromium, by countries

Year and country	Low-carbon ferrochromium (less than 3 percent carbon)			High-carbon ferrochromium (3 percent or more carbon)		
	Short tons		Value (thousands)	Short tons		Value (thousands)
	Gross weight	Chromium content		Gross weight	Chromium content	
1968:						
Canada	3	1	$1	------	------	------
France	2,345	1,714	634	53	36	$11
Germany, West	6,444	r 4,850	1,827	2,362	1,601	387
Italy	------	------	------	1,102	716	175
Japan	477	314	127	1,773	1,196	297
Norway	6,085	4,489	1,611	66	46	15
South Africa, Republic of	25,250	16,430	5,903	1,745	954	198
Sweden	6,545	4,846	1,802	1,158	680	156
Turkey	3,314	2,351	796	------	------	------
Yugoslavia	1,094	778	257	------	------	------
Total	51,557	r 35,773	12,958	8,259	5,229	1,239
1969:						
Australia	------	------	------	587	417	80
France	475	348	134	------	------	------
Finland	------	------	------	2,254	1,303	239
Germany, West	9,009	7,054	1,474	1,924	1,285	336
Italy	------	------	------	1,102	716	179
Japan	661	445	164	2,498	1,674	391
Mozambique	560	380	135	------	------	------
Norway	3,044	2,118	788	884	630	169
South Africa, Republic of	19,794	12,192	4,973	7,312	4,716	924
Sweden	3,800	2,865	1,098	------	------	------
Turkey	4,947	3,456	1,213	------	------	------
United Kingdom	(1)	(1)	1	------	------	------
Western Africa, n.e.c.	2,257	1,514	530	------	------	------
Western Portuguese Africa, n.e.c.	539	366	130	------	------	------
Total	45,086	30,738	10,640	16,561	10,741	2,318

r Revised.

1 Less than ½ unit.

Table 10.—U.S. imports for consumption of chromite, by grades and countries

(Thousand short tons and thousand dollars)

Country	Not more than 40 percent Cr_2O_3			More than 40 percent but less than 46 percent Cr_2O_3			46 percent or more Cr_2O_3			Total		
	Gross weight	Cr_2O_3 content	Value	Gross weight	Cr_2O_3 content	Value	Gross weight	Cr_2O_3 content	Value	Gross weight	Cr_2O_3 content	Value
1968:												
Albania	------	------	------	6	r 3	$120	------	------	------	6	r 3	$120
Philippines	167	55	$3,088	------	------	------	------	------	------	167	55	3,088
Rhodesia, Southern	------	------	------	1	(1)	11	------	------	------	1	(1)	11
South Africa, Republic of	25	9	334	r 292	r 128	r 3,162	r 107	r 53	r $1,207	424	r 190	r 4,703
Turkey	30	12	405	62	27	1,135	59	29	1,430	151	68	2,970
U.S.S.R.	------	------	------	------	------	------	335	183	7,297	335	183	7,297
Total	222	76	3,827	r 361	r 158	r 4,428	r 501	r 265	r 9,934	1,084	499	r 18,189
1969:												
Albania	------	------	------	12	5	257	------	------	------	12	5	257
Iran	------	------	------	------	------	------	13	6	253	13	6	253
Philippines	192	64	3,388	------	------	------	------	------	------	192	64	3,388
South Africa, Republic of	30	12	303	227	100	2,624	143	70	1,638	400	182	4,565
Turkey	33	13	471	64	29	1,360	74	35	1,929	171	77	3,760
U.S.S.R.	19	7	331	------	------	------	299	165	7,476	318	172	7,807
Total	274	96	4,493	303	134	4,241	529	276	11,296	1,106	506	20,030

r Revised.
[1] Less than ½ unit.

Table 11.—U.S. import duties

Tariff classification	Articles	Rate of duty, Jan. 1, 1970 [1]
	CHROMIUM ORES AND METAL PRODUCTS	
601.15	Chromium ore	Free.
607.30	Ferrochromium, less than 3 percent carbon	5.5 percent ad valorem.
607.31	Ferrochromium, over 3 percent carbon	0.625 cent per pound on chromium content.
632.18	Unwrought chromium other than alloys; waste and scrap [2]	7 percent ad valorem.
	CHROMIUM CHEMICALS AND RELATED PRODUCTS	
420.08	Potassium chromate and dichromate	1.5 cents per pound.
420.98	Sodium chromate and dichromate	1.2 cents per pound.
422.92	Chromium carbide	8.5 percent ad valorem.
	CHROMIUM PIGMENTS	
473.10	Chrome green	7 percent ad valorem.
473.12	Chrome yellow	Do.
473.14	Chromium oxide green	Do.
473.16	Hydrated chromium oxide green	Do.
473.18	Molybdenum orange	Do.
473.19	Strontium chromate	Do.
473.20	Zinc yellow	Do.

[1] Not applicable to Communist countries.
[2] Duty temporarily suspended on waste and scrap.

WORLD REVIEW

Afghanistan.—Two deposits of chromite in Afghanistan could be of economic importance. The Hesarak deposit of Nangarhar Province, about 70 miles southeast of Kabul, has been known for several years, but development has not been attempted. Preliminary reports describe the occurrence as containing good quality chromite in a series of widespread pockets suitable to low cost open pit mining methods. The Mohammad Agah-Kulangar deposit in Logar Valley, Kabul Province, was investigated by the Bureau of Mines in 1949. The deposit occurs in an area of altered ultramafic rock in an area approximately 28 miles long by 12 miles wide.

Table 12.—World production of chromite by countries

(Short tons)

Country [1]	1967	1968	1969 p
South America: Brazil	r 16,562	18,774	18,000
Europe:			
Albania	r 360,342	e 360,000	360,000
Finland	7,037	39,899	78,623
Greece	13,200	e 14,000	33,000
U.S.S.R. e [2]	1,731,000	1,820,000	1,874,000
Yugoslavia	51,987	49,891	43,468
Africa:			
Malagasy Republic	---------	---------	49,355
Rhodesia, Southern e	350,000	420,000	400,000
South Africa, Republic of	1,266,615	1,270,667	1,320,203
Sudan	r 27,600	24,300	24,000
Asia:			
Cyprus	24,037	27,672	25,951
India	120,740	226,698	237,000
Iran e	r 120,000	99,000	100,000
Japan	r 49,859	30,745	32,829
Pakistan	29,071	28,683	29,000
Philippines	462,694	446,282	517,709
Turkey	409,108	459,000	492,000
Oceania:			
Australia	154	---------	---------
New Caledonia	r 1,365	---------	---------
World total [3]	r 5,041,371	5,335,611	5,635,138

e Estimate. p Preliminary. r Revised.
[1] Chromite is also produced in Bulgaria, Colombia, Cuba, Rumania, North Korea, and North Vietnam but no data are available.
[2] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.
[3] Total is of listed figures only.

Finland.—In its first full year of operation, Outokumpu Oy mined 233,574 tons of crude ore, beneficiated 203,458 tons, and produced 78,623 tons of chromite concentrate. The associated ferroalloy plant produced 28,515 tons of charge chromium. Metall und Rohstoff AG (Lissauer group) signed a contract with Outokumpu Oy early in the year to market Outokumpu's chromium alloy output worldwide.

Greece.—Aspioti-Elka Chrome Mines Ltd. reopened its mine at Skoumtsa, in the Kozani district, which has been closed since 1966. Production of metallurgical grade chromite was expected to reach an annual rate of 15,000 tons during the year.

India.—Production of ferrochromium during 1968 totaled about 1,650 tons with Mysore Iron and Steel Works accounting for 1,500 tons. The balance was produced by R. Sen & Company, Electric Control Gear (P) Ltd., and Mehra Ferroalloys. The Indian chromium chemical industry with an installed capacity of about 8,000 tons of bichromate capacity consumed about 12,000 tons of chromite; the refractory industry utilized about 38,000 tons.

The Orissa State Industrial Development Corp. of India planned to initiate operation of a 10,000-ton-per-year furnace to produce ferrochromium during the last quarter of the year.

Japan.—The Japanese ferroalloy industry continued to expand to keep pace with the growth in its steel industry. It was estimated that 825,000 tons of chromite would be required for Japan's 1970 financial year. With the growth of the ferroalloy industry during the past 15 years, many small furnaces have been retired in favor of larger furnace installations of 20,000–30,000 kilo-volt-amperes. In addition, some producers have become integrated with the steel industry. Nisshin Steel, Japan's largest stainless steel producer, planned to receive molten ferrochromium from its neighbor Showa Denko Co., Ltd.

Malagasy Republic.—Compagnie Minière d'Andriamena (COMINA) placed in operation a new facility to produce 120,000 tons of chromite annually. Mining plans call for the removal of 552,000 tons of overburden per year to recover 192,000 tons of crude ore averaging 41 percent Cr_2O_3. After beneficiation, 120,000 tons of 51 percent Cr_2O_3 concentrate will be available for export to France. About 20 percent will be available for reexport to third countries.

Philippines.—Of the total chromite produced in the Philippines, refractory-grade chromite accounted for 76 percent and metallurgical-grade, 24 percent. Exports of refractory-grade chromite totaled 419,284 tons, of which the United States received 46 percent; United Kingdom, 22 percent; Japan, 12 percent; Canada, 7 percent, and eight other countries, 13 percent. Japan received all of the 133,245 tons of metallurgical-grade chromite exported.

South Africa.—Production of chromite in South Africa totaled 1,320,203 tons, 24 percent of which was less than 44 percent Cr_2O_3; 67 percent, 44 to 48 percent Cr_2O_3; and 9 percent, over 48 percent Cr_2O_3. Local sales accounted for 285,305 tons, and the balance was available for export.

The Swartkop Mine of Chrome Mines of South Africa Ltd. (CHROMSA), jointly owned by Union Corporation Ltd. and African Mining Trust, has an annual capacity of 280,000 tons of chromite. Five seams can be mined, and mine operations are flexible enough to allow switching men and equipment from area to area without loss of efficiency. Mining from the various seams together with two concentrating plants allows the production of a wide range of ores and concentrate ranging from plus 50 percent Cr_2O_3 to 41 percent Cr_2O_3, with chromium-to-iron ratios ranging from 2.25:1 down to 1.5:1.

Anglovaals' Associated Manganese Mines of South Africa Ltd. and United States Steel Corp. planned construction of a ferrochromium plant at Fairview, in the Sekukuniland border area in Eastern Transvaal. The plant, scheduled to begin operation in 1971, will produce chromium-bearing ingots and chromium alloys from ore mined in Sekukuniland and at Zeerust.

Albright & Wilson Ltd. (British) acquired a 50-percent interest in Chrome Chemicals (South Africa) Pvt. Ltd. from Farbenfabriken Bayer A. G. Both A&W and Bayer are producers of chromium chemicals. Chrome Chemicals plans to modernize and expand its plant, which now has a capacity of 10,000 tons of sodium dichromate equivalent per year.

Turkey.—The Turkish chromite industry, which at one time consisted of 30 active companies producing from 100 mines, has been reduced to three large and several small private producers and Etibank. High-grade reserves have been decreasing, and about 50 percent of exports are in the form of concentrate. Increasing costs, particularly for labor and transportation, have contributed to the closure of small mines located in the interior of the country.

Yugoslavia.—A new beneficiating plant with an annual capacity of 120,000 tons was constructed for the Radusa chromite mine. An American firm supplied the equipment for the fully automated plant.

TECHNOLOGY

Air Reduction Co. introduced a new refining process for the production of various types of steel, including a new series of straight chromium stainless steels comparable to nickel-chromium stainless, but with reportedly greater corrosion resistance. The new process is an extension of electron beam principles and allows more molten metal to be exposed to a hard vacuum environment, thereby allowing a higher percentage of volatile impurities to be evaporated. The process involves charging melt stock into an induction furnace housed in a primary refining chamber that operates at 10 microns to 1 atmosphere pressure. The molten metal is then transferred under vacuum by a launder into an induction-heated ladle housed in a secondary refining chamber that operates at 5 to 10 microns pressure. Finally, the molten metal flows down an electron-beam heated cascade hearth system into a casting station. This final refining chamber operates at 1 to 10 microns pressure. The electron beam heating along the cascade hearth creates localized areas of super heat, which results in a vigorous stirring action, thereby allowing more impurities to escape.[2]

Allegheny Ludlum Steel Corp. plans to install a new vacuum melting process for stainless steel, which reportedly would produce steels of superior quality. In addition, higher yields with savings of critical alloying materials and lower investment and operation costs were expected. In the new process, primary melting will be accomplished in existing electric furnaces and refining and adjustment of final composition will take place at reduced pressures in a special ladle fitted with induction-stirring coils, vacuum covers, and electrode heating capability. Results of the first 89 production heats were presented. These heats utilized the new duplex process whereby an electric furnace is used to produce a crude high-carbon, high-chromium hot metal for conversion to stainless steel, and a reactor vessel uses mixtures of argon and oxygen for refining.[3]

After 5 years of research, Fuji Steel (Japan) initiated production of stainless steel by conversion of blast furnace, hot metal in a basic oxygen furnace.

Recent developments in chromium and chromium alloys and areas for future work were discussed.[4]

Recently published data pertaining to stainless steel in the following general areas were reviewed:[5] Material selection, corrosion resistance, new alloys, new manufacturing techniques, and welding.

The American Iron and Steel Institute assigned numbers to six stainless steel compositions raising to 44 the number of stainless types recognized as being standard. Four of the new grades are nickel-free. The newly added compositions, types 384, 385, 420F, 429, 434, and 436, were developed to provide improved performance in areas of chemical processing, automobile trim, food processing, and manufacture of fasteners.

Caterpillar Tractor Co. installed at its Joiliet, Ill. facilities an automated chromium plating system that nearly doubled capacity as compared with manual operation. An additional benefit of automation was that chromium thickness and parts preparation are now uniform because each part is immersed for the proper amount of time and human error is minimized.[6]

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[2] American Metal Market. V. 76, No. 118, June 24, 1969, pp. 1, 11, 24.

[3] Soccomano, J. M., R. J. Choulet, and J. D. Ellis. Making Stainless Steel in the Argon-Oxygen Reactor at Joslyn. J. Metals, v. 21, No. 2, February 1969, pp. 59–64.

[4] Klopp, W. D. Recent Developments in Chromium and Chromium Alloys. J. Metals, v. 21, No. 11, November 1969, pp. 23–32.

[5] Fischer, Hugh B. Stainless Steels and Other Ferrous Alloys. Ind. & Eng. Chem., v. 61, No. 8, August 1969, pp. 42–47.

[6] Iron Age. V. 203, No. 2, Mar. 20, 1969, pp. 76–77.

Clays

By J. Robert Wells [1]

Overall the amounts of domestic clays sold or used by producers in 1969 were up nearly 3 percent in quantity and 7 percent in total value from 1968, and established new annual records for both tons and dollars. Increases in tonnage and total value were reported for each of the individual types of clay except for fire clay, which decreased in both respects. The fire clay figures—the lowest total value in any year since 1962 and the smallest total tonnage since World War II—were visible evidence of the continuing shift from the traditional types of refractories to the newer and more specialized materials.

Georgia, with a total output of 5.7 million tons of several types of clays, continued to hold first place as a producer, and, with $98 million in total value, far surpassed the State that ranked second in that respect. The States in order after Georgia that led in tonnage were Ohio, Texas, North Carolina, and Alabama; in value, Pennsylvania, Wyoming, Florida, and Ohio. Production of clays of one or more types was reported in 48 States; Alaska and Rhode Island were the two exceptions.

The Tax Reform Act signed by the President on December 30, 1969, authorized a 1-percentage point reduction in the depletion allowances applicable to certain types of clays. The reduction is from 15 percent to 14 percent for kaolin, ball clay, bentonite, fuller's earth, and fire clay; and from 23 to 22 percent for clays used for extraction of alumina or aluminum compounds. Allowances applicable to clay and shale used for making brick, tile, and lightweight aggregate were not changed.

[1] Physical scientist.

Table 1.—Salient clay and clay products statistics in the United States

(Thousand short tons and thousand dollars)

	1965	1966	1967	1968	1969
Domestic clays sold or used by producers	55,126	56,713	54,664	57,348	58,694
Value	$204,932	$221,714	$223,987	$246,938	$264,415
Exports	850	1,074	1,149	1,519	1,574
Value	$25,595	$31,135	$32,432	$44,134	$45,767
Imports for consumption	110	139	108	97	82
Value	$2,137	$2,883	$2,235	$1,951	$1,750
Clay refractories, shipments (value)	$228,876	$243,516	$225,116	$229,660	$257,346
Clay construction products, shipments (value)	$578,190	$554,667	$538,110	$590,776	$608,982

DOMESTIC PRODUCTION, PRICES, AND FOREIGN TRADE, BY TYPE OF CLAY

KAOLIN

The quanity of domestic kaolin sold or used by producers in 1969 represented the most notable increase in recent years, 13 percent more in tonnage and 11 percent more in total value than in in 1968. Of the 11 States that produced kaolin in 1969, Alabama, Arkansas, Georgia, South Carolina, and Texas reported larger outputs than in 1968, substantially outweighing decreases in California, Florida, Idaho, North Carolina, Pennsylvania, and Utah.

Arizona, where small tonnages of kaolin were reported in 1967 and 1968, had no production in 1969. Vermont, formerly a minor but consistent producer, has not appeared in the list of kaolin producing States since 1967.

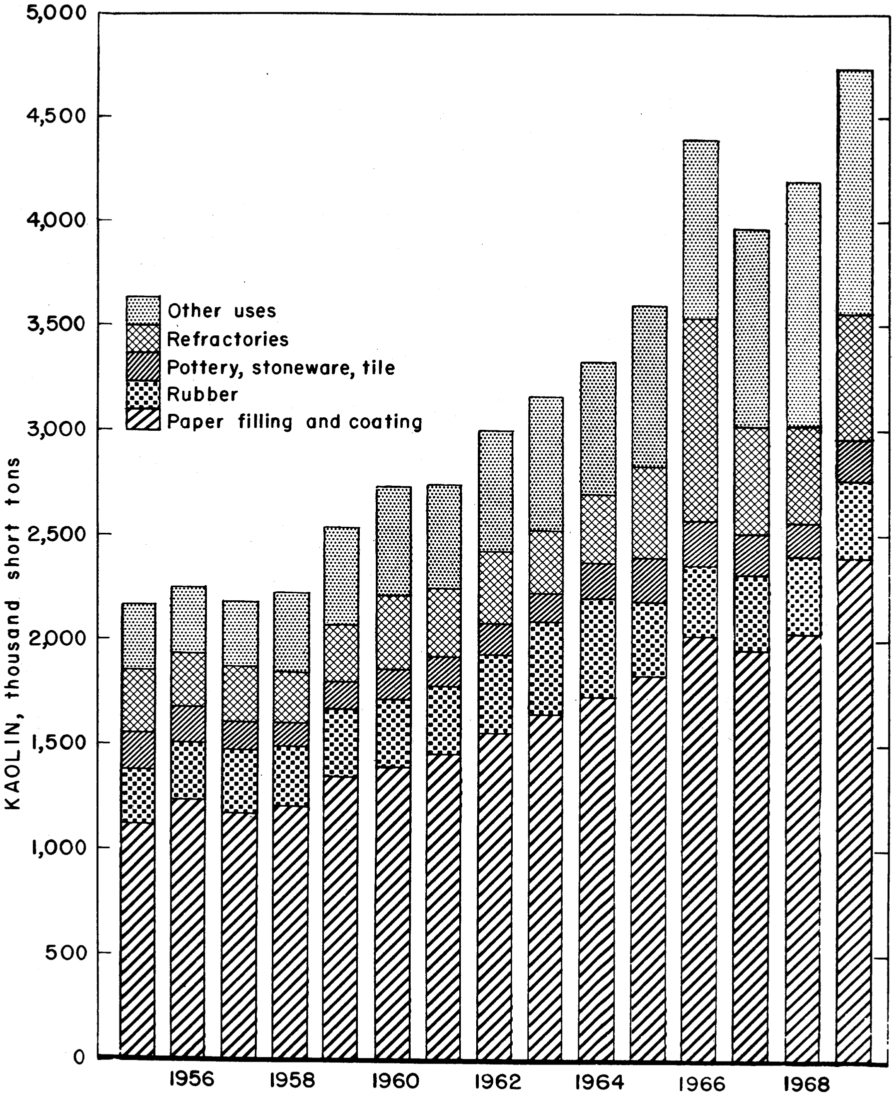

Figure 1.—Kaolin sold or used by domestic producers for specified uses.

Oil, Paint and Drug Reporter, December 29, 1969, quoted kaolin prices, $2 to $5.50 per ton higher than those previously reported, as follows:

Water washed, fully calcined, bulk, carload lots, f.o.b. Georgia, per ton	$60.00
Partially calcined, same basis, per ton	50.00
Paper-grade, uncalcined, same basis, per ton:	
No. 1 coating	$38.00-38.50
No. 2 coating	30.00-30.50
No. 3 coating	29.00-29.50
Filler, general purpose, same basis, per ton	17.50-18.00
Delaminated, water washed, uncalcined, paint-grade, 1-micron average, same basis, per ton	62.00
Dry-ground, airfloated, soft, same basis, per ton	12.50
National Formulary, powder, 50-pound bags, 5,000-pound lots, works, per pound	0.06-.75
National Formulary, colloidal, 150-pound drums, works, per pound	0.16-.50

Kaolin imports have been declining for a number of years, and that trend continued in 1969; quanity and total value—65,000 tons and $1.3 million—were 14 percent and 8 percent less than in 1968 and amounted to less than half the comparable figures for 1959. The United Kingdom, by a wide margin, retained its established position as principal foreign supplier of kaolin to the United States; Canada, the Netherlands, and West Germany contributed only minor quantities. In contrast to the dimished stature of kaolin imports, exports of that commodity in 1969, sustaining a noteworthy rate of growth, amounted to 478,000 tons and $14.8 million —increases of 23 percent and 14 percent, respectively, coming on top of corresponding increases of 21 percent and 31 percent in 1968. The kaolin that was exported in 1969 went to destinations in over 50 countries, foremost among which and receiving about one-third of the total, was Canada.

BALL CLAY

In 1969, production of domestic ball clay, for the second year in succession, scored an impressive increase of 8 percent in quantity and 16 percent in total value above that of 1968 and reached the highest level in history. Notable gains in tonnage were reported in three of the six ball clay producing States—10 percent in Tennessee, source of two-thirds of the National output, 13 percent in Kentucky, the State that ranks second, and 12 percent in Mississippi, the State in third place.

Oil, Paint and Drug Reporter, December 29, 1969, listed ball clay prices, unchanged from the 1968 quotations, as follows:

Domestic, airfloated, bags, carload lots, Atlantic ports, per ton	$49.00-50.75
Domestic, crushed, moisture-repellent, bulk, carload lots, Tennessee, per ton	8.00-11.25
Imported, airfloated, bags, carload lots, Atlantic ports, per ton	49.50-50.75
Imported, lump, bulk, Atlantic ports, per ton	31.50-37.50

U.S. imports in 1969 included 12,800 tons of beneficiated and unbeneficiated ball clay valued at $228,000; both figures are about one-fourth less than those of 1968. Ball clay exports were reported as part of a "not elsewhere classified" basket category, of which the total in 1969 was 395,000 tons and $15.3 million, as compared with 485,000 tons and $15.5 million in 1968.

FIRE CLAY

The total quantity of fire and stoneware clay sold or used by domestic producers in 1969 represented a 10-percent drop from the 1968 level in both tonnage and total value. This is clear reflection of industry's growing divergence from conventional guidelines for the selection of refractories. Factors conductive to some of the changing emphases in present-day refractories practice were outlined in an industrial magazine article that implicitly foreshadowed a progressively diminishing reliance on fire clay.[2]

In 1969, exports of fire clay totaled about 163,000 tons valued at $2.6 million, 7 percent more tonnage than in 1968 but about 2 percent less in dollar volume. These exports went to consignees in 40 countries. Canada was the leading recipient, followed by Mexico. There were no fire clay imports in 1969.

BENTONITE

Production and consumption of bentonite have grown with notable consistency from year to year throughout the last two decades. That trend was strikingly manifest in 1969, when the total quanity of bentonite sold or used by domestic producers overtook the previous historic high reached in 1968 and established a new annual record 8 percent higher still. Bentonite

[2] Oberschmidt, Leo E. Refractories Challenge for 1969—Cut Costs and Improve Quality. Brick & Clay Record, v. 154, No. 1, January 1969, pp. 41-47.

was produced in 1969 in 15 States; among which the leaders were Wyoming, with 74 percent of the National total tonnage; Mississippi, 11 percent; and Texas, 4 percent. It is worthy of mention that the 1969 list of bentonite producers, for the first time on record, included Missouri.

Reflections of the ever-greater industrial significance of bentonitic clays was the inauguration in 1969 of three bentonite processing facilities with an aggregate annual capacity around half a million tons. The new plants were of Ashland Chemical Co. at Glasgow, Valley County, Montana; International Minerals & Chemical Corp. at Aberdeen, Monroe County, Mississipi; and A. P. Green Refractories Co. at Oran, Scott County, Missouri.

Use of domestic bentonite in iron ore pelletizing, after remaining virtually static in 1968, resumed its upward trend and scored an impressive 45-percent increase.

Oil, Paint and Drug Reporter, December 29, 1969, quoted bentonite prices, without change since yearend 1965, as follows: Domestic, 200-mesh, bags carload lots, f.o.b. mines, $14 per ton; and imported Italian, white, high-gel, bags, 5-ton lots, ex-warehouse, $91 per ton. The average unit value reported for domestic bentonite sold or used by producers in 1969 was $9.81, practically the same as the previous year's figure. Per-ton values reported in the various producing States ranged from $3.91 to $15.10, but most of the larger producers tended to center upon the Wyoming figure of $9.67.

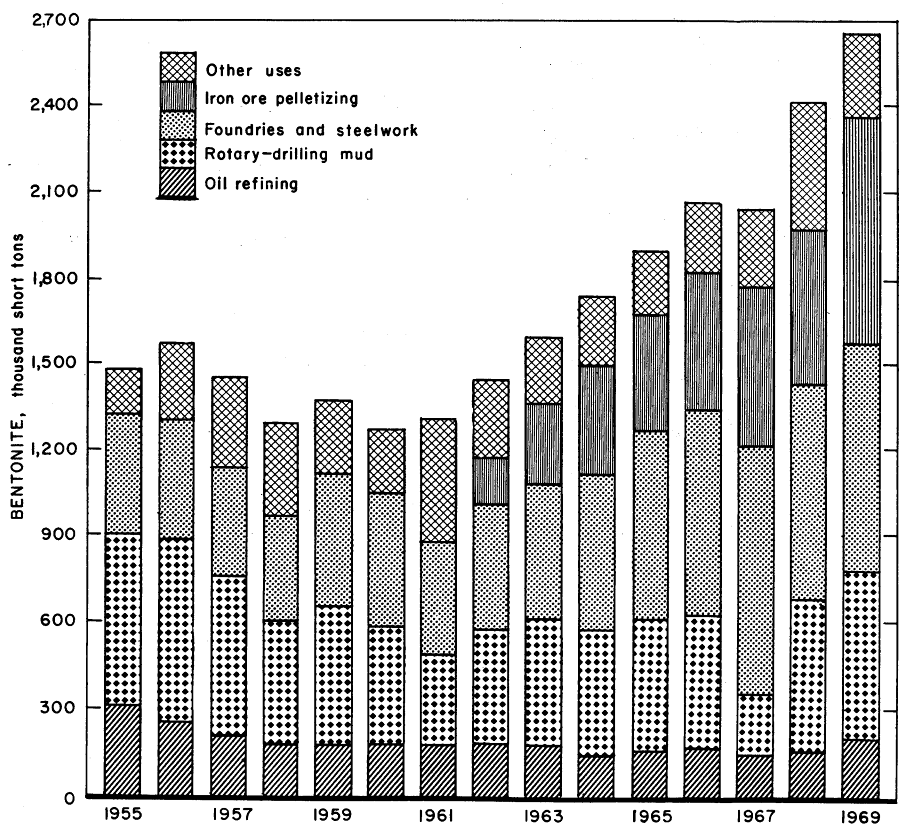

Figure 2.—Bentonite sold or used by domestic producers for specified uses.

In 1969, the United States exported bentonite to 66 foreign countries, among which Canada, recipient of 56 percent, and Australia, 11 percent, ranked first and second, respectively. The exported clay amounted to 501,000 tons and reached $11.5 million in total value, compared with 477,000 tons and $11 million in 1968, the higherto record year. Bentonite imports in 1969 were confined to 76 tons of special-purpose material shipped from Canada and Italy.

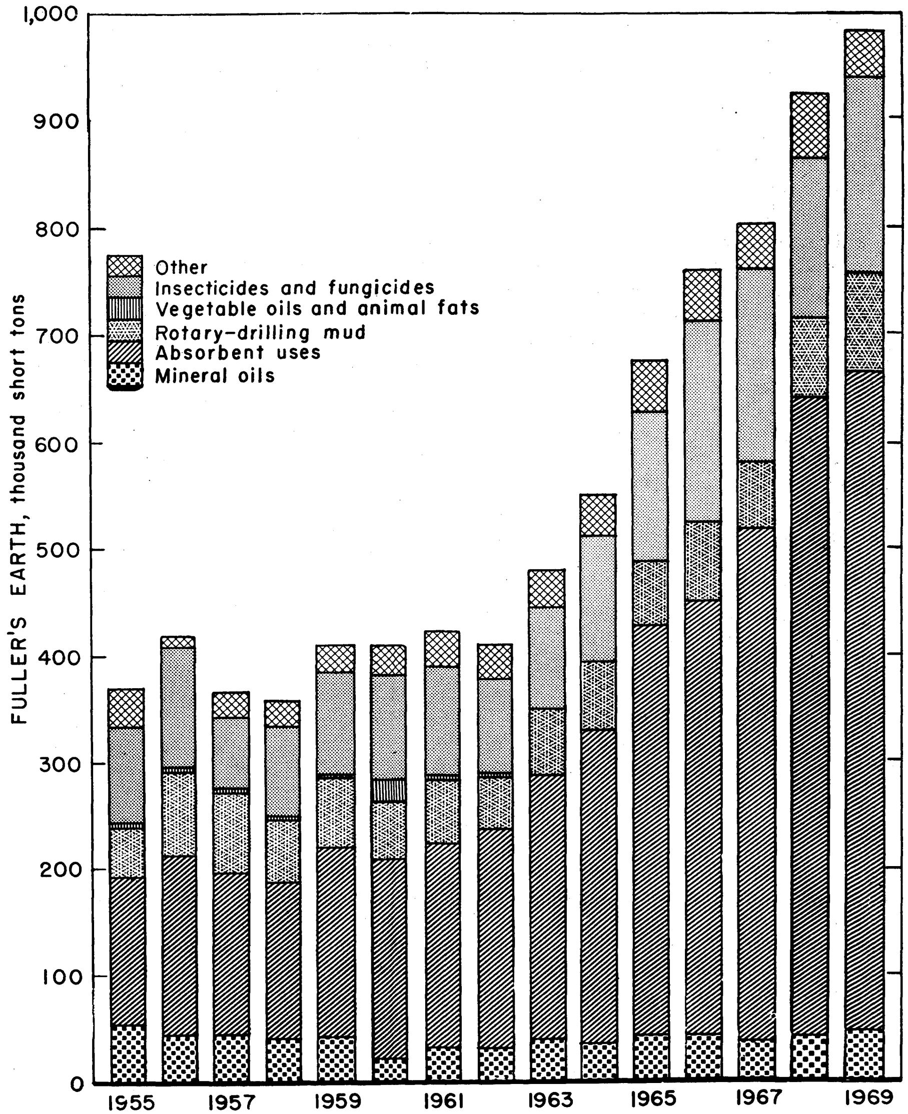

Figure 3.—Fuller's earth sold or used by domestic producers for specified uses.

FULLER'S EARTH

Domestic output of fuller's earth, as measured by the quanity sold or used by producers, increased substantially in 1969, exceeding the former-record production of 1968 by 7 percent in tonnage and by 10 percent in total value. The most significant increases among the eight producing States (nine in 1968) were 15 percent for Florida and 5 percent for Georgia. Illinois and Tennessee, against smaller bases, marked increases of 34 percent and 10 percent, respectively. In 1969, Missouri made its first appearance among the fuller's earth producers, while California and Nevada, both with past records of minor but consistent production, dropped out of the list.

Utilization of fuller's earth in insecticides and fungicides, after 2 years of retreat, gained ground in 1969 almost to the historic high point reached in 1966. The quantity of fuller's earth consumed for general absorbent purposes was 3 percent higher than in the previous year, and it is worthy of note that, for the first time, data on a growing component of that end use category—for animal litter—became available as a separate item.

Prices for fuller's earth were not publicly quoted in 1969, but the average per-ton value reported by producers was $25.77, as compared with $25.15 in 1968.

Fuller's earth imports in 1969 were limited to 68 tons of beneficiated material with a reported value of $4,789 from the United Kingdom. Exports of fuller's earth totaling 37,000 tons—of which Canada received 46 percent—and valued at $1.6 million were distributed among 30 countries.

MISCELLANEOUS CLAY

The common clays and shales of the various types that are used in the manufacture of structural clay products, lightweight aggregate, and portland cement are grouped together in the miscellaneous category, which accounts for about 70 percent by weight of all clays that are produced domestically. Most manufacturers of brick, drain tile, sewer pipe, and other heavy clay products mine their own raw materials, and at least 95 percent of all domestic production of miscellaneous clay in 1969 was from captive operations.

The quantity of miscellaneous clay sold or used by U.S. producers in 1969, slightly over 42 million tons and valued at $63.4 million, was an alltime record and represented a 3-percent increase in tonnage and a 12 percent increase in value, compared with the respective figures for 1968.

Exports of clays that were not separately classified as to type added up to about 395,000 tons with a total value of $15.3 million, as compared with 458,000 tons and $15.5 million in 1968. The countries receiving the major shares of these unclassified clays were Canada, 28 percent; Japan, 14 percent; Italy, 9 percent; and Mexico, 8 percent. The remaining 41 percent was distributed among about 80 other countries. The unit values recorded for these exports, $39 per ton in 1969 and $34 per ton in 1968, are evidence that a large proportion of these materials belonged to grades of a higher order than the common clays destined for structural products use, which ordinarily are rated at not over $1.50 per ton. There were no significant imports of miscellaneous clays in 1969.

CONSUMPTION AND USES

The manufacturing of heavy clay products, cement, and lightweight aggregate accounted for 39 percent, 21 percent, and 17 percent, respectively, of the total 1969 domestic consumption of all clays, as compared with 41 percent, 20 percent, and 16 percent in 1968. The total tonnage of clays used in refractories, maintaining the same relationship as in the year before, was equivalent to 9 percent of the 1969 total.

Refractories.—Fire clay, bentonite, and miscellaneous clay consumed in 1969 in the manufacture of refractories showed little change from the tonnages reported in 1968. Utilization of kaolin in refractories, however, was 29 percent greater, and the total quantity of all clays so consumed was 4 percent more than in the previous year. The total value of clay refractories shipped in 1969 was 12 percent higher than in 1968; the total value of nonclay refractories was 15 percent higher. By rough surmise, those increases might be attributed perhaps one-half to larger production volume and one-half to inflationary trends that were evident in generally higher unit values.

Heavy Clay Products.—The values reported for shipments of heavy clay products in 1969 represented small-to-substantial increases for most categories; the overall total was 3 percent higher than in the previous year, but the trend in the corresponding quantities was less consistent. Thousand-unit counts for building brick and for facing tile were 4 percent and 5 percent, respectively, below those in 1968. Shipments of unglazed structural tile regained some of the ground lost in the past several years by scoring an increase of 26 percent in quanity and an even more impressive 65-percent rise in total value.

Lightweight Aggregate.—Consumption of clay and shale in the making of lightweight aggregate, more than doubling since 1958, has increased in all but three of the 17 years since statistics on this end use first because separately available. The quanity of clay and shale devoted to this purpose in 1969 was 6 percent more than in 1968 and 12 percent more than in 1967. Among significant news items relating to the lightweight aggregate industry in 1969 were notices of the construction of several new clay and shale plants or major additions to other facilities already in operation. It was also announced that Hercules, Inc., of Wilmington, Del., expected to have a new expanded-slate plant in full production at Snowden, Va., by mid-1970. It was stated that the multimillion dollar installation, designed with special attention to minimizing ecological impairment, would use three rotary kilns to process locally mined slate at the rate of approximately 6,000 tons per day. It should be noted that the tonnage of raw material mentioned in table 10 for lightweight aggregate production refers only to clay and shale and does not include the quantity of slate similarly used. In 1968, a total of 707,000 tons of slate was expanded for lightweight aggregate, and it is estimated that in 1969 at least 750,000 tons of slate was used for this purpose.

WORLD REVIEW

Algeria.—Under direction of a national clays research agency, the government mining authority started open pit mining of kaolin at Djebel Debagh to provide raw material for domestic pottery makers. It was predicted that this operation, initiated at the rate of 4,000 tons per year, will soon be expanded to supply a wider ceramics market and perhaps also to furnish clays in filler grades for use in paper manufacturing.

Belgium.—Lightweight aggregate for use in prefabricated concrete structural units is increasingly in demand by European builders. A three-way consortium of Belgiun industrial organizations was formed to manufacture expanded-shale aggregate in large quantities to supply the growing national requirement.

Canada.—Domestic production of specialty clays—swelling, Wyoming-type bentonite, largely for use in drilling muds and iron concentrate pelletizing, and the fireclay, ball clay, and kaolin types of ceramics and refractories—falls far short of national requirements, and substantial quantities of these essential materials must be imported. Canada's deficiencies in clays and clay products have had to be balanced in recent years by an annual outflow of around $70 million to foreign suppliers, principally the United States and the United Kingdom. It was pointed out that Wyoming-type bentonite, not yet fully exploited, occurs in Alberta. Further hope for a possible alleviation of a burdensome situation was aroused by an announcement that Algacen Mines, Ltd., may soon begin exploring a vast silica-kaolin deposit near the Moose River in the James Bay drainage area of Ontario. It was stated that "reserves could be in the hundreds of millions of tons," but the site's difficulty of access was mentioned as a formidably adverse consideration. A pipeline carrying material either in slurry form or else encased in capsules was suggested as a possible system for conveying the prospective mineral products across the many miles of muskeg terrain to railhead or, alternatively, to Great Lakes port.

Ceylon.—The Ceylon Ceramics Corp. overcame a persistent problem at an opencast kaolin mining operation at Boralesgamuwa—contamination of the product with off-color overburden material—by replacing the former dragline system with a modern excavating machine. The new equipment, designated as the HY—MAC 580B excavator, made it possible to achieve increases in both the quantity and the quality of the output.[3]

Cuba.—Installation of new equipment at the government-operated kaolin processing plant on the Isle of Pines, which is the site of Cuba's principal kaolin deposits, is expected to raise output of that commodity by 25 percent and make it possible for the first time for the Nation to be self-sufficient in that respect.

India.—India's bentonite and fuller's earth are produced in substantial quantities for domestic consumption, but exports have been of limited importance. A coming change in this situation was heralded by the announcement that Ambica Minechem Industries, currently applying the latest modern mining, processing, and control equipment to the exploitation of extensive bentonite deposits in the Bhaynagar and Kutch districts of Gujarat State, is now able to provide ample tonnages of that clay in foundry and drilling-mud grades for the export market.

New Zealand.—Canterbury Bentonite, Ltd., completed the construction at Coalgate on South Island of an all-new preparation plant and entered into full-scale production of processed bentonite from the company's adjacent and newly developed open pit mine. Reserves at the site, consisting of material suitable for foundry use, drilling muds, and iron ore pelletizing, have been estimated at more than 20 million tons. The domestic steel industry is expected to consume at least 10,000 tons per year of the new plant's output. The first foreign shipment of pellet-grade material was 500 tons consigned to Australia's Port Latta pelletizing plant at Savage River in Tasmania. A greatly expanded export market in mainland Australia is foreseen for the New Zealand bentonite.

Construction of another $500,000 plant —this one near Kerikeri in the Bay of Islands for the processing of china clay—was announced as a joint enterprise of Crown Lynn Potteries (Aukland) with Georgia Kaolin Co. (New Jersey, U.S.A.). The initial undertaking is intended to serve as a pilot-plant operation with the potential of eventual amplification to a scale providing a capacity of 100,000 tons per year.

Pakistan.—Clay deposits previously discovered in Swat (West Pakistan) were surveyed and estimated to contain 2 million tons of good-quality china clay. Plans were drawn for a processing plant with an annual production capacity of 5,000 tons, equivalent to about one-half the national requirement, supplied at present only by imports.

South Africa, Republic of.—The existence of a hitherto unknown national resource was revealed by G. and W. Industrial Base Minerals, a subsidiary of the Anglo American Corp. of South Africa. Deposits of bentonite have been described as "very promising" near Plettenberg Bay in Cape Province. The report of this discovery was welcome news because South Africa's consumption of that mineral currently outweighs the domestic output almost 2 to 1.

Spain.—The properties and business of the Cía. Mercantil Bentonitas y Minerales, S.A.—an important bentonite producer based at Melilla, Morocco—were acquired by the Cía. Española de Carbones Activos, S.A. of Madrid, a subsidiary of the French firm Carbonisation et Charbons Actifs. Spain currently mines about 20,000 tons annually of bentonite from domestic sources and, although a net importer of some grades, still ships significant quantities to destinations overseas. An article in a U.S. journal presented details of the operations and equipment of a new, highly automated plant near Madrid that produces 200 tons per day of the clay tile beams and spans used to an important extent in the majority of Spanish floor and ceiling construction.[4]

Turkey.—Engineers of the Turkish Minerals Research and Exploration Institute found an extensive body of high-grade calcium bentonite in the Cankiri district approximately 70 kilometers northeast of Ankara, about half way between that capital and the Black Sea. Tentative plans were laid for the construction of a processing plant to prepare material from the newly discovered deposit for domestic consumption as foundry-sand binder and in drilling muds.

United Kingdom.—The sustained prosperity of Britain's china clay industry has enabled that product to reach and hold a place among the nation's bulk exports that is second only to that of coal. Exploitable deposits of china clay are closely concen-

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[3] Mining Journal (London). Kaolin Mining in Ceylon. V. 272, No. 6960, Jan. 10, 1969, p. 28.

[4] Svec, J. J. Cerámica Estela Drys Span Tile in One Hour. Brick & Clay Record, v. 155, No. 6, December 1969, pp. 37–39.

trated near Land's End in Cornwall's southwestern toe tip, and after more than two centuries of activity, the workings are becoming progressively cramped by an indeferrable problem of residue disposal. Furthermore, opening of a new pit in West Penwith was vigorously opposed recently by private individuals and a number of county and urban representative bodies on the grounds of pollution and landscape disfigurement. Faced with these and related considerations, a number of the china clay producers in the area launched a project for doing away with practices that long have kept Cornwall's rivers running milky with suspended clay plant washings. Under the proposed scheme, in the future, these residues will be discarded far out to sea. Approximately $6 million will be spent in constructing an 8-inch pipeline and the 13 miles of concrete-lined tunnel through which the washings will be led underground from the clay processing plants to the shoreline and thence outward, 40 feet below the sea bed, to a vertical discharge outlet under 60 feet of water and a mile from the coast. Proponents of the system believe that no damage to sea life will result from this method of disposal.

British ball clays, which are ceramic materials with exceptional plastic and bonding properties, used extensively in the manufacture of earthenware, floor and wall tiles, sanitary ware, electrical porcelain, and tableware, are marketed in at least 40 other countries. Britain's foremost ball clay producing firm, with three-quarters of its output sold abroad, received the Queen's Award to Industry for both export achievement and technical innovation. An article published in a London magazine described the operations of that company and of a number of others that likewise are engaged in mining ball clay deposits of England's southwestern county of Devon. Subsequent issues of the same periodical carried an outstanding series of articles devoted to bentonite and the closely related material, fuller's earth.[5]

It was announced that the British brick industry would switch to the metric system at yearend and that the familiar 9 x 4½ x 3-inch brick will be replaced by an almost imperceptibly smaller unit that will measure 225 by 112.5 by 75 millimeters. About 105 of the new units will fill the volume occupied by 100 bricks of the former standard size.

TECHNOLOGY

The 71st Annual Meeting and First Annual Exposition of the American Ceramic Society, May 3–8, 1969, brought to Washington, D.C., the world's largest gathering of ceramic scientists and representatives of the clays-oriented industries. The excellent organization and scheduling of the various division meetings, symposia, and joint sessions made possible the presentation of approximately 400 technical and scientific papers. The concurrent expositon, which was the first of its kind and consisted of the instructive displays of about 120 domestic and foreign-based companies, provided an unprecedented wide-angle view of up-to-date ceramic equipment, processes, materials, products, and practical industrial literature. One of the tour options offered to attendees was an excursion to the newly installed headquarters of the Structural Clay Products Institute in McLean, Va. There the visitors toured the modern offices and laboratories of the Institute, and were given an opportunity to watch the compression testing to destruction of a two-story brick and mortar pylon in an upright hydraulic press designed to bear down with the force of a million pounds while measuring the resulting deflections in thousandths of an inch. This experience contributed a graphic conception of what is meant by the construction-industry term "bearing wall."

Something new has been added to the already long list of forms in which clays serve the needs of mankind—ceramic foam. This completely inorganic foamed-clay material is resistant to weathering and to moisture penetration, decay-proof, noncompacting, incombustible, and practically im-

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[5] Industrial Minerals (London). Bouyant Market for Ball Clays. No. 17, February 1969, pp. 9–15.
———. The Bentonite Industry Expands Capacity, etc. No. 24, September 1969, pp. 10–45.
———. Bentonite's Indispensable Role in Industry, etc. No. 25, October 1969, pp. 9–33, 45.
———. Erbsloh & Co. Pioneer Producer of Sodium-Exchanged Bentonite, etc. No. 27, December 1969, pp. 33, 35–37.

mune to thermal shock or chemical attack, while combining controllably variable degrees of lightness with greater structural strength than that of the earlier developed and widely used polystyrene and urethane plastic foams.[6] Although first introduced as a heat insulating agent for the lagging of tanks, pipes, and reactors, this new product, with such an impressive list of uncommon characteristics, certainly seems destined to find a much wider field of applications. As just one example, it is predicted that ceramic-foam shingles, already being marketed in limited quantities, will provide virtual immortality for a roof upon which they are used as a covering.[7]

A journal article presented information that is not usually available concerning the specialized materials and procedures involved in the fabrication of some ceramic components used in the electronics industry, that, although frequently inconspicuous, are yet critically essential in many of today's sophisticated mechanisms.[8]

Approximately 350 U.S., Canadian, and British patents issued in 1969 were directly related to clays or other ceramic materials. The foremost subject of interest was refractories, with about 100 patents; followed by kaolin with 70, and bentonite with 60.

As chemical and metallurgical processes push more and more against temperature ceilings, active search continues in a parallel course for refractories able to serve under conditions unimaginable less than a generation ago. In this unending contest with the limitations of materials, a major advance has been the advent of fused-cast refractories. The technology of these extremely durable and heat-resistant materials, and the properties that determine their superiority in specialized applications, were reviewed in an industrial magazine.[9] No longer ago than 1962, the best magnesite refractory available did not achieve a transverse strength in excess of 300 psi at 2300° C, but in 1969 basic-oxygen-process steel furnaces were being lined with mass-produced magnesite bricks testing over 1000 psi at that temperature. This is one of the facts brought out in an article which discussed significant developments and changes in emphasis in the refractories field.[10] Three generations ago the Bessemer converter yielded its first place as a steel maker to the open-hearth furnace. In August 1969, for the first time, open-hearth steel lost out in tonnage to that from a more efficient producer, the basic-oxygen-process furnace. How long this roaring giant will retain the supremacy is not easy to predict, but it is clear that its rapidly increasing dominance will work profound changes in the refractories requirements of the steel industry, which is by far the largest consumer of refractory products. The Bureau of Mines Eastern Field Operations Center at Pittsburgh, in an effort to anticipate these and other impending transformations, initiated a project to assess the impact of changing technology upon refractories demand and upon the refractories producing and consuming industries.

The length of time which a blast furnace can be operated without relining is a prime determinant of that unit's efficiency and, consequently, of the specific weight of metal obtainable from it per input dollar. The life span of the refractory furnace lining is directly dependent upon its ability to retard the progress of certain physical, chemical, and mineralogical changes, and that ability, is largely dependent upon the nature of the substances constituting the lining material. Georgia kaolin clay, in bricks fired at high temperatures to provide high density, low permeability, and great mechanical strength, is being used increasingly as the preferred refractory for today's hot-running, high-productivity blast furnaces. Important factors in furnace lining erosion and some of the considerations by which it can be minimized were outlined in an industrial journal.[11]

The Georgia operations of one of the world's largest producers of wet-process kaolin were described with technical details in a British periodical. The same article listed some of the major end uses served by the wide range of water-washed kaolin products from the company's plants and reported on the continuing research pro-

[6] Steel. Dow Foams Clay for Insulation Markets. V. 164, No. 16, Apr. 21, 1969, p. 52h. Chemical Week. Technology Newsletter: Dow is Making a Splash in Ceramic Foam. V. 105, No. 23, Dec. 10, 1969, p. 68.

[7] American Ceramic Society Bulletin. Corning's Ceramic Shingles Available in Oklahoma. V. 48, No. 8, August 1969, p. 793.

[8] Kell, R. C. High-Quality Ceramics for Use in the Electrical Industry. J. Sci. & Technol. (London), v. 36, No. 3, September 1969, pp. 125–129.

[9] Brown, R. W., and K. H. Sandmeyer, Applications of Fused-Cast Refractories. Chem. Eng., v. 76, No. 13, June 16, 1969, pp. 106–114.

[10] Wicken, O. M. Higher Quality Refractories. Min. Eng., v. 22, No. 1, January 1970, p. 66.

[11] Moffat, John. Kaolin Firebrick Increases Lining Life. Brick & Clay Record, v. 155, No. 5, November 1969, pp. 38–39.

gram being conducted to achieve advantageous innovations in the mining, processing, and utilization of those materials.[12] A journal article was published outlining automated procedure adopted in West Germany to expedite the dehydration of kaolin slurries.[13] The production capacities of two plants of a large producer of Georgia paper-grade kaolins were substantially increased by the completion of a 2-year expansion program. Besides the addition of a fourth high-capacity spray drier to the three such units already operating, installation of major new equipment included that of an automated, gas-fired rotary kiln 10 feet in diameter and 160 feet long for calcining kaolin and of two filter presses weighting 30 tons each. A noteworthy feature of the huge new filters, the only two of their kind in the United States, is the unconventional construction of their plates and spacers. The filter cake, to circumvent any possibility of its being contaminated by contact with metal, will be collected in frames consisting entirely of resin-bonded glass fiber. It was stated that the expansion of the two facilities was in response to the steadily mounting demand for the more than 90 individual grades of kaolin marketed by the firm.[14]

All open pit mining involves some disruption of the natural environment, and more and more attention is being directed toward the restoration of landscapes after completion of mining operations. In Georgia, the State that is foremost in production of kaolin, the legislature put into effect a new statute requiring the rehabilitation of all lands disturbed by surface mining after the start of 1969. A brief account was published discussing fertilization schedules and seeding techniques that have been successful there for the propagation of various specified types of grasses, clovers, and evergreens as cover for mined-out kaolin terrains.[15]

Bentonite, with special reference to its use in iron ore pellets, was the principal subject of discussion at a meeting of the Minerals Beneficiation Division of A.I.M.E. in Chisholm, Minn., on November 19, 1969. The meeting, which featured the presentation of a paper by James French entitled "Standardization of Bentonite Testing Methods and Specifications for the Iron Ore Industry," was summarized in an industrial journal.[16] In a continuing series of tests at the Bureau of Mines Metallurgy Research Laboratory at Tuscalcoosa, Ala., bentonite was one of the substances that was evaluated as a bonding agent for the experimental production of building blocks from the nonmagnetic materials, largely waste glass, salvaged from municipal incinerator residues. The Bureau of Mines Twin Cities Mineral Supply Field Office brought to completion an investigation of the suitability of clays in the Lake Superior region for use in place of Wyoming bentonite as binding material for iron ore pelletizing. The data obtained indicated that none of the clays tested could be considered suitable for the stated purpose. Results of this research were published late in 1968.[17] A property of bentonite and of other clays that would seem to bear a close relation to their bonding capabilities was the topic of a report, accompained by quantitative data, in a scientific magazine.[18]

In an age of technology capable of imprinting man's footsteps in the sands of the moon, an estimation of the "feel" of molding sands is still the basic and only generally used test applied to those materials in most foundries. More scientific and less subjective procedures for prejudging the moldability of bentonite-sand mixes and for correlating that behavior with a number of common variables were discussed in a trade journal.[19]

Clays-related activities of the Bureau of Mines in 1969, in addition to the bentonite studies referred to, included continuing cooperative programs with a number of in-

[12] Industrial Minerals (London). Whiter, Brighter Kaolin Clays. No. 17, February 1969, pp. 17–19.
[13] Zrenner, Franz, and Hans Siegert. One-Stage Drying/Milling of Filter Cakes. Minerals Processing, v. 10, No. 8, August 1969, pp. 17–21.
[14] American Paint Journal. Georgia Kaolin Company's Multi-Million Dollar Plant Expansion on Stream. V. 54, No. 8, Sept. 15, 1969, pp. 18–19, 22.
[15] U.S. Department of Agriculture. Bringing Back Life. Agricultural Research, v. 17, No. 11, May 1969, p. 3.
[16] Skillings' Mining Review. Bentonite Discussed at Technical Meeting. V. 58, No. 50, Dec. 13, 1969, p. 16.
[17] Aase, James H., and George E. Leonhard. Field Investigation and Testing of Minnesota Clay Resource for Iron Ore Pellet Bonding. BuMines Rept. of Inv. 7206, December 1968, 17 pp., 8 figs.
[18] Anderson, Scott, Dinesh Tandon, L. B. Kohlenberger, and F. G. Blair. Strength of Adhesion of Dried Clay Slurries to Window Glass as a Function of Slurry pH. J. Am. Ceram. Soc., v. 52, No. 9, September 1969, p. 521.
[19] Caine, John B. and R. E Toepke. Another Look at Moldability. Foundry, v. 97, No. 6, June 1969, pp. 74–77.

dividual States for the sampling, testing, and evaluation of clays and other ceramic materials. As part of one such program, a report entitled "Analyses of Clays and Shales in East Tennessee" was prepared in the Bureau's Knoxville Mineral Supply Field Office and submitted to the Tennessee Division of Geology for consideration as a State publication. Bureau of Mines Report of Investigations 7244 "Raw Materials for Lightweight Aggregate in Appalachian Region, Alabama and Georgia" was published in March 1969.

A report was published detailing the results of a program of research in which the Bureau of Mines collaborated with the Louisiana Geological Survey in the testing of clay samples from each of the 64 parishes. It was concluded that deposits of clays suitable for the production of lightweight building materials are widespread throughout almost all of that State.[20]

A group of expanded shale producers in California organized the Ceramic Lightweight Aggregate Association for the declared purpose of disseminating technical information regarding their product and thus advancing a better understanding of its capabilities, not only as a building material, but also for road surfacing and soil conditioning. The techniques of dust collection and air-pollution control were stressed as prime concerns of the new association. The raw materials, automated equipment, and operating procedures employed by a firm supplying lightweight aggregate to customers in Montana, Idaho, and Washington were the subjects dealt with in articles in two technical journals. Some account was given also of fuel-cost experience at the newly enlarged plant and of the end uses being served by the product.[21] A method devised by the American Concrete Institute for determining the correct proportions of water and cement for mixing with expanded aggregate appears to be a notable advance in the technology of those lightweight materials. The new method makes it possible to determine a common density factor for any lightweight aggregate, which then serves as a guide for the selection of the optimum cement-water-aggregate ratio.[22]

[20] Louisiana Geological Survey, Department of Conservation, Baton Rouge, La. Clay Resources Bulletin No. 2: Occurrence, Test Data, and Evaluation of Clay for Making Lightweight Aggregte. January 1969, 145 pp., 1 map.

[21] Levine, Sidney. Montana Lightweight Producer Expands to Satisfy Growing Market. Rock Products, v. 72, No. 3, March 1969, pp. 63–66.
Trauffer, Walter E. Montana Lightweight Aggregate Plant Expanded. Pit & Quarry, v. 61, No. 11, May 1969, pp. 169–171, 178.

[22] Science News. Method for Concrete Mixing. V. 96, No. 3, July 19, 1969, p. 49.

Table 2.—Value of clays produced in the United States, by States

(Thousand dollars)

	1968	1969	Kind of clay produced in 1969					
			Kaolin	Ball Clay	Fire Clay	Benton-ite	Fuller's earth	Miscel-laneous
Alabama	$6,995	$7,083	x		X	x		X
Arizona	347	394			x	x		x
Arkansas	2,134	2,426	x		x			X
California	6,630	7,443	x	x	X	x		X
Colorado	1,222	1,619			X	x		x
Connecticut	325	341						x
Delaware	12	11						x
Florida	11,699	13,627	x				X	x
Georgia	88,632	98,462	X				X	X
Hawaii	4	9						x
Idaho	[1,2]14	[1,2]51	x		x			x
Illinois	[3]4,813	[3]4,321			X		x	X
Indiana	2,355	2,264			x			X
Iowa	1,747	1,660						X
Kansas	1,433	[2]1,070			x			X
Kentucky	[4]1,952	[4]2,076		X	X			X
Louisiana	1,163	2,943						X
Maine	[2]65	[2]56			x			x
Maryland	[2,4]1,252	[2,4]1,369		x	x			X
Massachusetts	314	624						x
Michigan	2,906	3,037						X
Minnesota	[2]359	[2]412			x			x
Mississippi	9,075	8,660		X	x	X	X	X
Missouri	6,158	[5,3]6,405			X	x	x	X
Montana	[5]34	[5]63				x		x
Nebraska	206	223						x
New Hampshire	41	40						x
New Jersey	1,008	1,123			x			x
New Mexico	89	89			x			x
New York	1,790	1,783						X
North Carolina	[1]2,148	[1]2,610	x					X
Ohio	15,216	11,693			X			X
Oklahoma	[5]967	[5]1,182			x	x		x
Oregon	[2]284	[2]321			x	x		x
Pennsylvania	[1]17,679	[1]19,637	x		X			X
South Carolina	8,923	10,911	X					X
South Dakota	1,119	1,171				x		x
Tennessee	[3]5,772	[3]7,064		X			x	X
Texas	8,860	8,664	x	x	X	X	x	X
Utah	[1]476	1,286	x		x	x	x	x
Virginia	1,714	1,504						X
Washington	[r,2]253	[2]434			x			x
West Virginia	[2]219	[2]348			X			x
Wisconsin	34	24						x
Wyoming	17,275	18,970				X		x
Other [6]	11,225	8,910						
Total [7]	[r]246,938	264,415						
Puerto Rico	481	454						

[r] Revised.
X Major producing States which account for approximately 90 percent of production. x Other producing States.
[1] Value of kaolin included with "Other" to avoid disclosing individual company confidential data.
[2] Value of fire clay included with "Other" to avoid disclosing individual company confidential data.
[3] Value of fuller's earth included with "Other" to avoid disclosing individual company confidential data.
[4] Value of ball clay included with "Other" to avoid disclosing individual company confidential data.
[5] Value of bentonite included with "Other" to avoid disclosing individual company confidential data.
[6] Includes Nevada, North Dakota, Vermont and value indicated by footnote 1 through 5.
[7] Data may not add to totals shown because of independent rounding.

Table 3.—Kaolin sold or used by producers in the United States, by States

(Thousand short tons and thousand dollars)

Year and State	Sold by producers	Used by producers	Total [1]	
	Quantity	Quantity	Quantity	Value
1965	3,214	389	3,604	$69,461
1966	3,664	721	4,385	81,984
1967	3,336	637	3,973	81,321
1968:				
Arizona	(2)	---	(2)	2
California	W	W	23	292
Florida and North Carolina	39	---	39	903
Georgia	2,881	284	3,165	79,061
South Carolina	498	83	581	7,694
Other States [3]	160	256	393	4,534
Total [1]	3,579	622	4,201	92,486
1969:				
California	W	W	W	268
Georgia	3,310	366	3,676	87,956
South Carolina	481	115	596	8,884
Other States [3]	154	313	467	5,154
Total [1]	3,944	794	4,739	102,262

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Data may not add to totals shown because of independent rounding.
[2] Less than ½ unit.
[3] Includes Alabama, Arkansas, Florida (1969), Idaho, North Carolina (1969), Pennsylvania, Texas, Utah, and States indicated by symbol W.

Table 4.—Georgia kaolin sold or used by producers, by uses

(Thousand short tons and thousand dollars)

Year	China clay paper clay, etc.	Refractory uses	Total kaolin		
	Quantity	Quantity	Quantity	Value: Total	Value: Average per ton
1965	2,478	243	2,721	$57,411	$21.10
1966	2,719	487	3,206	67,156	20.95
1967	2,708	301	3,009	69,327	23.04
1968	2,947	218	3,165	79,061	24.98
1969	3,358	318	3,676	87,956	23.93

Table 5.—Ball clay sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Quantity	Value
1965	591	$8,197
1966	571	7,322
1967	559	7,446
1968	630	8,351
1969	682	9,720

Table 6.—Fire clay, including stoneware clay, sold or used by producers in the United States, by States

Year and State	Sold by producers	Used by producers	Total[1]	
	Short tons	Short tons	Short tons	Value (thousands)
1965	2,823,837	6,191,812	9,015,649	$43,114
1966	2,596,470	6,181,695	8,778,165	42,179
1967	2,512,411	5,460,002	7,972,413	42,157
1968:				
Alabama	W	W	581,699	3,032
Arizona	30	---------	30	1
California	126,249	396,154	522,403	1,335
Colorado	128,045	112,475	240,520	830
Illinois	93,013	153,727	246,740	1,466
Indiana	130,314	51,285	181,599	340
Kansas	W	W	157,848	349
Kentucky	80,573	115,028	195,601	950
Missouri	68,226	996,008	1,064,234	4,334
New Jersey	W	W	84,120	624
New Mexico	W	W	2,024	13
Ohio	895,986	1,117,053	2,013,039	10,081
Oklahoma	---------	476	476	5
Pennsylvania	435,852	988,160	1,424,012	11,317
Texas	W	W	766,165	1,988
Utah	W	W	11,916	42
Other States [2]	589,590	1,575,708	561,526	5,389
Total	2,547,878	5,506,074	8,053,952	42,094
1969:				
Alabama	W	W	462,820	1,994
Arizona	---------	15	15	(3)
Colorado	154,188	133,975	288,163	1,073
Illinois	W	W	215,176	1,618
Indiana	W	W	165,847	314
Kentucky	66,195	131,976	198,171	1,054
Missouri	69,843	970,521	1,040,364	4,968
New Jersey	W	W	81,764	575
New Mexico	W	W	2,432	12
Ohio	1,106,711	924,888	2,031,599	6,731
Oklahoma	---------	381	381	4
Pennsylvania	382,930	823,531	1,206,461	12,921
Texas	W	W	635,102	1,669
Other States [2]	922,377	1,573,619	932,855	4,842
Total	2,702,244	4,558,906	7,261,150	37,775

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Data may not add to totals shown because of independent rounding.
[2] Includes Arkansas, California (1969), Idaho, Kansas (1969), Maine, Maryland, Minnesota, Mississippi, Nevada, Oregon, Utah (1969), Washington, West Virginia, Wyoming (1968), and States indicated by symbol W.
[3] Less than ½ unit.

Table 7.—Bentonite sold or used by producers in the United States, by States

Year and State	Short tons	Value (thousands)	Year and State	Short tons	Value (thousands)
1965	1,887,947	$20,407	1969:		
1966	2,060,616	22,010	Colorado	1,428	$7
1967	2,042,841	20,490	Mississippi	299,123	3,525
			Oregon	604	7
1968:			Texas	99,828	655
Arizona	28,197	318	Wyoming	1,952,174	18,871
California	33,139	655	Other States [1]	287,055	2,859
Colorado	1,885	13			
Mississippi	277,449	3,128	Total	2,640,212	25,924
Oregon	1,022	12			
Texas	92,487	611			
Utah	1,556	26			
Wyoming	1,777,383	17,163			
Other States [1]	224,408	2,044			
Total	2,437,526	23,970			

[1] Alabama, Arizona (1969), California (1969), Montana, Nevada, North Dakota (1969), Oklahoma, South Dakota, and Utah (1969).

Table 8.—Fuller's earth sold or used by producers in the United States, by States

Year and State	Short tons	Value (thousands)	Year and State	Short tons	Value (thousands)
1965	674,422	$15,795	1969:		
1966	759,638	18,354	Florida and Georgia	778,175	$21,123
1967	803,919	20,539	Utah	2,834	51
			Other States [1]	203,603	4,199
1968:					
Florida and Georgia	704,572	18,609	Total	984,612	25,373
Utah	2,993	55			
Other States [1]	213,985	4,512			
Total	921,550	23,176			

[1] Includes California (1968), Illinois, Mississippi, Nevada (1968), Tennessee, and Texas.

Table 9.—Miscellaneous clay and shale sold or used by producers in the United States, by States

(Thousand short tons and thousand dollars)

Year and State	Sold by producers	Used by producers	Total[1]	
	Quantity	Quantity	Quantity	Value
1965	1,310	38,043	39,354	$47,957
1966	1,156	39,005	40,161	49,865
1967	1,054	38,259	39,312	52,035
1968:				
Alabama	W	W	2,043	2,553
Arizona	W	W	49	26
Arkansas	------	760	760	1,164
California	346	1,806	2,153	4,206
Colorado	8	366	374	379
Connecticut	------	195	195	325
Delaware	------	12	12	12
Georgia	------	1,631	1,631	1,619
Hawaii	3	------	3	4
Idaho	------	12	12	14
Illinois	6	2,074	2,080	3,347
Indiana	271	1,098	1,369	2,015
Iowa	------	1,264	1,264	1,747
Kansas	------	774	774	1,084
Kentucky	W	W	1,023	1,002
Louisiana	------	863	863	1,163
Maine	------	42	42	65
Maryland	W	W	1,078	1,252
Massachusetts	------	257	257	314
Michigan	------	2,599	2,599	2,906
Minnesota	------	240	240	359
Mississippi	------	1,063	1,063	1,422
Missouri	------	1,369	1,369	1,824
Montana	------	30	30	34
Nebraska	------	148	148	206
New Hampshire	------	41	41	41
New Jersey	------	289	289	384
New Mexico	W	W	64	76
New York	W	W	1,675	1,790
North Carolina	------	3,310	3,310	2,148
Ohio	285	2,452	2,737	5,136
Oklahoma	------	726	726	963
Oregon	W	W	212	272
Pennsylvania	W	W	1,610	6,362
South Carolina	------	1,355	1,355	1,229
Tennessee	------	1,151	1,151	674
Texas	------	3,756	3,756	5,388
Utah	1	142	143	354
Virginia	------	1,462	1,462	1,714
Washington	W	W	r 255	r 253
West Virginia	W	W	194	219
Wisconsin	------	17	17	34
Other States[2]	537	r 8,343	677	786
Total[1]	1,456	r 39,647	r 41,104	r 56,863

See footnotes at end of table.

Table 9.–Miscellaneous clay and shale sold or used by producers in the United States, by States–Continued

(Thousand short tons and thousand dollars)

Year and State	Sold by producers	Used by producers	Total [1]	
	Quantity	Quantity	Quantity	Value
1969:				
Alabama	294	2,144	2,438	$3,335
Arkansas	------	833	833	1,091
California	836	1,737	2,573	5,876
Colorado	W	W	442	539
Connecticut	------	197	197	341
Delaware	------	11	11	11
Georgia	W	W	1,663	2,001
Hawaii	------	2	2	9
Idaho	W	W	23	51
Illinois	W	W	1,648	2,703
Indiana	W	W	1,317	1,950
Iowa	------	1,199	1,199	1,660
Kansas	W	W	797	1,070
Kentucky	W	W	1,034	1,022
Louisiana	------	1,078	1,078	2,943
Maine	------	42	42	56
Maryland	W	W	1,152	1,369
Massachusetts	------	332	332	625
Michigan	------	2,667	2,667	3,037
Minnesota	------	275	275	412
Mississippi	W	W	1,099	1,136
Missouri	------	1,211	1,211	1,437
Montana	W	W	34	63
Nebraska	W	W	149	223
New Hampshire	------	44	44	40
New Jersey	W	W	245	547
New Mexico	W	W	67	77
New York	W	W	1,623	1,783
North Carolina	W	W	3,342	2,610
Ohio	215	2,340	2,555	4,962
Oklahoma	------	802	802	1,178
Oregon	W	W	215	314
Pennsylvania	90	1,430	1,520	6,716
South Carolina	------	1,848	1,848	2,026
Tennessee	W	W	1,265	1,130
Texas	W	W	3,593	5,402
Virginia	------	1,677	1,677	1,504
Washington	25	205	230	434
West Virginia	W	W	247	348
Wisconsin	------	12	12	24
Wyoming	------	40	40	99
Other States [2]	1,032	19,770	845	1,208
Total [1]	2,493	39,894	42,387	63,361

[r] Revised. W Withheld to avoid disclosing individual company confidential data.
[1] Data may not add to totals shown because of independent rounding.
[2] Includes States indicated by symbol W and Arizona (1969), Florida, Nevada, North Dakota, South Dakota, Utah (1969), Vermont, and Wyoming (1968).

Table 10.—Clay sold or used by producers in the United States in 1969, by kinds [1]

(Thousand short tons)

	Miscellaneous clay and shale	Fire clay	Kaolin	Bentonite	Fuller's earth	Ball clay	Total
Heavy clay products:							
Building brick	17,355	2,579	(2)	-----	---	(2)	[3] 19,933
Drain tile	886	(4)	(2)	-----	---	---	[3] 886
Vitrified sewer pipe	1,471	362	(2)	-----	---	---	[3] 1,832
Other heavy clay products	261	113	-----	-----	---	---	511
Total	19,973	3,053	(2)	-----	---	(2)	23,163
Portland and other cements	12,049	23	45	(2)	---	---	[5] 12,117
Lightweight aggregate	9,826	(2)	-----	-----	(2)	---	[5] 9,826
Refractories:							
Firebrick and block	(4)	2,819	480	-----	---	(4)	3,315
Foundries, steelworks (bulk)	(4)	492	(4)	[6] 787	---	(4)	1,387
High alumina brick (Min 50% Al_2O_3)	------	63	(4)	-----	---	---	[3] 63
Mortar	(4)	104	(4)	-----	---	---	122
Saggers, pins, stilts, and wads	------	(4)	(4)	-----	---	(4)	(4)
Other refractories	74	245	123	(6)	---	113	414
Total	74	3,723	604	787	---	113	5,300
Filler:							
Fertilizers	(4)	-----	95	-----	(2)	---	98
Insecticides and fungicides	(4)	(2)	25	2	187	---	[3] 215
Paint	(4)	-----	122	(4)	(2)	---	125
Paper coating and filling	------	-----	2,389	(4)	(2)	(2)	[3] 2,389
Plastics	------	-----	(4)	(4)	---	---	(4)
Rubber	------	-----	371	(4)	---	---	[3] 371
Other filler uses	16	(2)	161	10	(2)	---	228
Total	16	(2)	3,164	12	[5] 187	(2)	3,426
Absorbent uses:							
Animal litter	------	-----	-----	(4)	150	---	[3] 150
Floor sweeping compound	------	-----	-----	(4)	284	---	[3] 284
Other absorbent uses	(2)	-----	-----	16	186	---	[5] 202
Total	(2)	-----	-----	16	620	---	[5] 636
Rotary-drilling mud	2	(2)	-----	582	92	(2)	[5] 676
Floor and wall tile	46	188	43	(2)	---	93	[5] 370
Pelletizing (iron ore)	------	-----	-----	787	---	---	787
Pottery and stoneware:							
Whiteware	(4)	(4)	[7] 161	(2)	---	[7] 389	[5] [7] 550
Other pottery and stoneware	44	74	(7)	-----	---	(7)	[7] 118
Total	44	74	161	(2)	---	389	[5] 668
Filtering, decolorizing and clarifying	------	-----	-----	197	47	---	244
Catalysts (oil refining)	(2)	-----	67	(2)	3	---	[5] 70
Other chemicals	------	(2)	90	(2)	(2)	---	[5] 90
Miscellaneous other uses	358	201	566	259	35	87	1,320
Grand total:							
1969	42,387	7,261	4,739	2,640	985	682	58,694
1968	r 41,104	8,054	4,201	2,438	922	630	r 57,348

r Revised.
[1] Data may not add to totals shown because of independent rounding.
[2] Included with "Miscellaneous other uses."
[3] Incomplete figure; remainder included with "Other."
[4] Included with "Other."
[5] Incomplete figure; remainder included with "Miscellaneous other uses."
[6] Some "Other refractories" included with foundries.
[7] Some "Other pottery and stoneware" included with whiteware.

Table 11.—Shipments of refractories in the United States, by kinds

Product	Unit of quantity	Shipments 1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)
CLAY REFRACTORIES					
Fire clay (including semisilica) brick and shapes, except superduty.	1,000 9-inch equivalent	260,397	$50,745	269,751	$56,852
Superduty fire-clay brick and shapes	do	71,075	23,152	75,189	26,268
High-alumina brick and shapes (50 percent Al_2O_3 and over) made substantially of calcined diaspore or bauxite.[1]	do	54,872	30,821	65,020	37,199
Insulating firebrick and shapes	do	50,928	15,269	59,989	17,788
Ladle brick	do	200,203	26,118	205,850	27,386
Sleeves, nozzles, runner brick and tuyeres	do	44,768	12,075	54,082	15,545
Glasshouse pots, tank blocks, feeder parts and upper structure shapes used only for glass tanks.[1][2]					
Hot-top refractories	Short tons	49,357	4,289	37,350	3,134
Clay-kiln furniture, radiant-heater elements, potters' supplies, and other miscellaneous shaped refractory items.		NA	8,817	NA	10,391
Refractory bonding mortars, air-setting (wet and dry types).[3]	Short tons	62,856	8,309	77,675	10,375
Refractory bonding mortars, except air-setting types.[3]	do	12,687	1,589	15,974	1,974
Plastic refractories and ramming mixes[3]	do	177,623	17,108	170,219	15,202
Castable refractories (hydraulic-setting)	do	164,512	18,613	178,394	19,987
Insulating castable refractories (hydraulic-setting).	do	37,973	5,453	41,165	6,168
Other clay refractory materials sold in lump or ground form.[4][5]	do	281,796	7,302	345,227	9,077
Total clay refractories		XX	229,660	XX	257,346
NONCLAY REFRACTORIES					
Silica brick and shapes	1,000 9-inch equivalent	59,568	$14,793	68,668	$17,476
Magnesite and magnesite-chrome brick and shapes (magnesite predominating) (excluding molten cast and fused magnesia.)	do	93,273	96,522	103,642	112,601
Chrome and chrome-magnesite brick and shapes (chrome predominating) (excluding molten cast).	do	20,312	18,391	21,637	20,816
Graphite crucibles, retorts, stopper heads, and other shaped refractories containing natural graphite.	Short tons	14,661	13,641	16,416	15,057
Mullite brick and shapes made predominantly of kyanite, sillimanite, andalusite, or synthetic mullite (excluding molten-cast).	1,000 9-inch	5,136	8,293	6,212	9,937
Extra-high alumina brick and shapes made predominantly of fused bauxite, fused or dense-sintered alumina (excluding molten cast).	do	2,918	8,245	3,705	9,558
Silicon carbide brick and shapes made predominantly of silicon carbide (including kiln furniture).	do	3,823	11,988	3,695	13,530
Zircon and zirconia brick and shapes made predominantly of either of these materials.	do	1,722	5,480	2,114	6,508
Fosterite, pyrophyllite, molten-cast, dolomite, dolomite-magnesite, and other nonclay brick and shapes including carbon refractories except those containing natural graphite.	do	23,973	39,901	25,612	48,462
Mortars:					
Basic bonding mortars (magnesite or chrome ore predominating).	Short tons	87,433	7,746	95,210	8,335

See footnotes at end of table.

Table 11.—Shipments of refractories in the United States, by kinds—Continued

Product	Unit of quantity	Shipments 1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)
Mortars—Continued					
Other nonclay refractory mortars	do	32,771	$5,799	25,027	$4,576
Nonclay refractory castables (hydraulic-setting).	do	33,710	7,950	38,410	8,778
Plastic refractories and ramming mixes (wet and dry types):					
Basic (magnesite, dolomite, or chrome ore predominating).	do	144,484	17,926	168,474	24,503
Other nonclay plastic refractories and ramming mixes.	do	65,825	14,455	64,171	13,631
Dead-burned magnesia or magnesite	do	118,913	7,308	119,831	8,098
Nonclay gunning mixes	do	260,188	25,270	249,573	26,209
Other nonclay refractory materials sold in lump or ground form. [4]	do	151,203	9,459	256,820	10,827
Total nonclay refractories		XX	313,167	XX	359,102
Grand total refractories		XX	542,827	XX	616,448

NA Not available. XX Not applicable.

[1] Excludes data for mullite and extra-high alumina refractories. These products are included with mullite and extra-high alumina brick and shapes in the nonclay refractories section.

[2] Now included with fireclay (including semisilica) brick and shapes, except superduty.

[3] Includes data for bonding mortars which contain up to 60 percent Al_2O_3, dry basis. Bonding mortars which contain more than 60 percent Al_2O_3, dry basis, are included in the nonclay refractories section.

[4] Represents only shipments by establishments classified in "manufacturing" industries, and excludes shipments to refractories producers for the manufacture of brick and other refractories.

[5] Includes data for calcined clay, ground brick, and siliceous and other gunning mixes.

Table 12.—Shipments of principal structural clay products in the United States

Product	1965	1966	1967	1968	1969
Unglazed brick (buildings) 1,000 standard brick	8,089,131	7,606,237	7,117,353	7,556,809	7,289,669
Value thousands	$301,038	$292,914	$285,630	$318,365	$318,892
Unglazed structural tile short tons	313,260	267,431	234,517	191,067	241,509
Value thousands	$5,128	$5,317	$4,900	$4,169	$6,875
Vitrified clay sewer pipe and fittings short tons	1,732,159	1,610,318	1,572,167	1,705,528	1,783,546
Value thousands	$103,420	$96,707	$97,330	$109,465	$120,420
Facing tile, ceramic glazed, including glazed brick 1,000-brick equivalent	307,944	292,525	230,064	211,223	200,074
Value thousands	$25,430	$25,179	$21,274	$19,708	$19,188
Facing tile, unglazed and salt glazed 1,000-tile, 8-by 5- by 12-inch, equivalent	6,327	5,207	3,352	3,032	2,965
Value thousands	$1,435	$1,284	$837	$750	$729
Clay floor and wall tile and accessories, including quarry tile 1,000 square feet	283,385	272,688	257,532	274,512	284,780
Value thousands	$141,739	$133,266	$128,139	$138,319	$142,878
Total value thousands	$578,190	$554,667	$538,110	$590,776	$608,982

Table 13.—World production of china clay, by countries

(Thousand short tons)

Country [1]	1967	1968	1969 p
North America:			
Mexico	87	83	99
United States [2]	3,973	4,201	4,739
South America:			
Argentina	71	80	NA
Chile	32	29	46
Colombia	12	93	97
Ecuador	(3)	1	NA
Peru	------	1	NA
Europe:			
Austria (marketable)	108	106	e 110
Belgium	109	e 110	NA
Bulgaria	138	140	143
Czechoslovakia	369	376	e 390
Denmark:			
Crude	17	e 17	e 17
Washed and pressed	3	e 3	e 3
France [4]	483	474	e 490
Germany, West (marketable)	445	451	e 480
Greece	77	77	66
Hungary	73	73	e 70
Italy:			
Crude	97	90	106
Kaolinitic earth	17	e 10	NA
Portugal	41	45	e 45
Rumania e	55	55	55
Spain (marketable)	238	250	e 250
Sweden	r 32	31	e 30
U.S.S.R. e	1,900	1,900	2,000
United Kingdom	r 2,901	3,094	e 3,000
Africa:			
Ethiopia	8	14	14
Kenya	2	1	2
Mozambique	1	(3)	(3)
Nigeria	(3)	(3)	1
South Africa, Republic of	36	36	37
Swaziland	2	2	2
Tanzania	(3)	1	1
United Arab Republic [4]	35	34	NA
Asia:			
Ceylon	3	3	3
Hong Kong	9	6	5
India [5]	565	558	621
Japan	166	187	208
Korea, South	113	133	150
Lebanon	3	NA	3
Malaysia	2	2	2
Pakistan	3	3	e 3
Taiwan	r 68	NA	12
Oceania: Australia [6]	r 73	66	e 70
Total [7]	12,367	12,836	13,370

e Estimate. p Preliminary. r Revised. NA Not available.
[1] China clay is also produced in Brazil, China, mainland, East Germany, Indonesia, Iran, Israel, Southern Rhodesia, South Vietnam, Thailand, and Yugoslavia, but data on production are not available; small quantities are produced in Angola, Malagasy Republic, Morocco, and Paraguay.
[2] Kaolin sold or used by producers.
[3] Less than ½ unit.
[4] Includes kaolinitic clay.
[5] Total crude production, including clay saleable as produced and clay requiring further processing to make it of saleable grade.
[6] Includes ball clay.
[7] Totals are of listed figures only.

Coal—Bituminous and Lignite

By J. J. Gallagher [1] and L. W. Westerstrom [1]

For the second year in a row the demand for bituminous coal and lignite was greater than production. United States bituminous coal and lignite consumption plus exports increased in 1969 to 563.5 million tons, a gain of 14 million tons, or 2.6 percent over that of 1968. Production reached the level of 560.5 million tons, 3.0 million tons less than demand but 15.3 million tons greater than output in 1968. This paradox, as in 1968, reflected in large part a continuation of wildcat strikes.

With consumption and exports up and production lagging behind, consumers again went into their stockpiles in 1969, reducing them by more than 5 million tons.

The electric utility industry established a new record of coal consumption in 1969. The total burn of bituminous coal and lignite in 1969 was 308.5 million tons, compared with 294.7 million tons in 1968, an increase of 4.7 percent. Electric heating, including sizable increases in commercial and industrial installations, continued to add significantly to electric demand.

Although gas and oil gave added compe-

[1] Industry economist, Division of Fossil Fuels.

Table 1.—Salient statistics of the bituminous coal and lignite industry in the United States

Item	1965	1966	1967	1968	1969
Production------------thousand short tons--	512,088	533,881	552,626	545,245	560,505
Value-------------------------thousands--	$2,276,022	$2,421,293	$2,555,378	$2,546,340	$2,795,509
Consumption---------thousand short tons--	459,164	486,266	480,416	498,830	507,275
Stocks at end of year:					
Industrial consumers and retail yards thousand short tons--	77,393	74,466	93,128	85,525	80,482
Stocks on upper lake docks-------do----	2,347	2,342	2,280	1,937	1,484
Exports [1]---------------------------do----	50,181	49,302	49,528	50,637	56,234
Imports [1]---------------------------do----	184	178	227	224	109
Price indicators, average per net ton:					
Cost of coking coal at merchant coke ovens------------------------------	$9.65	$9.81	$10.33	$10.58	$10.75
Railroad freight charge [2]---------------	$3.13	$3.01	$3.00	$3.01	$3.10
Value f.o.b. mines (sold in open market)--	$4.13	$4.24	$4.34	$4.38	$4.65
Value f.o.b. mines---------------------	$4.44	$4.54	$4.62	$4.67	$4.99
Method of mining:					
Hand-loaded underground thousand short tons--	36,028	28,243	19,219	14,755	11,700
Mechanically loaded underground-do----	296,633	310,281	329,914	329,387	335,431
Percentage mechanically loaded---------	89.2	91.7	94.5	95.7	96.6
Percentage cut by machine-------------	53.9	51.0	49.1	48.4	46.2
Mined by stripping-thousand short tons--	165,241	180,058	187,134	185,836	197,023
Percentage mined by stripping----------	32.3	33.7	33.9	34.1	35.2
Mined at auger mines thousand short tons--	14,186	15,299	16,360	15,267	16,350
Percentage mined at auger mines--------	2.8	2.9	2.9	2.8	2.9
Mechanically cleaned---thousand short tons--	332,226	340,626	349,402	340,923	334,761
Percentage mechanically cleaned-----------	64.9	63.8	63.2	62.5	59.7
Number of mines-------------------------	7,228	6,749	5,873	5,327	5,118
Capacity at 280 days---thousand short tons--	655,000	683,000	707,000	694,000	NA
Average number of men working daily [3]------	133,732	131,752	131,523	127,894	NA
Average number of days worked [3]----------	219	219	219	220	NA
Average days lost per man on strike [4]--------	4	7	3	5	4
Production per man per day-----short tons--	17.52	18.52	19.17	19.37	NA
Production per man per year---------do----	3,829	4,052	4,198	4,263	NA

NA Not available.
[1] Bureau of the Census, U.S. Department of Commerce.
[2] Interstate Commerce Commission.
[3] Based on data supplied by Accident Analysis Branch U.S. Bureau of Mines.
[4] Bureau of Labor Statistics, U.S. Department of Labor.

tition to coal, the nuclear pressure decreased markedly in 1969. Coal had to contend with accelerated drives for clean air and water. Helping to offset these factors as they relate to future demand is the lively expectation that oil and gas production from coal will start in the not-too-distant future.

In 1969 many new coal mines yielded their first output, and a sizable number of new mines was announced for future openings as the industry set its sights on new production records in the near future.

The bituminous coal and lignite industry continued its search for solutions to the shortage of manpower to fill the job openings at the new and expanding mines. With the new Federal Coal Mine Health and Safety Act, producing companies concentrated more attention on methods of improving the underground working environment while increasing overall safety.

This chapter includes all coal produced in the United States except Pennsylvania anthracite, lignite produced in Texas, and bituminous coal and lignite from mines that produced less than 1,000 tons during the year. All tonnage figures refer to marketable coal and exclude washery and other refuse. Information on employment and output per man in 1969 will be published as a supplement to the Mineral Industry Survey, the Weekly Coal Report, and in the 1970 Minerals Yearbook

DISTRIBUTION AND SHIPMENTS

Shipments of bituminous coal and lignite, summarized by districts of origin, States of destination, type of consumer use and by methods of transportation, show the participation of the bituminous coal and lignite industry in various energy markets of the Nation, both locally and nationally.

The distribution data by consumer use do not necessarily conform to the consumption data because the latter represent actual use at consumers' facilities whereas the distribution data represent shipments from the mines, some of which were in transit or in consumers' storage.

Total shipments in 1969 increased 2.7 percent from those in 1968, with most geographic divisions sharing in the increase. The largest increases were in the East North Central, West North Central, and Mountain geographic divisions. Shipments to New England, Middle Atlantic, and West South Central areas were lower than in 1968. Of the total 14.6 million ton net increase in shipments in 1969, electric utilities were up 14.6 million tons, coke and gas plants increased 2.1 million tons, overseas exports grew 5.4 million tons. Decreases of 2.0 and 6.0 million tons occurred in shipments to retail dealers and "all others," respectively. Miscellaneous items such as railroad fuel, mine fuel, employees' coal, Canadian and United States Great Lakes dock storage accounts, U.S. tidewater dock storage accounts, and net change in mine inventory were up 0.5 million tons.

The quantitative changes in total tons shipped, expressed in indexes, that took place throughout the country, by geographic division, State of destination, and consumer use, are shown for the years 1957 and 1965 through 1969 in table 42. The year 1957 is used as the base year, and represents 100. For example, 1957 (base year) shipments of bituminous coal and lignite in the United States amounted to 493,895,000 tons. Total shipments in 1965 represented 103.8 percent of the 1957 level; in 1966 total shipments, compared with 1957 figures, amounted to 107.8 percent. In 1969 they represented 113.4 percent.

To indicate the size of the bituminous coal and lignite market, quantitatively, in each geographic division, State, and consumer use category, the 1957 total tons shipped are shown in lieu of the index numbers of 100, which each tonnage figure represents (except those otherwise noted).

These distribution data are based on reports submitted quarterly, to the Bureau of Mines voluntarily by producers, sales agents, distributors, and wholesalers who normally produce or sell 100,000 tons or more annually. The unprecedented cooperation of these respondents resulted in their reporting about 94 percent of all coal produced or shipped. To account for total industry shipments, estimates for the remaining shipments are included, based on data from coal trade and other reliable coal statistical reporting agencies.

Additional details of bituminous coal and lignite distribution for 1969 are presented in a Bureau of Mines report.[2]

[2] Bureau of Mines. Bituminous Coal and Lignite Distribution Calendar Year 1969. Mineral Industry Survey, April 1970, 39 pp.

FOREIGN TRADE

United States imported only 109,000 tons of bituminous coal and lignite in 1969, less than half the quantity imported in 1968. Except for 47 tons, all coal imported in 1969 was produced in Canada.

After World War II bituminous coal exports became an important item of foreign trade, contributing significantly to our international balance of payments.

In 1969 the United States continued to be the largest coal exporter in the world. Total exports rose to 56.2 million tons and were valued at $585 million, increases of 5.6 million tons and $89.5 million over 1968. Nearly 95 percent of U.S. exports in 1969 were shipped to Japan, Canada, and Europe. The bulk of the remaining 5 percent went to Brazil, Argentina, Chile, Ecuador, and Mexico.

Shipments of coal to the "iron curtain" countries during 1969 amounted to 159,000 tons, all destined for East Germany and Rumania; 1968 exports to these East bloc countries totaled 184,000 tons.

While exports of coal fluctuated widely prior to 1961 because of various emergencies abroad, since then, with no major fuel emergencies, exports have increased considerably. There is reason to believe that because of its high quality and competitive price, U.S. coal will continue to provide an important part of the coal supply in Canada, Japan, and Western Europe.

WORLD REVIEW

World production of coal totaled 3,171,390,000 tons in 1969, an increase of 2.6 percent over the revised total of 1968. The United States supplied nearly 571 million tons of bituminous coal, anthracite, and lignite, or 18 percent of the world output in 1969.

North America's contribution to world output increased 2.4 percent from the 1968 level. The production of all other continents increased. South America rose 5.5 percent; Europe increased 1.1 percent; Africa was up 1.7 percent; Oceania showed the greatest percentage increase, amounting to 7.8 percent; Asia was second highest with a gain of 7.3 percent.

Production in the U.S.S.R., the largest coal-producing country in the world, was estimated at 670 million tons in 1969, an increase of 2.4 percent from the revised 1968 tonnage.

TECHNOLOGY

New production records were set at many mines in 1969 as a record number of continuous mining machines were pressed into service. The new units appeared in more powerful designs and are equipped with dual-voltage of 480 and 950 volts (ac.). These machines continue to contribute to new production records. In one operation, a continuous miner working in thick coal produced some 2,100 tons in a shift.

Other highlights of 1969 included the installation of more battery-powered front-end loaders capable of handling a variety of jobs and the successful use of the electric wheel shuttle car. These cars, which were introduced in 1968, made gains in 1969, particularly in mines with wet, soft bottoms. Tractor-trailers also increased in number and were utilized in a wide range of conditions.

A roof-control technique was introduced in 1969 that not only increased safety but boosted productivity as well. The application of this machine, called a miner-bolter, eliminates bolting bottlenecks by making it possible to bolt and mine simultaneously. The miner, for example, can advance four feet without interfering with the bolting cycle in which bolts can be set vertically in any pattern.

Many new mines are relying on belt conveyors, mostly rope sideframe units, for transporting coal in panel entries, and an increasing number of mines rely on belts to carry coal from the section to the surface. Dust problems and spillage at transfer points were minimized by more effective use of water sprays and transfer chutes. At deep shaft mines, fully automated hoists improved efficiency and dependability in handling coal, men, and materials.

An increasing number of mines adopted bulk rock dusting systems that included surface storage tanks that can deliver rock-dust through boreholes to pressurized cars or tanks for delivery to the faces as needed.

In the continuing drive to improve worker environment and safety producers developed new methods to control dust, remove methane, and to protect machine operators. Methods to control dust involved water infusion, the use of water sprays on face equipment and belt conveyors and improved ventilation. One company successfully drilled boreholes to longwall job areas to effectively bleed off methane from air returns. Expanded use of protective cabs on shuttle cars, loaders and cutters helped to reduce injuries to machine operators.

Treatment of acid mine drainage water was much more widely employed in 1969. Treatment methods included the use of limestone or slaked lime to neutralize mine water. Where lime was used, systems included automatic feeding of lime slurry to raw water, aeration and subsequent settling of solids in large ponds.

In transportation, significant advances were made in unit train and barge loading facilities. One western mine can now load a unit train at the rate of 11,000 tph from a 70,000-ton stockpile. A loading tunnel runs under the stockpile making possible the loading of 84,100-ton cars in less than 1 hour.

These loading concepts were also adopted by mines located on or near rivers. At a Kentucky property, a 5,000-tph loading rate made possible the filling of 15 barges in less than 5 hours.

Coal by pipeline will again reach commercial status as construction began on the 273-mile Black Mesa slurry line from Peabody Coal Company's Kayenta mine in northeastern Arizona, to the Mohave power plant at Davis Dam, Nevada. Operation is expected to begin in 1970 with a delivery capacity of 660 tons of coal per hour.

Air pollution control efforts were intensified. The U.S. Department of Health, Education, and Welfare through its National Air Pollution Control Administration delineated air-quality regions and an air-quality criteria for the guidance of States in pollution control. At State and local levels, as well as the Federal, there was major emphasis on the substitution of low-sulfur coal, oil, and natural gas in power and other industrial and commercial facilities. The Bureau of Mines assisted HEW under contract to study the availability of low-sulfur coals in the Appalachian region.

Substantial research was conducted in coal utilization by the Bureau of Mines. Contract work began on construction of three pilot plants for research on synthetic fuels. Two of these plants are for additional research on coal gasification processes, and one is a plant combining research on both liquids and gas. These projects, as well as other work being conducted under Office of Coal Research contracts, offer the potential for creation of a synthetic fuels industry in the United States during the middle 1970's. To meet this time table, however, planning is required for the demonstration plant stage of effort to be combined with industry participation on a major level.

Table 2.–Production of bituminous coal and lignite, in the United States, in 1969, by States, with estimates by months [1]

(Thousand short tons)

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Alabama	1,467	1,305	1,456	1,467	1,405	1,334	1,172	1,506	1,646	1,694	1,341	1,663	17,456
Alaska	86	71	61	53	38	45	40	49	56	62	51	55	667
Arkansas	24	22	22	17	19	16	18	17	17	19	15	22	228
Colorado	580	464	494	417	376	393	291	454	467	500	509	585	5,530
Illinois	5,338	5,266	5,674	5,319	5,779	4,886	3,680	5,641	5,453	6,202	5,431	6,053	64,722
Indiana	1,621	1,597	1,692	1,656	1,775	1,535	1,379	1,727	1,737	1,946	1,631	1,790	20,086
Iowa	65	66	61	91	84	67	65	89	81	83	75	76	903
Kansas	78	92	127	124	139	103	43	108	120	105	107	167	1,313
Kentucky:													
Eastern	4,987	4,475	5,036	4,812	5,770	5,122	5,016	5,618	4,272	5,920	5,013	5,543	61,584
Western	4,434	4,143	3,952	3,224	3,865	3,333	3,283	3,978	4,434	4,448	3,672	4,700	47,466
Total	9,421	8,618	8,988	8,036	9,635	8,455	8,299	9,596	8,706	10,368	8,685	10,243	109,050
Maryland	100	91	84	118	100	100	109	168	157	148	92	101	1,368
Missouri	196	159	246	360	290	256	374	462	454	176	167	161	3,301
Montana:													
Bituminous	27	22	21	17	25	23	29	137	102	96	99	124	722
Lignite	11	9	9	7	11	10	13	59	44	41	42	52	308
Total	38	31	30	24	36	33	42	196	146	137	141	176	1,030
New Mexico	301	271	292	340	430	347	317	389	484	634	308	358	4,471
North Dakota (lignite)	442	490	418	286	316	312	311	272	336	521	456	544	4,704
Ohio	4,504	3,820	4,334	4,251	4,439	3,709	2,977	5,034	4,683	4,896	4,087	4,508	51,242
Oklahoma	90	103	135	100	155	129	126	207	191	179	183	240	1,838
Pennsylvania	6,689	6,317	6,873	6,854	6,862	6,315	4,956	6,379	6,800	7,475	6,479	6,632	78,631
Tennessee	699	594	618	702	737	673	614	724	664	755	649	653	8,082
Utah	479	435	473	400	388	387	216	348	378	297	392	464	4,657
Virginia	3,077	2.641	3,028	2,879	3,065	2,774	2,416	3,091	2.961	3,560	2.900	3,163	35,555
Washington	8	7	6	7	3	3	3	3	3	5	4	6	58
West Virginia	12,182	9,486	9,298	13,467	13,411	12,146	8,297	11,585	13,251	13,640	11,476	12,772	141,011
Wyoming	552	363	324	254	277	239	251	302	366	504	508	662	4,602
Total	48,037	42,309	44,734	47,222	49,759	44,257	35,996	48,347	49,157	53,906	45,687	51,094	560,505

[1] Figures are based principally upon railroad carloadings and shipments on the Allegheny and Monogahela Rivers, supplemented by direct reports from certain local sources. These estimates include coal both shipped by truck, and used at the mines, and the totals represent output for all mines producing 1,000 tons or more per year.

Table 3.—Production of bituminous coal and lignite in the United States, with estimates by weeks

(Thousand short tons)

1968				1969			
Week ended—	Production	Maximum number of working days	Average production per working day	Week ended—	Production	Maximum number of working days	Average production per working day
Jan. 6	8,443	5	1,689	Jan. 4	4,551	[1]3	[2]1,517
Jan. 13	10,177	6	1,696	Jan. 11	10,826	6	1,804
Jan. 20	10,275	6	1,713	Jan. 18	11,400	6	1,900
Jan. 27	10,929	6	1,822	Jan. 25	10,922	6	1,820
Feb. 3	8,672	6	1,445	Feb. 1	10,891	6	1,815
Feb. 10	10,769	6	1,795	Feb. 8	11,038	6	1,840
Feb. 17	11,058	6	1,843	Feb. 15	11,229	6	1,872
Feb. 24	10,802	6	1,800	Feb. 22	10,821	6	1,804
Mar. 2	11,337	6	1,888	Mar. 1	9,218	6	1,536
Mar. 9	11,370	6	1,895	Mar. 8	7,893	6	1,316
Mar. 16	10,928	6	1,821	Mar. 15	10,196	6	1,699
Mar. 23	11,309	6	1,885	Mar. 22	12,020	6	2,003
Mar. 30	12,078	6	2,013	Mar. 29	11,733	6	1,956
Apr. 6	9,727	5.3	1,835	Apr. 5	9,994	5.3	1,886
Apr. 13	11,447	6	1,908	Apr. 12	10,791	6	1,799
Apr. 20	11,520	6	1,920	Apr. 19	11,269	6	1,878
Apr. 27	11,554	6	1,926	Apr. 26	11,451	6	1,909
May 4	11,064	6	1,844	May 3	11,451	6	1,909
May 11	11,384	6	1,897	May 10	11,380	6	1,897
May 18	11,101	6	1,850	May 17	11,431	6	1,905
May 25	11,149	6	1,858	May 24	11,617	6	1,936
June 1	9,583	5.1	1,879	May 31	9,929	5.1	1,947
June 8	11,664	6	1,944	June 7	11,723	6	1,954
June 15	11,707	6	1,951	June 14	10,090	6	1,682
June 22	11,664	6	1,944	June 21	9,924	6	1,654
June 29	5,645	2.7	2,091	June 28	11,325	6	1,888
July 6	4,025	1.7	2,368	July 5	4,612	1.9	2,427
July 13	9,969	4.7	2,121	July 12	4,995	2.2	2,270
July 20	10,778	5.7	1,891	July 19	9,253	4.3	2,152
July 27	11,386	6	1,898	July 26	9,752	5.3	1,840
Aug. 3	11,084	6	1,847	Aug. 2	11,577	6	1,930
Aug. 10	11,149	6	1,858	Aug. 9	11,693	6	1,949
Aug. 17	11,250	6	1,875	Aug. 16	11,521	6	1,920
Aug. 24	11,417	6	1,903	Aug. 23	10,675	6	1,779
Aug. 31	11,572	6	1,929	Aug. 30	11,406	6	1,901
Sept. 7	9,725	5	1,945	Sept. 6	9,848	5	1,970
Sept. 14	11,596	6	1,933	Sept. 13	11,632	6	1,939
Sept. 21	11,607	6	1,935	Sept. 20	11,839	6	1,973
Sept. 28	12,309	6	2,052	Sept. 27	11,930	6	1,988
Oct. 5	8,415	6	1,403	Oct. 4	11,658	6	1,943
Oct. 12	4,674	6	779	Oct. 11	12,086	6	2,014
Oct. 19	7,332	6	1,222	Oct. 18	11,567	6	1,928
Oct. 26	10,914	6	1,819	Oct. 25	11,874	6	1,979
Nov. 2	11,597	6	1,933	Nov. 1	11,869	6	1,978
Nov. 9	11,008	6	1,835	Nov. 8	11,607	6	1,935
Nov. 16	9,898	5.3	1,868	Nov. 15	10,670	5.3	2,013
Nov. 23	11,343	6	1,891	Nov. 22	11,678	6	1,946
Nov. 30	9,614	5	1,923	Nov. 29	10,579	5	2,116
Dec. 7	10,489	6	1,748	Dec. 6	12,499	6	2,083
Dec. 14	11,251	6	1,875	Dec. 13	12,333	6	2,056
Dec. 21	11,084	6	1,847	Dec. 20	12,056	6	2,009
Dec. 28	8,038	5	1,608	Dec. 27	8,261	4.5	1,836
Jan. 4	[1]4,365	[1]2	[2]1,743	Jan. 3	5,922	[1]3	[2]1,974
Total[3]	545,245	298.5	1,827	Total[3]	560,505	295.9	1,894

[1] Figures represent output and number of working days in that part of week included in calendar year shown.
[2] Average daily output for the working days in the calendar year shown.
[3] Data may not add to totals shown because of independent rounding.

Table 4.—Number of mines, production, value, men working daily, days active, man-days, and output per man per day at bituminous coal and lignite mines in the United States, in 1968, by States

State	Number of active mines	Production (thousand short tons): Shipped by rail or water [1]	Production: Shipped by truck	Production: Used at mine [2]	Production: Total [3]	Average value per ton [4]	Average number of men working daily	Average number of days worked	Number of man-days worked (thousands)	Average tons per man per day
Alabama	142	13,295	2,416	729	16,440	$7.04	4,907	219	1,073	15.33
Alaska	3	745	4	1	750	6.00	99	214	21	35.52
Arkansas	8	208	3	---------	211	7.47	101	201	20	10.40
Colorado	54	4,176	1,298	85	5,558	4.82	1,314	232	306	18.20
Illinois	70	53,635	5,677	3,129	62,441	4.01	8,405	250	2,104	29.67
Indiana	44	13,659	2,352	2,475	18,486	3.88	2,165	253	547	33.80
Iowa	15	612	264	---------	876	3.75	166	255	42	20.70
Kansas	4	1,245	23	---------	1,268	5.15	193	298	57	22.06
Kentucky	1,395	92,139	8,950	68	101,156	3.91	22,738	198	4,513	22.41
Maryland	61	808	640	---------	1,447	3.67	329	210	69	20.92
Missouri	12	1,628	346	1,232	3,205	4.20	346	310	107	29.85
Montana:										
Bituminous	9	155	34	---------	189	3.12	45	143	6	29.37
Lignite	2	329	1	---------	330	1.89	16	242	4	85.13
Total [3]	11	484	35	---------	519	2.34	61	169	10	50.33
New Mexico	6	1,151	2,278	---------	3,429	3.94	294	225	66	51.88
North Dakota (lignite)	22	2,950	315	1,221	4,487	1.78	297	217	64	69.65
Ohio	372	32,328	13,129	2,866	48,323	3.96	8,002	238	1,904	25.38
Oklahoma	8	1,076	9	4	1,089	5.88	245	249	61	17.86
Pennsylvania	805	57,587	15,261	3,352	76,200	5.37	21,544	229	4,938	15.43
Tennessee	182	5,944	2,204	---------	8,148	3.64	2,029	206	417	19.54
Utah	23	3,878	421	17	4,316	5.77	1,155	224	259	16.68
Virginia	809	34,511	2,241	214	36,966	4.84	10,654	210	2,232	16.56
Washington	5	10	168	---------	178	4.63	52	214	11	15.96
West Virginia	1,263	139,687	3,668	2,566	145,921	5.32	42,471	218	9,255	15.77
Wyoming	13	1,571	51	2,207	3,829	3.16	327	232	76	50.55
Total [3]	5,327	463,328	61,753	20,165	545,245	4.67	127,894	220	28,153	19.37

[1] Includes coal loaded at mines directly into railroad cars or river barges, hauled by trucks to railroad sidings, and hauled by trucks to waterways.
[2] Includes coal used at mine for power and heat, made into beehive coke at mine, used by mine employees, used for all other purposes at mine, and transported from mine to point of use by conveyor, tram, or pipeline.
[3] Data may not add to totals shown because of independent rounding.
[4] Value received or charged for coal, f.o.b. mine. Includes a value, estimated by producer, for coal not sold.

Table 5.—Number of mines, production, value, men working daily, days active, man-days, and output per man per day at bituminous coal and lignite mines in the United States, in 1968, by districts

District	Number of active mines	Production (thousand short tons)				Average value per ton [4]	Average number of men working daily	Average number of days worked	Number of man-days worked (thousands)	Average tons per man per day
		Shipped by rail or water [1]	Shipped by truck	Used at mine [2]	Total [3]					
1. Eastern Pennsylvania	643	28,725	10,037	2,647	41,408	$4.52	11,571	230	2,656	15.59
2. Western Pennsylvania	240	32,312	6,405	705	39,422	6.09	10,961	229	2,507	15.72
3. Northern West Virginia	342	42,004	1,251	4	43,260	4.82	10,670	218	2,324	18.62
4. Ohio	372	32,328	13,129	2,866	48,323	3.96	8,002	238	1,904	25.38
5. Michigan	---	---	---	---	---	---	---	---	---	---
6. Panhandle	17	4,383	255	2,311	6,949	4.42	1,881	234	440	15.81
7. Southern Numbered 1	479	37,226	904	172	38,302	6.39	14,496	217	3,145	12.18
8. Southern Numbered 2	2,659	144,476	7,323	352	152,151	4.70	44,542	202	8,984	16.94
9. West Kentucky	84	40,159	6,347	8	46,515	3.42	5,177	246	1,275	36.49
10. Illinois	70	53,635	5,677	3,129	62,441	4.01	8,405	250	2,104	29.67
11. Indiana	44	13,659	2,352	2,475	18,486	3.88	2,165	253	547	33.80
12. Iowa	15	612	264	---	876	3.75	166	255	42	20.70
13. Southeastern	193	14,686	2,858	729	18,272	6.71	5,374	217	1,167	15.66
14. Arkansas-Oklahoma	12	571	3	4	579	7.82	243	215	52	11.09
15. Southwestern	20	3,586	378	1,232	5,195	4.51	642	302	194	26.80
16. Northern Colorado	4	445	207	2	654	4.25	184	226	42	15.71
17. Southern Colorado	52	4,494	1,094	83	5,670	5.37	1,270	230	292	19.39
18. New Mexico	4	389	2,275	---	2,664	2.66	154	241	37	71.93
19. Wyoming	13	1,571	51	2,207	3,829	3.16	327	232	76	50.55
20. Utah	23	3,878	421	17	4,316	5.77	1,155	224	259	16.68
21. North-South Dakota	22	2,950	315	1,221	4,487	1.78	297	217	64	69.65
22. Montana	11	484	35	---	519	2.34	61	169	10	50.33
23. Washington	8	755	172	1	928	5.74	151	212	32	28.76
Total [3]	5,327	463,328	61,753	20,165	545,245	4.67	127,894	220	28,153	19.37

[1] Includes coal loaded at mine directly into railroad cars or river barges, hauled by trucks to railroad sidings, and hauled by trucks to waterways.
[2] Includes coal used at mine for power and heat, made into beehive coke at mine, used by mine employees, used for all other purposes at mine, and transported from mine to point of use by conveyor, tram, or pipeline.
[3] Data may not add to totals shown because of independent rounding.
[4] Value received or charged for coal, f.o.b. mines. Includes a value, estimated by producer for coal not sold.

Table 6.—Number of mines, production, and value, at bituminous coal and lignite mines in the United States, in 1969, by districts

District	Number of active mines	Production (thousand short tons)				Average value per ton [4]
		Shipped by rail or water [1]	Shipped by truck	Used at mine [2]	Total [3]	
1. Eastern Pennsylvania	677	28,337	10,218	5,207	43,761	$5.18
2. Western Pennsylvania	236	33,175	6,255	78	39,508	6.63
3. Northern West Virginia	317	39,538	1,445	3	40,986	5.07
4. Ohio	322	32,675	13,909	4,657	51,242	4.10
5. Michigan	--------	--------	--------	--------	--------	--------
6. Panhandle	15	5,373	377	2,354	8,104	4.71
7. Southern Numbered 1	451	35,473	472	192	36,138	7.02
8. Southern Numbered 2	2,554	147,490	8,359	312	156,161	5.09
9. West Kentucky	80	40,682	6,782	1	47,466	3.52
10. Illinois	65	54,854	6,110	3,759	64,722	4.32
11. Indiana	38	14,626	2,884	2,576	20,086	4.13
12. Iowa	14	595	306	1	903	3.76
13. Southeastern	186	15,127	3,130	771	19,029	7.17
14. Arkansas-Oklahoma	13	763	3	--------	766	8.18
15. Southwestern	18	4,008	492	1,414	5,913	4.67
16. Northern Colorado	4	426	144	2	572	4.52
17. Southern Colorado	51	4,737	1,038	19	5,793	5.79
18. New Mexico	4	439	3,197	--------	3,637	2.58
19. Wyoming	12	1,702	48	2,852	4,602	3.36
20. Utah	21	4,240	393	24	4,657	6.31
21. North-South Dakota	20	2,974	378	1,352	4,704	1.85
22. Montana	12	992	37	--------	1,030	2.13
23. Washington	8	673	52	1	726	6.68
Total [3]	5,118	468,900	66,030	25,575	560,505	4.99

[1] Includes coal loaded at mine directly into railroad cars on river barges, hauled by trucks to railroad sidings, and hauled by trucks to waterways.
[2] Includes coal used at mine for power and heat, made into beehive coke at mine, used by mine employees, used for all other purposes at mine, and transported from mine to point of use by conveyor, tram, or pipeline.
[3] Data may not add to totals shown because of independent rounding.
[4] Value received or charged for coal, f.o.b. mine. Includes a value, estimated by producer, for coal not sold.

Table 7.—Number and production of bituminous coal and lignte mines in the United States, in 1969, by States, size of output, and type of mining

(Thousand short tons)

State	500,000 tons and over		200,000 to 500,000 tons		100,000 to 200,000 tons		50,000 to 100,000 tons		10,000 to 50,000 tons		Less than 10,000 tons		Total [1]	
	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity
Alabama:														
Underground	7	6,974	5	1,793	-------	-------	1	66	14	253	47	201	74	9,287
Strip	3	2,098	5	1,619	18	2,448	20	1,539	12	395	6	30	64	8,130
Auger	-------	-------	-------	-------	-------	-------	-------	-------	1	39	-------	-------	1	39
Total [1]	10	9,072	10	3,412	18	2,448	21	1,605	27	687	53	231	139	17,456
Alaska: Strip	-------	-------	2	664	-------	-------	-------	-------	-------	-------	1	3	3	667
Arkansas:														
Underground	-------	-------	-------	-------	-------	-------	-------	-------	2	61	-------	-------	2	61
Strip	-------	-------	-------	-------	-------	-------	1	88	2	67	3	12	6	167
Total [1]	-------	-------	-------	-------	-------	-------	1	88	4	128	3	12	8	228
Colorado:														
Underground	2	1,486	4	1,125	3	524	2	144	14	275	18	61	43	3,615
Strip	3	1,777	-------	-------	-------	-------	1	69	2	56	3	13	9	1,915
Total [1]	5	3,264	4	1,125	3	524	3	214	16	331	21	73	52	5,530
Illinois:														
Underground	17	29,107	1	410	3	368	2	142	3	48	2	7	28	30,082
Strip	21	32,768	4	1,393	2	248	2	149	3	53	5	29	37	34,640
Total [1]	38	61,874	5	1,804	5	616	4	291	6	102	7	36	65	64,722
Indiana:														
Underground	2	1,838	-------	-------	1	107	2	149	1	15	-------	-------	6	2,110
Strip	12	16,904	1	361	3	388	3	232	3	54	10	37	32	17,976
Total [1]	14	18,743	1	361	4	495	5	381	4	69	10	37	38	20,086
Iowa:														
Underground	-------	-------	1	217	1	149	-------	-------	-------	-------	1	2	3	368
Strip	-------	-------	-------	-------	1	113	2	188	6	220	2	14	11	534
Total [1]	-------	-------	1	217	2	262	2	188	6	220	3	16	14	903
Kansas: Strip	1	1,013	1	291	-------	-------	-------	-------	-------	-------	2	8	4	1,313

Kentucky:														
Underground	36	35,843	23	7,257	38	5,242	83	5,893	347	8,003	501	2,098	1,028	64,336
Strip	18	26,427	18	5,535	16	2,281	25	1,678	57	1,451	29	130	163	37,503
Auger	-------	-------	4	1,267	14	1,776	31	2,318	73	1,733	28	116	150	7,211
Total [1]	54	62,271	45	14,058	68	9,300	139	9,890	477	11,187	558	2,344	1,341	109,049
Maryland:														
Underground	-------	-------	-------	-------	1	106	1	81	4	100	14	36	20	322
Strip	-------	-------	-------	-------	-------	-------	9	658	10	260	12	45	31	962
Auger	-------	-------	-------	-------	-------	-------	-------	-------	3	59	4	24	7	83
Total [1]	-------	-------	-------	-------	1	106	10	739	17	418	30	105	58	1,368
Missouri:														
Underground	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	1	1	1	1
Strip	3	2,747	1	372	1	106	-------	-------	3	74	-------	-------	8	3,299
Total [1]	3	2,747	1	372	1	106	-------	-------	3	74	1	1	9	3,301
Montana:														
Underground	-------	-------	-------	-------	-------	-------	-------	-------	1	11	6	24	7	35
Strip	1	521	1	307	1	164	-------	-------	-------	-------	2	3	5	995
Total [1]	1	521	1	307	1	164	-------	-------	1	11	8	27	12	1,030
New Mexico:														
Underground	1	832	-------	-------	-------	-------	-------	-------	-------	-------	3	4	4	836
Strip	1	3,187	1	441	-------	-------	-------	-------	-------	-------	1	7	3	3,636
Total [1]	2	4,020	1	441	-------	-------	-------	-------	-------	-------	4	11	7	4,471
North Dakota: Strip	3	3,553	2	738	2	266	1	62	2	36	10	48	20	4,704
Ohio:														
Underground	17	17,345	2	686	1	162	3	209	9	176	14	47	46	18,625
Strip	14	16,777	18	5,564	24	3,356	42	2,994	76	2,011	56	312	230	31,014
Auger	-------	-------	-------	-------	1	110	11	828	26	630	8	33	46	1,602
Total [1]	31	34,122	20	6,249	26	3,628	56	4,031	111	2,818	78	392	322	51,242
Oklahoma:														
Underground	-------	-------	-------	-------	1	108	-------	-------	-------	-------	1	8	2	115
Strip	1	1,196	1	250	1	164	2	101	-------	-------	2	3	7	1,713
Auger	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	1	9	1	9
Total [1]	1	1,196	1	250	2	271	2	101	-------	-------	4	20	10	1,838
Pennsylvania:														
Underground	39	40,712	31	9,969	22	3,051	11	893	42	1,096	83	318	228	56,039
Strip	1	713	3	1,182	50	6,566	81	5,566	275	7,247	131	695	541	21,970
Auger	-------	-------	-------	-------	-------	-------	-------	-------	24	436	37	187	61	622
Total [1]	40	41,425	34	11,152	72	9,617	92	6,459	341	8,779	251	1,200	830	78,631

See footnote at end of table.

Table 7.—Number and production of bituminous coal and lignite mines in the United States, in 1969, by States, size of output and type of mining—Continued

(Thousand short tons)

State	500,000 tons and over		200,000 to 500,000 tons		100,000 to 200,000 tons		50,000 to 100,000 tons		10,000 to 50,000 tons		Less than 10,000 tons		Total [1]	
	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity
Tennessee:														
Underground	2	1,498	2	562	6	927	10	627	28	581	64	277	112	4,473
Strip	-------	-------	-------	-------	11	1,627	15	943	29	767	7	34	62	3,371
Auger	-------	-------	-------	-------	-------	-------	1	50	8	169	2	19	11	238
Total [1]	2	1,498	2	562	17	2,554	26	1,621	65	1,516	73	330	185	8,082
Utah: Underground	4	3,081	2	575	6	777	1	72	5	146	3	7	21	4,657
Virginia:														
Underground	14	14,666	9	2,631	23	3,449	24	1,670	300	6,815	228	1,143	598	30,373
Strip	-------	-------	2	645	5	743	5	377	59	1,769	5	27	76	3,561
Auger	-------	-------	-------	-------	1	126	2	120	69	1,318	10	57	82	1,621
Total [1]	14	14,666	11	3,275	29	4,318	31	2,166	428	9,902	243	1,227	756	35,555
Washington:														
Underground	-------	-------	-------	-------	-------	-------	-------	-------	2	46	1	8	3	53
Strip	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	2	5	2	5
Total [1]	-------	-------	-------	-------	-------	-------	-------	-------	2	46	3	13	5	58
West Virginia:														
Underground	67	69,837	102	32,464	61	8,432	63	4,449	219	4,989	355	1,451	867	121,623
Strip	1	891	13	4,040	24	3,340	48	3,439	104	2,551	39	203	229	14,464
Auger	-------	-------	2	445	9	1,432	19	1,312	59	1,616	22	119	111	4,924
Total [1]	68	70,728	117	36,950	94	13,205	130	9,200	382	9,156	416	1,773	1,207	141,011
Wyoming:														
Underground	-------	-------	-------	-------	1	113	-------	-------	-------	-------	3	9	4	122
Strip	4	3,889	2	567	-------	-------	-------	-------	1	23	1	2	8	4,481
Total [1]	4	3,889	2	567	1	113	-------	-------	1	23	4	11	12	4,602
United States:														
Underground	208	223,219	182	57,689	168	23,515	203	14,395	991	22,615	1,345	5,702	3,097	347,132
Strip	87	114,461	75	23,969	159	21,810	257	18,083	644	17,034	329	1,660	1,551	197,023
Auger	-------	-------	6	1,712	25	3,444	64	4,628	263	6,000	112	564	470	16,350
Total [1]	295	337,683	263	83,370	352	48,770	524	37,108	1,898	45,649	1,786	7,925	5,118	560,505

[1] Data may not add to totals shown because of independent rounding.

Table 8.—Production of bituminous coal and lignite in the United States, in 1969, by districts, and by underground, strip, and auger mining

(Thousand short tons)

District	Underground	Strip	Auger	Total
1. Eastern Pennsylvania	23,762	19,306	692	43,761
2. Western Pennsylvania	34,670	4,760	79	39,508
3. Northern West Virginia	35,343	5,453	190	40,986
4. Ohio	18,625	31,014	1,602	51,242
5. Michigan	--------	--------	--------	--------
6. Panhandle	7,889	215	--------	8,104
7. Southern Numbered 1	31,772	3,688	678	36,138
8. Southern Numbered 2	122,933	20,182	13,048	156,161
9. West Kentucky	19,834	27,618	14	47,466
10. Illinois	30,082	34,640	--------	64,722
11. Indiana	2,110	17,976	--------	20,086
12. Iowa	368	534	--------	903
13. Southeastern	10,251	8,739	39	19,029
14. Arkansas-Oklahoma	176	580	9	766
15. Southwestern	1	5,912	--------	5,913
16. Northern Colorado	572	--------	--------	572
17. Southern Colorado	3,878	1,915	--------	5,793
18. New Mexico	1	3,636	--------	3,637
19. Wyoming	122	4,481	--------	4,602
20. Utah	4,657	--------	--------	4,657
21. North-South Dakota	--------	4,704	--------	4,704
22. Montana	35	995	--------	1,030
23. Washington	53	672	--------	726
Total [1]	347,132	197,023	16,350	560,505

[1] Data may not add to totals shown because of independent rounding.

Table 9.—Underground mine data for bituminous coal

(Thousand

State	Number of mines	Production	Cut by hand and shot from solid	Cut by machines: Quantity	Cut by machines: Number of coal cutting machines	Cut by machines: Average output per machine	Mined by continuous mining machines
Alabama	74	9,287	144	8,491	96	88	652
Arkansas	2	61	--------	61	6	10	--------
Colorado	43	3,615	2	837	54	16	2,776
Illinois	28	30,082	--------	12,212	51	239	17,832
Indiana	6	2,110	--------	1,952	15	130	158
Iowa	3	368	--------	368	5	74	--------
Kentucky	1,028	64,336	4,410	48,300	777	62	11,624
Maryland	20	322	33	202	16	13	87
Missouri	1	1	--------	1	1	1	--------
Montana	7	35	--------	35	10	4	--------
New Mexico	4	836	2	2	1	2	832
Ohio	46	18,625	--------	8,363	79	106	10,262
Oklahoma	2	115	--------	--------	--------	--------	115
Pennsylvania	228	56,039	66	8,778	209	42	45,228
Tennessee	112	4,473	240	3,731	110	34	502
Utah	21	4,657	2	520	19	27	3,693
Virginia	598	30,373	2,021	15,277	440	35	11,543
Washington	3	53	53	--------	--------	--------	--------
West Virginia	867	121,623	925	50,997	879	58	67,336
Wyoming	4	122	--------	122	11	11	--------
Total [1]	3,097	347,132	7,898	160,247	2,779	58	172,642

[1] Data may not add to totals shown because of independent rounding.

and lignite mines in the United States, in 1969, by States

short tons)

Mined by longwall machines	Number of mines using power drills	Number of power drills and production: Face or coal drills: Handheld and post mounted: Number	Handheld and post mounted: Quantity	Mobile: Number	Mobile: Quantity	Roof or rock drills: Roof bolting: Rotary	Roof bolting: Percussion	Other uses: Rotary	Other uses: Percussion
--------	59	99	4,307	41	4,288	53	58	4	14
--------	2	6	61	--------	--------	-------	-------	1	--------
--------	32	46	179	5	262	15	32	-------	--------
38	28	2	17	59	12,194	164	-------	-------	--------
--------	6	3	122	10	1,830	25	1	-------	2
--------	2	--------	--------	3	366	3	-------	-------	--------
--------	855	999	19,355	207	32,887	421	24	9	5
--------	12	21	207	--------	--------	8	2	-------	--------
--------	--------	--------	--------	--------	--------	-------	-------	-------	--------
--------	7	12	35	--------	--------	-------	-------	-------	--------
--------	1	1	1	--------	--------	2	3	-------	--------
--------	40	23	241	47	8,119	125	3	8	--------
--------	2	--------	--------	--------	--------	6	-------	-------	2
1,967	160	160	1,783	35	6,956	304	273	17	33
--------	85	159	3,225	3	544	19	2	1	1
441	21	9	39	10	469	9	41	-------	--------
1,532	543	678	11,854	30	5,330	187	49	10	7
--------	3	13	53	--------	--------	-------	-------	-------	--------
2,365	678	842	19,108	250	31,861	980	167	34	34
--------	5	9	117	1	2	4	-------	-------	--------
6,344	2,541	3,082	60,706	701	105,110	2,325	655	84	98

Table 10.—Haulage units and length of rail track in use in bituminous coal and lignite underground mines in the United States, in 1969, by States

State	Locomotives			Tractors, rubber-tired	Mine cars		Shuttle cars		Shuttle buggies	Gathering and haulage conveyors		Rail track reported (miles)		
	Trolly	Battery	All other		Rail	Rubber-tired	Cable reel	Battery		Units	Miles	Main line	All other	Total
Alabama	119	-------	-------	48	2,306	-------	153	-------	-------	84	33.0	83.6	34.7	118.3
Arkansas	-------	-------	-------	-------	11	-------	-------	-------	-------	2	.6	.5	-------	.5
Colorado	66	17	-------	3	1,961	12	110	10	1	27	11.1	29.5	15.9	45.4
Illinois	58	9	-------	26	553	38	314	10	-------	204	95.7	23.5	21.3	44.8
Indiana	3	-------	-------	-------	96	-------	33	-------	-------	13	6.4	3.3	-------	3.3
Iowa	4	-------	-------	-------	138	-------	5	-------	-------	-------	-------	2.6	1.3	3.9
Kentucky	340	36	12	769	4,908	1,147	678	123	294	436	149.2	180.1	58.5	238.6
Maryland	-------	1	-------	3	38	3	4	-------	20	7	1.4	1.1	1.0	2.1
Montana (bituminous)	6	1	-------	-------	94	-------	5	-------	-------	-------	-------	2.5	2.0	4.5
New Mexico	-------	1	-------	4	20	-------	10	-------	-------	6	2.9	.5	.1	.6
Ohio	169	4	-------	2	2,820	6	202	25	-------	108	40.0	76.8	26.0	102.8
Oklahoma	-------	-------	-------	-------	-------	-------	6	-------	-------	2	.2	-------	-------	-------
Pennsylvania	970	45	4	59	13,876	146	1,008	26	12	574	206.1	431.3	236.6	667.9
Tennessee	69	10	-------	52	284	103	54	-------	16	40	20.8	14.8	1.1	15.9
Utah	74	5	1	9	1,889	9	98	2	-------	45	11.9	45.5	17.2	62.7
Virginia	139	12	2	961	2,316	2,496	274	35	9	232	95.7	78.0	33.0	111.0
Washington	3	-------	-------	-------	14	-------	1	-------	-------	-------	-------	.7	-------	.7
West Virginia	1,225	21	6	383	29,058	864	2,126	65	180	1,313	450.1	745.3	288.4	1,033.7
Wyoming	-------	-------	-------	-------	6	-------	7	-------	-------	4	1.1	.3	-------	.3
Total	3,245	162	25	2,319	60,388	4,824	5,088	296	532	3,097	1,126.2	1,719.9	737.1	2,457.0

Table 11.—Method of haulage at bituminous coal and lignite underground mines in the United States in 1969, by States

(Thousand short tons)

State	Production from mines					
	Reporting rail mine cars	Reporting rubber-tired mine cars	Reporting shuttle buggies	With conveyor haulage only	Not reporting type of haulage	Total [1]
Alabama	4,553	----------	----------	4,323	411	9,287
Arkansas	36	----------	----------	----------	25	61
Colorado	1,757	16	3	1,239	600	3,615
Illinois	4,744	----------	----------	25,338	----------	30,082
Indiana	272	----------	----------	1,838	----------	2,110
Iowa	368	----------	----------	----------	----------	368
Kentucky	17,626	6,115	3,172	26,202	11,221	64,336
Maryland	8	44	52	196	22	322
Missouri	----------	----------	----------	----------	1	1
Montana: (bituminous)	24	----------	----------	----------	11	35
New Mexico	2	----------	----------	832	2	836
Ohio	11,563	3	----------	6,714	345	18,625
Oklahoma	----------	----------	----------	8	107	115
Pennsylvania	33,887	67	22	21,937	126	56,039
Tennessee	1,520	321	24	1,294	1,314	4,473
Utah	3,430	93	----------	838	296	4,657
Virginia	5,541	5,568	15	14,296	4,953	30,373
Washington	53	----------	----------	----------	----------	53
West Virginia	79,924	2,257	821	34,885	3,736	121,623
Wyoming	2	----------	----------	113	7	122
Total [1]	165,310	14,485	4,109	140,053	23,177	347,132

[1] Data may not add to totals shown because of independent rounding.

Table 12.—Rail mine cars used and haulage at bituminous coal and lignite underground mines in the United States, in 1969, by States

State	Capacity							Production, by size of mine car reported (thousand short tons)						
	1 ton	2 tons	3 tons	4–5 tons	6–9 tons	10 tons and over	Total	1 ton	2 tons	3 tons	4–5 tons	6–9 tons	10 tons and over	Total [1]
Alabama	8	19	225	691	985	378	2,306	3	770	286	907	2,383	968	5,318
Arkansas	--	--	--	--	11	--	11	--	--	--	--	36	--	36
Colorado	94	1,026	381	360	--	100	1,961	47	337	229	422	--	722	1,757
Illinois	36	45	80	152	166	74	553	14	91	190	905	2,222	1,322	4,744
Indiana	--	55	20	21	--	--	96	--	122	62	87	--	--	272
Iowa	50	--	88	--	--	--	138	2	--	366	--	--	--	368
Kentucky	15	265	1,176	1,265	477	1,710	4,908	18	373	1,870	3,123	2,698	9,544	17,626
Maryland	30	8	--	--	--	--	38	6	1	--	--	--	--	8
Montana: (bituminous)	--	12	62	--	--	20	94	--	3	19	--	--	1	24
New Mexico	20	--	--	--	--	--	20	2	--	--	--	--	--	2
Ohio	51	96	100	438	920	1,215	2,820	23	51	90	1,472	2,751	7,177	11,563
Pennsylvania	426	1,269	1,283	545	6,864	3,489	13,876	603	415	1,791	807	17,416	13,351	34,383
Tennessee	29	38	52	105	60	--	284	15	14	165	803	524	--	1,520
Utah	--	21	--	1,574	294	--	1,889	--	12	--	2,470	948	--	3,430
Virginia	30	80	227	1,119	210	650	2,316	4	57	465	1,313	605	3,098	5,541
Washington	--	--	--	14	--	--	14	--	--	--	53	--	--	53
West Virginia	80	650	5,074	10,552	4,119	8,583	29,058	39	659	5,713	18,850	14,418	40,245	79,924
Wyoming	--	6	--	--	--	--	6	--	2	--	--	--	--	2
Total [1]	869	3,590	8,768	16,836	14,106	16,219	60,388	776	2,907	11,246	31,212	44,001	76,428	166,571

[1] Data may not add to totals shown because of independent rounding.

Table 13.—Rubber-tired mine cars used and haulage at bituminous coal and lignite underground mines in the United States, in 1969, by States

State	Capacity							Production, by size of mine car reported (thousand short tons)						
	1 ton	2 tons	3 tons	4–5 tons	6–9 tons	10 tons and over	Total [1]	1 ton	2 tons	3 tons	4–5 tons	6–9 tons	10 tons and over	Total [1]
Colorado	--	10	--	2	--	--	12	--	15	--	1	--	--	16
Illinois	1	--	--	--	37	--	38	--	--	--	--	--	--	--
Kentucky	45	535	242	210	45	70	1,147	323	2,399	1,382	1,519	--	492	6,115
Maryland	--	--	3	--	--	--	3	--	--	44	--	--	--	44
Ohio	--	6	--	--	--	--	6	--	3	--	--	--	--	3
Pennsylvania	--	51	32	26	--	37	146	--	64	3	--	--	--	67
Tennessee	4	11	67	11	10	--	103	2	12	192	60	54	--	321
Utah	--	4	--	1	4	--	9	--	--	--	1	92	--	93
Virginia	287	1,725	326	158	--	--	2,496	406	3,355	1,277	530	--	--	5,568
West Virginia	40	500	192	71	51	10	864	131	679	940	282	211	16	2,257
Total [1]	377	2,842	862	479	147	117	4,824	861	6,527	3,839	2,393	357	508	14,485

[1] Data may not add to totals shown because of independent rounding.

Table 14.—Number and production of underground bituminous coal and lignite mines using gathering and haulage conveyors, and number and length of units in use, in the United States, by States [1]

State	Number of mines		Production (thousand short tons)		Number of units in use		Average length (feet)		Total length (miles)	
	1968	1969	1968	1969	1968	1969	1968	1969	1968	1969
Alabama	6	7	4,200	3,389	79	84	2,115	2,076	31.6	33.0
Arkansas	---	1	-------	25	-----	2	-----	1,500	-------	.6
Colorado	7	6	1,919	1,961	28	27	2,250	2,163	11.9	11.1
Illinois	22	20	25,125	29,663	214	204	2,138	2,478	86.7	95.7
Indiana	2	2	1,875	1,838	11	13	2,759	2,600	5.7	6.4
Kentucky	73	84	33,589	39,385	353	436	2,068	1,807	138.2	149.2
Maryland	4	4	210	196	7	7	1,057	1,057	1.4	1.4
New Mexico	1	1	763	832	5	6	2,040	2,550	1.9	2.9
Ohio	23	19	13,806	15,914	103	108	1,875	1,954	36.6	40.0
Oklahoma	---	2	-------	115	-----	2	-----	500	-------	.2
Pennsylvania	115	109	34,283	36,925	578	574	1,752	1,896	191.8	206.1
Tennessee	9	9	1,831	2,163	41	40	2,525	2,739	19.6	20.8
Utah	14	12	3,918	4,034	56	45	1,608	1,397	17.1	11.9
Virginia	39	40	16,219	18,598	240	232	2,315	2,179	105.2	95.7
West Virginia	312	317	102,385	95,424	1,250	1,313	1,725	1,810	408.4	450.1
Wyoming	1	1	106	122	4	4	1,500	1,500	1.1	1.1
Total [2]	628	634	240,229	250,584	2,969	3,097	1,880	1,920	1,057.2	1,126.2

[1] Includes all mines using belt conveyors, 500 feet long or more for transporting coal underground. Excludes main-slope conveyors.
[2] Data may not add to totals shown because of independent rounding.

Table 15.—Number of mines, men working daily, days active, and output per man per day at bituminous coal and lignite mines in the United States, in 1968, by State and counties

State and county	Number of mines			Average number of men working daily			Average number of days worked			Average tons per man per day [1]			
	Underground	Strip	Auger	Underground	Strip	Auger	Underground	Strip	Auger	Underground	Strip	Auger	Total
Alabama:													
Jefferson	35	16	-------	2,613	244	-------	219	267	-------	10.71	34.25	-------	13.11
Walker	9	16	2	638	335	24	226	189	192	15.18	32.69	13.95	20.38
Other counties [2]	36	28	-------	570	483	-------	198	228	-------	8.27	25.61	-------	16.84
Total	80	60	2	3,821	1,062	24	217	225	192	11.15	29.85	13.95	15.33
Alaska	-------	3	-------	-------	99	-------	-------	214	-------	-------	35.52	-------	35.52
Arkansas:													
Franklin	-------	1	-------	-------	19	-------	-------	179	-------	-------	19.30	-------	19.30
Johnson	2	3	-------	40	36	-------	220	209	-------	6.65	10.91	-------	8.59
Sebastian	-------	2	-------	-------	6	-------	-------	101	-------	-------	8.81	-------	8.81
Total	2	6	-------	40	61	-------	220	187	-------	6.65	13.32	-------	10.40

See footnotes at end of table.

Table 15.—Number of mines, men working daily, days active, and output per man per day at bituminous coal and lignite mines in the United States, in 1968, by State and counties—Continued

State and county	Number of mines			Average number of men working daily			Average number of days worked			Average tons per man per day [1]			
	Underground	Strip	Auger	Underground	Strip	Auger	Underground	Strip	Auger	Underground	Strip	Auger	Total
Colorado:													
Fremont	13	------	------	70	------	------	232	------	------	14.34	------	------	14.34
Garfield	1	------	------	6	------	------	70	------	------	4.48	------	------	4.48
Gunnison	5	------	------	133	------	------	226	------	------	17.09	------	------	17.39
Huerfano	2	------	------	25	------	------	239	------	------	4.46	------	------	4.46
LaPlata	4	------	------	22	------	------	133	------	------	7.91	------	------	7.91
Weld	4	------	------	183	------	------	226	------	------	15.71	------	------	15.71
Other counties [2]	20	5	------	763	112	------	236	252	------	12.84	63.49	------	19.72
Total	49	5	------	1,202	112	------	231	252	------	13.57	63.49	------	18.20
Illinois:													
Adams	------	1	------	------	9	------	------	140	------	------	9.95	------	9.95
Fulton	------	6	------	------	811	------	------	263	------	------	31.83	------	31.83
Jackson	------	4	------	------	68	------	------	90	------	------	44.03	------	44.03
Perry	------	4	------	------	528	------	------	322	------	------	61.28	------	61.28
Vermilion	2	1	1	30	103	2	171	291	136	9.70	26.21	35.72	23.85
Williamson	8	4	------	715	269	------	226	285	------	16.34	28.95	------	20.39
Other counties [2]	23	16	------	4,413	1,457	------	232	286	------	23.16	37.34	------	27.26
Total	33	36	1	5,158	3,245	2	231	282	140	22.17	39.44	35.72	29.67
Indiana:													
Clay	------	5	------	------	142	------	------	286	------	------	26.15	------	26.15
Parke	------	1	------	------	6	------	------	200	------	------	9.71	------	9.71
Warrick	2	9	------	17	582	------	216	274	------	7.98	46.97	------	46.07
Other counties [2]	7	20	------	423	995	------	242	241	------	20.85	32.39	------	28.93
Total	9	35	------	440	1,725	------	242	255	------	20.40	37.03	------	33.80
Iowa:													
Mahaska	------	7	------	------	62	------	------	270	------	------	18.06	------	18.06
Marion	------	4	------	------	44	------	------	285	------	------	21.52	------	21.52
Van Buren	------	1	------	------	7	------	------	132	------	------	14.66	------	14.66
Other counties [2]	3	------	------	53	------	------	231	------	------	23.97	------	------	23.97
Total	3	12	------	53	113	------	231	266	------	23.97	19.41	------	20.70
Kansas: Total [2]	------	4	------	------	193	------	------	298	------	------	22.06	------	22.06
Kentucky:													
Eastern:													
Bell	31	17	17	508	218	128	171	182	113	11.13	37.10	55.49	23.01
Clinton	4	------	------	24	------	------	145	------	------	7.55	------	------	7.55
Elliott	------	3	------	------	9	------	------	94	------	------	12.37	------	12.37

Floyd	154	3	3	2,029	34	40	173	145	111	12.10	33.13	45.13	12.79
Harlan	87	11	16	2,119	90	76	213	104	134	13.49	38.84	44.70	14.66
Johnson	21	2	-------	157	21	-------	133	231	-------	7.96	107.95	-------	107.95
Knott	63	3	15	559	28	92	158	158	124	19.30	50.52	32.66	22.07
Knox	43	1	1	171	10	14	128	40	44	6.27	16.26	15.69	6.69
Laurel	1	-------	-------	7	-------	-------	117	-------	-------	12.51	-------	-------	12.51
Leslie	30	1	1	751	6	10	179	230	139	12.39	27.33	27.31	12.69
Letcher	152	8	11	1,969	80	41	191	147	152	13.48	51.77	31.27	14.90
Perry	54	11	24	1,055	111	200	182	197	150	12.26	31.87	42.16	17.70
Pike	362	4	44	5,247	17	249	182	71	121	18.51	54.04	62.32	19.89
Whitley	31	2	-------	179	12	-------	173	61	-------	12.86	14.57	-------	12.87
Other counties [2]	50	16	14	935	228	137	191	221	189	13.02	42.76	30.70	20.69
Total	1,083	82	146	15,710	864	987	184	246	137	14.81	27.30	44.60	16.87
Western:													
Henderson	4	-------	-------	69	-------	-------	226	-------	-------	12.52	-------	-------	12.52
Hopkins	14	12	3	1,243	335	13	232	247	119	23.88	60.99	102.35	32.45
Muhlenberg	7	11	-------	542	977	-------	232	311	-------	27.58	56.51	-------	47.94
Other counties [2]	13	18	2	1,459	478	61	219	282	15	22.87	46.05	62.43	29.81
Total	38	41	5	3,313	1,790	74	226	292	33	23.83	54.41	87.59	36.49
Grand total	1,121	123	151	19,023	2,654	1,061	191	276	129	16.67	46.58	45.37	22.41
Maryland: Total [2]	21	33	7	157	157	15	188	236	177	12.02	26.81	37.27	20.92
Missouri:													
Callaway	-------	1	-------	-------	8	-------	-------	286	-------	-------	11.95	-------	11.95
Dade	-------	1	-------	-------	1	-------	-------	67	-------	-------	56.12	-------	56.12
Putnam	-------	2	-------	-------	16	-------	-------	170	-------	-------	20.41	-------	20.41
Vernon	-------	3	-------	-------	24	-------	-------	239	-------	-------	11.06	-------	11.06
Other counties [2]	-------	5	-------	-------	297	-------	-------	325	-------	-------	31.65	-------	31.65
Total	-------	12	-------	-------	346	-------	-------	310	-------	-------	29.85	-------	29.85
Montana:													
Bituminous: Total [2]	7	2	-------	35	10	-------	153	106	-------	6.70	143.80	-------	29.37
Lignite: Total [2]	-------	2	-------	-------	16	-------	-------	242	-------	-------	85.13	-------	85.13
Total Montana	7	4	-------	35	26	-------	153	190	-------	6.70	97.77	-------	50.33
New Mexico: Total [2]	3	3	-------	147	147	-------	199	251	-------	26.22	72.26	-------	51.88
North Dakota (lignite):													
Adams	-------	1	-------	-------	5	-------	-------	133	-------	-------	17.05	-------	17.05
Bowman	-------	1	-------	-------	10	-------	-------	243	-------	-------	54.05	-------	54.05
Grant	-------	3	-------	-------	4	-------	-------	110	-------	-------	26.69	-------	26.69
McLean	-------	2	-------	-------	17	-------	-------	201	-------	-------	8.46	-------	8.46
Mercer	-------	3	-------	-------	123	-------	-------	257	-------	-------	105.18	-------	105.18
Stark	-------	3	-------	-------	12	-------	-------	237	-------	-------	42.49	-------	42.49
Williams	-------	1	-------	-------	2	-------	-------	50	-------	-------	40.00	-------	40.00
Other counties [2]	-------	8	-------	-------	124	-------	-------	185	-------	-------	37.42	-------	37.42
Total	-------	22	-------	-------	297	-------	-------	217	-------	-------	69.65	-------	69.65

See footnotes at end of table.

Table 15.—Number of mines, men working daily, days active, and output per man per day at bituminous coal and lignite mines in the United States, in 1968, by State and counties—Continued

State and county	Number of mines			Average number of men working daily			Average number of days worked			Average tons per man per day [1]			
	Under-ground	Strip	Auger	Under-ground	Strip	Auger	Under-ground	Strip	Auger	Under-ground	Strip	Auger	Total
Ohio:													
Columbiana	3	28	12	13	155	23	190	271	292	12.70	20.03	39.86	22.23
Harrison	6	15	1	1,724	348	7	242	245	317	13.73	55.66	26.32	20.87
Hocking	------	9	------	------	34	------	------	190	------	------	20.11	------	20.11
Holmes	------	5	------	------	30	------	------	262	------	------	27.91	------	27.91
Jackson	3	18	------	13	122	------	175	219	------	14.05	32.94	------	31.53
Meigs	1	2	1	8	22	3	182	117	140	6.90	13.26	11.07	11.04
Stark	------	11	------	------	71	------	------	206	------	------	22.91	------	22.91
Vinton	2	8	------	3	63	------	145	216	------	11.95	16.27	------	16.12
Wayne	------	1	------	------	3	------	------	269	------	------	45.05	------	45.05
Other counties [2]	40	166	40	2,335	2,893	132	233	244	165	19.32	33.05	52.50	27.50
Total	55	263	54	4,096	3,741	165	237	242	188	16.86	33.75	47.36	25.38
Oklahoma:													
Craig	------	1	------	------	15	------	------	300	------	------	11.35	------	11.35
Muskogee	------	1	------	------	3	------	------	138	------	------	4.11	------	4.11
Other counties [2]	1	4	1	58	165	4	267	248	15	2.00	24.68	100.00	18.49
Total	1	6	1	58	183	4	267	248	15	2.00	23.17	100.00	17.86
Pennsylvania:													
Allegheny	11	11	------	1,307	99	------	239	207	------	14.20	34.75	------	15.47
Armstrong	25	36	7	1,032	353	56	226	173	95	21.28	24.79	33.41	22.21
Bedford	3	2	------	29	6	------	246	145	------	11.40	4.95	------	10.70
Blair	1	------	------	5	------	------	155	------	------	3.91	------	------	3.91
Butler	9	30	7	177	238	17	235	220	121	17.86	21.29	41.17	20.25
Cambria	46	18	2	2,699	187	3	235	260	118	10.79	18.85	51.07	11.38
Centre	1	14	------	92	87	------	245	270	------	14.45	12.11	------	15.89
Clearfield	18	58	7	395	1,030	18	219	275	177	16.51	16.30	36.14	16.52
Clinton	------	11	------	------	122	------	------	287	------	------	22.62	------	22.62
Elk	5	11	5	134	49	12	39	268	166	10.15	19.17	26.61	17.61
Fayette	6	22	------	78	302	------	225	70	------	12.45	13.71	------	13.14
Greene	18	3	------	3,508	12	------	233	97	------	14.27	21.36	------	14.28
Indiana	41	24	12	1,929	208	21	203	241	138	14.61	15.71	48.91	14.95
Jefferson	13	37	11	213	189	27	206	206	80	15.89	21.09	27.40	18.57
Lawrence	------	22	------	------	215	------	------	286	------	------	16.48	------	16.48
Lycoming	------	3	------	------	16	------	------	209	------	------	17.92	------	17.92
Mercer	------	5	------	------	44	------	------	255	------	------	16.47	------	16.47
Somerset	35	60	------	590	468	------	217	267	------	11.25	21.34	------	16.24
Venango	------	13	------	------	77	------	------	236	------	------	24.52	------	24.52
Washington	14	16	1	3,865	151	4	240	179	21	14.21	15.03	35.75	14.24
Westmoreland	12	20	------	755	105	------	225	163	------	15.91	14.30	------	15.76
Other counties [2]	3	73	3	70	543	7	177	287	55	2.27	24.09	44.90	22.54
Total	261	489	55	16,878	4,501	165	228	237	111	14.19	19.56	36.36	15.43

Tennessee:													
Anderson	24	10	2	414	65	4	222	209	241	16.08	42.72	47.10	19.77
Campbell	16	19	4	133	194	15	169	178	129	12.69	34.87	46.89	26.83
Fentress	5	------	1	24	------	12	242	------	138	6.43	------	36.17	13.03
Marion	25	------	------	290	------	------	203	------	------	17.01	------	------	17.01
Morgan	9	9	------	76	49	------	117	169	------	10.84	33.25	------	21.63
Overton	6	------	------	24	------	------	221	------	------	6.06	------	------	6.06
Rhea	2	------	------	8	------	------	174	------	------	13.34	------	------	13.34
Van Buren	1	5	------	2	50	------	120	218	------	5.00	26.11	------	25.73
Other counties [2]	26	16	2	510	152	7	227	213	237	14.43	29.14	20.48	17.67
Total	114	59	9	1,481	510	38	210	196	165	14.87	32.99	37.04	19.54
Utah:													
Carbon	11	------	------	826	------	------	227	------	------	16.34	------	------	16.34
Emery	8	------	------	312	------	------	218	------	------	17.14	------	------	17.14
Kane	1	------	------	2	------	------	136	------	------	5.97	------	------	5.97
Summit	1	------	------	7	------	------	199	------	------	9.16	------	------	9.16
Other counties [2]	2	------	------	8	------	------	199	------	------	45.88	------	------	45.88
Total	23	------	------	1,155	------	------	224	------	------	16.68	------	------	16.68
Virginia:													
Buchanan	430	21	27	5,202	87	89	207	187	155	13.66	32.47	41.21	14.28
Dickenson	58	18	12	1,991	141	38	219	206	163	17.09	46.43	42.63	19.23
Lee	34	10	9	300	134	37	177	110	105	15.26	20.88	28.07	17.11
Russell	21	3	2	535	9	8	241	181	162	15.16	18.15	21.08	15.26
Tazewell	6	2	1	78	26	2	227	232	67	7.26	27.74	12.77	12.48
Wise	107	32	14	1,710	193	63	221	196	157	16.77	44.07	55.50	20.10
Other counties [2]	2	------	------	11	------	------	132	------	------	6.86	------	------	6.86
Total	658	86	65	9,827	590	237	213	179	149	15.01	38.36	43.10	16.56
Washington:													
Lewis	------	2	------	------	16	------	------	152	------	------	52.80	------	52.80
Other counties [2]	3	------	------	36	------	------	242	------	------	5.73	------	------	5.73
Total	3	2	------	36	16	------	242	152	------	5.73	52.78	------	15.96
West Virginia:													
Barbour	25	17	3	677	193	13	202	156	123	12.49	59.02	22.03	20.89
Boone	42	12	19	1,970	178	181	228	197	180	17.49	36.27	35.57	19.91
Braxton	2	------	------	6	------	------	76	------	------	5.77	------	------	5.77
Brooke	3	4	1	176	25	2	263	147	108	14.99	26.03	90.05	16.11
Fayette	54	12	9	1,643	89	62	212	218	260	11.57	34.81	33.17	13.65
Gilmer	6	1	------	35	13	------	134	249	------	12.47	13.44	------	12.80
Greenbrier	33	------	------	239	------	------	193	------	------	14.84	------	------	14.84
Kanawha	57	8	13	2,614	95	136	218	202	145	18.18	29.76	38.24	19.19
Lewis	1	4	1	11	99	21	284	108	28	3.22	25.21	31.78	20.72
Logan	48	6	11	4,399	82	135	232	194	145	14.07	21.20	40.78	14.67
Marion	10	5	2	3,063	50	4	243	114	42	18.10	8.66	38.04	18.03
Marshall	4	------	------	1,035	------	------	239	------	------	13.80	------	------	13.80
Mason	4	2	1	131	23	4	152	196	16	13.02	18.83	54.83	14.22

See footnotes at end of table.

Table 15.—Number of mines, men working daily, days active, and output per man per day at bituminous coal and lignite mines in the United States, in 1968, by State and counties—Continued

State and county	Number of mines			Average number of men working daily			Average number of days worked			Average tons per man per day [1]			
	Under-ground	Strip	Auger	Under-ground	Strip	Auger	Under-ground	Strip	Auger	Under-ground	Strip	Auger	Total
West Virginia—Continued													
McDowell	184	25	9	6,057	286	79	210	148	187	12.17	30.78	12.91	12.77
Mercer	17	3	2	491	28	9	213	178	74	11.35	23.69	17.11	11.95
Monongalia	27	9	1	1,923	48	4	245	154	42	21.26	27.80	38.04	21.37
Nicholas	64	10	3	2,363	88	24	220	159	31	13.33	30.70	44.77	13.83
Pocahontas	9	-------	-------	91	-------	-------	137	-------	-------	10.79	-------	-------	10.79
Preston	43	17	-------	481	143	-------	185	277	-------	14.44	24.16	-------	17.44
Raleigh	62	23	8	2,877	224	60	226	178	170	10.76	29.67	35.56	12.20
Randolph	15	5	2	267	30	10	161	92	99	10.44	17.83	12.51	10.89
Taylor	9	5	-------	59	37	-------	152	57	-------	6.69	28.13	-------	10.75
Upshur	8	8	1	81	66	4	215	87	30	16.50	45.75	49.22	23.87
Webster	14	5	2	153	56	11	118	101	103	9.40	15.97	14.47	11.13
Other counties [2]	193	39	21	8,428	463	126	221	212	176	15.57	22.97	45.36	16.27
Total	934	220	109	39,270	2,316	885	222	177	160	14.81	29.48	35.12	15.77
Wyoming:													
Campbell	-------	1	-------	-------	29	-------	-------	258	-------	-------	72.13	-------	72.13
Sheridan	-------	2	-------	-------	36	-------	-------	248	-------	-------	39.63	-------	39.63
Other counties [2]	4	6	-------	63	199	-------	175	243	-------	10.63	58.33	-------	49.48
Total	4	9	-------	63	264	-------	175	245	-------	10.63	57.34	-------	50.55
Total United States	3,381	1,492	454	102,940	22,358	2,596	217	243	145	15.40	34.24	40.46	19.37

[1] In certain counties the average tons per man per day is large because of auger mining, strip mining, or mechanical loading underground.

[2] Other counties. Alabama, underground: Bibb, Jackson, Marion, Shelby, Tuscaloosa; strip: Bibb, Blount, Cullman, Etowah, Jackson, Marion, Fayette, Tuscaloosa, Winston. Colorado, Underground: Delta, Las Animas, Mesa, Moffat, Pitkin, Rio Blanco, Routt; strip: Mesa, Montrose, Routt. Illinois, underground: Christian, Douglas, Franklin, Gallatin, Jefferson, Logan, Macoupia, Mercer, Montgomery, Randolph, St. Clair, Saline, Washington; strip: Gallatin, Grundy, Knox, Peoria, Randolph, St. Clair, Saline, Stark, Will. Indiana, underground: Gibson, Knox, Pike, Sullivan, Vigo; strip: Daviess, Fountain, Gibson, Greene, Owen, Pike, Spencer, Sullivan, Vigo. Iowa, underground: Appanoose, Lucas, Monroe. Kansas, strip: Cherokee, Crawford. Kentucky, eastern, underground: Breathitt, Carter, Clay, Jackson, Lee, McCreary, Magoffin, Martin, Morgan, Pulaski; strip: Boyd, Breathitt, Clay, Jackson, Magoffin, Morgan, Pulaski; auger: Breathitt, Clay, Lawrence, Magoffin, Wayne. Kentucky, western, underground: Butler, Ohio, Union, Webster; strip: Butler, Daviess, Ohio, Webster; auger: Ohio. Maryland, underground: Allegany, Garrett; strip: Allegany, Garrett; auger: Allegany, Garrett. Missouri, strip: Boone, Henry, Macon. Montana, bituminous, underground: Blaine, Musselshell; strip: Big Horn, Rosebud. Montana, lignite, strip: Powder River, Richland. New Mexico, underground: Colfax, San Juan; strip: McKinley, San Juan. North Dakota, strip: Burke, Morton, Oliver, Ward. Ohio, underground: Athens, Belmont, Coshocton, Gallia, Guernsey, Jefferson, Monroe, Muskingum, Perry, Tuscarawas; strip: Athens, Belmont, Carroll, Coshocton, Gallia, Guernsey, Jefferson, Lawrence, Mahoning, Morgan, Muskingum, Noble, Perry, Tuscarawas, Washington; auger: Belmont, Carroll, Coshocton, Gallia, Guernsey, Jefferson, Muskingum, Noble, Perry, Tuscarawas. Oklahoma, underground: LeFlore; strip: Haskell, Rogers; auger, Haskell. Pennsylvania, underground: Beaver, Clarion, Huntingdon; strip: Beaver, Clarion, Huntingdon, Tioga; auger: Clarion. Tennessee, underground: Claiborne, Hamilton, Putnam, Scott, Sequatchie; strip: Bledsoe, Claiborne, Cumberland, Grundy, Hamilton, Scott, Sequatchie; auger: Claiborne, Scott. Utah, underground: Iron, Sevier. Virginia, underground: Montgomery, Scott. Washington, underground: King, Thurston. West Virginia, underground: Clay, Grant, Harrison, Mineral, Mingo, Ohio, Wayne, Wyoming; strip: Clay, Grant, Hancock, Harrison, Mineral, Mingo, Tucker, Wyoming; auger: Harrison, Mingo, Ohio, Wyoming. Wyoming, underground: Hot Springs, Sweetwater; strip: Carbon, Converse, Lincoln.

Table 16.—Production, shipments, and value at bituminous coal and lignite mines, in the United States, in 1969, by States and counties

(Thousand short tons)

State and county	Production: Underground: Number of mines	Production: Underground: Quantity	Production: Strip: Number of mines	Production: Strip: Quantity	Production: Auger: Number of mines	Production: Auger: Quantity	Shipments: Rail or water[1]	Shipments: Truck	Shipments: Used at mine[2]	Shipments: Total	Average value per ton[3]
Alabama:											
Bibb	1	66	3	507	-	-	529	43	1	573	W
Blount	-	-	2	204	-	-	139	64	-	204	W
Cullman	-	-	W	W	-	-	-	W	-	W	W
Etowah	-	-	W	W	-	-	-	W	-	W	W
Jackson	W	W	W	W	-	-	545	33	-	577	$4.58
Jefferson	37	6,115	16	2,403	-	-	7,404	1,113	1	8,518	8.04
Marion	24	278	5	274	-	-	230	322	-	553	5.20
St. Clair	-	-	W	W	-	-	-	W	-	W	W
Shelby	W	W	-	-	-	-	W	W	-	W	W
Tuscaloosa	1	9	12	1,859	-	-	1,580	289	-	1,868	5.46
Walker	6	2,257	20	1,843	1	39	2,853	516	770	4,139	7.81
Winston	-	-	W	W	-	-	W	W	-	W	W
Other counties	5	562	6	1,041	-	-	585	440	-	1,025	8.84
Total[4]	74	9,287	64	8,130	1	39	13,864	2,821	771	17,456	7.47
Alaska	-	-	3	667	-	-	663	3	1	667	6.54
Arkansas:											
Franklin	-	-	2	93	-	-	93	-	-	93	7.72
Johnson	2	61	2	67	-	-	128	-	-	128	8.05
Sebastian	-	-	2	7	-	-	4	3	-	7	7.70
Total[4]	2	61	6	167	-	-	225	3	-	228	7.90
Colorado:											
Delta	W	W	-	-	-	-	W	W	W	W	W
Fremont	11	198	3	21	-	-	2	218	-	220	4.08
Garfield	1	2	-	-	-	-	-	2	-	2	10.00
Gunnison	4	569	-	-	-	-	528	41	-	569	7.06
Huerfano	2	25	-	-	-	-	-	25	-	25	8.26
La Plata	W	W	W	W	-	-	-	19	-	19	W
Las Animas	W	W	-	-	-	-	W	W	-	W	W
Mesa	3	40	1	45	-	-	-	68	17	85	W
Moffat	W	W	-	-	-	-	W	W	-	W	W
Montrose	-	-	W	W	-	-	-	W	-	W	W
Pitkin	W	W	-	-	-	-	W	-	-	W	W
Rio Blanco	W	W	-	-	-	-	-	W	-	W	W
Routt	1	14	3	1,777	-	-	1,237	554	-	1,791	3.53
Weld	4	572	-	-	-	-	426	144	2	572	4.52
Other counties	17	2,194	2	72	-	-	2,137	110	1	2,247	6.45
Total[4]	43	3,615	9	1,915	-	-	4,331	1,179	20	5,530	5.27

See footnotes at end of table.

Table 16.—Production, shipments, and value at bituminous coal and lignite mines, in the United States, in 1969, by States and counties—Continued

(Thousand short tons)

State and county	Production						Shipments				Average value per ton [3]
	Underground		Strip		Auger						
	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Rail or water [1]	Truck	Used at mine [2]	Total	
Illinois:											
Adams	---	---	1	4	---	---	---	4	---	4	$7.22
Christian	1	5,403	---	---	---	---	2,504	333	2,566	5,403	W
Douglas	1	913	---	---	---	---	493	420	---	913	W
Franklin	4	8,558	---	---	---	---	8,533	25	1	8,558	W
Fulton	---	---	6	6,510	---	---	5,823	685	2	6,510	4.46
Gallatin	2	1,417	1	1,129	---	---	2,546	---	---	2,546	W
Grundy	---	---	1	240	---	---	139	101	---	240	W
Jackson	---	---	2	101	---	---	101	---	---	101	W
Jefferson	3	4,654	---	---	---	---	4,480	155	19	4,654	W
Johnson	---	---	2	29	---	---	---	29	---	29	W
Kankakee	---	---	1	115	---	---	67	48	---	115	W
Knox	---	---	1	1,773	---	---	1,702	71	---	1,773	W
Mercer	1	15	1	6	---	---	---	20	---	21	W
Montgomery	2	3,264	---	---	---	---	1,719	393	1,152	3,264	W
Peoria	---	---	4	2,352	---	---	1,633	719	---	2,352	W
Perry	---	---	4	10,428	---	---	10,205	217	5	10,428	3.67
Randolph	1	974	1	1,351	---	---	2,263	62	---	2,325	W
St. Clair	2	519	2	5,256	---	---	4,197	1,579	---	5,776	W
Saline	2	1,842	3	1,099	---	---	2,915	19	7	2,941	W
Stark	---	---	1	877	---	---	877	---	---	877	W
Vermilion	2	57	1	630	---	---	93	593	2	687	W
Washington	1	14	---	---	---	---	---	14	---	14	W
Will	---	---	1	673	---	---	391	283	---	673	W
Williamson	6	2,451	4	2,066	---	---	4,174	339	4	4,517	4.68
Total [4]	28	30,082	37	34,640	---	---	54,854	6,110	3,759	64,722	4.32
Indiana:											
Clay	---	---	5	1,176	---	---	472	702	1	1,176	$4.42
Daviess	---	---	1	21	---	---	---	21	---	21	W
Fountain	---	---	W	W	---	---	---	W	---	W	W
Gibson	1	766	---	---	---	---	705	60	1	766	W
Greene	---	---	6	2,035	---	---	1,811	224	---	2,035	W
Owen	---	---	W	W	---	---	---	W	---	W	W
Parke	---	---	1	2	---	---	---	2	---	2	4.00
Pike	1	62	5	3,318	---	---	3,013	366	1	3,380	W
Spencer	---	---	W	W	---	---	W	W	---	W	W
Sullivan	2	1,180	4	3,124	---	---	2,760	495	1,049	4,304	W
Vigo	1	87	---	---	---	---	---	87	---	87	W
Warrick	1	15	7	8,201	---	---	5,845	848	1,523	8,216	3.96
Other counties	---	---	3	98	---	---	20	77	---	98	4.40

Total [4]	6	2,110	32	17,976			14,626	2,884	2,576	20,086	4.13
Iowa:											
Appanoose	1	2						2		2	8.00
Lucas	1	149					137	12		149	4.00
Mahaska			5	269			169	100		269	3.63
Marion			4	243			243			243	3.81
Monroe	1	217	1	8			47	177	1	225	3.56
Van Buren			1	14				14		14	5.18
Total [4]	3	368	11	534			595	306	1	903	3.76
Kansas:											
Cherokee			2	1,020			1,017	3		1,020	5.51
Crawford			2	292			267	26		292	5.08
Total [4]			4	1,313			1,284	29		1,313	5.42
Kentucky:											
Eastern:											
Bell	27	797	15	930	15	557	2,057	227		2,284	3.57
Boyd			2	13				13		13	5.07
Breathitt	W	W	8	2,381	W	W	2,603	15		2,618	3.48
Carter	W	W						W		W	W
Clay	21	353	W	W	W	W	248	271		519	4.37
Clinton	W	W						W		W	W
Floyd	142	4,026	W	W	W	W	4,086	569		4,655	5.64
Harlan	83	7,076	10	448	17	530	7,513	521	21	8,055	5.73
Jackson	W	W						W		W	W
Johnson	27	240	W	W	W	W	969	62		1,031	5.61
Knott	52	1,637	5	315	22	886	2,339	499		2,838	4.19
Knox	37	103	5	47			25	126		150	3.60
Laurel	1	6						6		6	3.84
Lawrence	1	15	2	56				71		71	3.74
Lee	W	W						W		W	W
Leslie	28	1,455	1	28	7	291	1,745	31		1,774	4.44
Letcher	119	4,496	11	837	18	644	5,709	242	26	5,977	5.42
McCreary	5	409	4	128			438	99		537	4.45
Magoffin			W	W	W	W	755			755	2.25
Martin	5	914			2	354	1,266	2		1,268	3.57
Morgan	W	W	W	W				33		33	5.92
Perry	50	2,677	16	1,657	22	1,728	5,853	202	7	6,062	4.30
Pike	368	19,588	12	661	31	1,524	21,210	558	6	21,773	4.28
Pulaski	5	445	5	359			349	454		804	3.70
Rockcastle			1	2				2		2	3.35
Wayne			W	W				W		W	W
Whitley	18	214	4	61			225	50		275	4.22
Other counties	10	50	12	1,962	15	681		83		83	4.35
Total [4]	999	44,502	113	9,885	149	7,197	57,387	4,138	59	61,584	4.60
Western:											
Butler	1	36	6	163				198		198	4.77
Daviess			1	912			400	512		912	3.00
Henderson	3	118						117	1	118	3.75

See footnotes at end of table.

Table 16.—Production, shipments, and value at bituminous coal and lignite mines, in the United States, in 1969, by States and counties—Continued

(Thousand short tons)

State and county	Production						Shipments				Average value per ton [3]
	Underground		Strip		Auger		Rail or water [1]	Truck	Used at mine [2]	Total	
	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity					
Kentucky—Continued											
Western—Continued											
Hopkins	W	W	15	5,072	W	W	12,111	327	---------	12,438	$3.79
Muhlenberg	7	4,367	15	17,054	---------	---------	15,940	5,481	---------	21,420	3.47
Ohio	W	W	W	W	---------	---------	6,169	148	---------	6,317	3.45
Union	W	W	---------	---------	---------	---------	W	---------	---------	W	W
Webster	W	W	W	W	---------	---------	1,362	---------	---------	1,362	2.71
Other counties	18	15,313	13	4,418	1	14	4,700	---------	---------	4,700	3.50
Total [4]	29	19,834	50	27,618	1	14	40,682	6,782	1	47,466	3.52
Grand total [4]	1,028	64,336	163	37,503	150	7,211	98,069	10,920	60	109,049	4.14
Maryland:											
Allegany	9	63	14	251	1	5	84	235	---------	319	4.54
Garrett	11	259	17	712	6	78	924	124	---------	1,049	3.63
Total [4]	20	322	31	962	7	83	1,008	360	---------	1,368	3.85
Missouri:											
Boone	---------	---------	1	568	---------	---------	309	259	---------	568	5.08
Callaway	---------	---------	1	29	---------	---------	---------	29	---------	29	4.33
Henry	---------	---------	2	1,786	---------	---------	365	7	1,413	1,786	3.99
Macon	---------	---------	1	766	---------	---------	756	10	---------	766	4.57
Putnam	1	1	1	34	---------	---------	---------	35	---------	35	4.33
Randolph	---------	---------	1	106	---------	---------	---------	106	---------	106	4.29
Vernon	---------	---------	1	11	---------	---------	11	1	---------	11	4.54
Total [4]	1	1	8	3,299	---------	---------	1,441	447	1,413	3,301	4.33
Montana (bituminous):											
Big Horn	---------	---------	W	W	---------	---------	---------	W	---------	W	W
Blaine	1	1	---------	---------	---------	---------	---------	1	---------	1	W
Musselshell	6	33	---------	---------	---------	---------	2	31	---------	33	9.20
Rosebud	---------	---------	W	W	---------	---------	W	---------	---------	W	W
Other counties	---------	---------	3	687	---------	---------	685	2	---------	687	1.83
Total [4]	7	35	3	687	---------	---------	686	35	---------	722	2.18
Montana (lignite):											
Powder River	---------	---------	1	1	---------	---------	---------	1	---------	1	5.64
Richland	---------	---------	1	307	---------	---------	306	1	---------	307	W
Total [4]	---------	---------	2	308	---------	---------	306	2	---------	308	2.03

Total Montana [4]	7	35	5	995	--	--	992	37	--	1,030	2.13
New Mexico:											
Colfax	W	W	--	--	--	--	W	W	--	W	W
McKinley	--	--	W	W	--	--	W	W	--	W	W
San Juan	W	W	W	W	--	--	--	W	--	W	W
Other counties	4	836	3	3,636	--	--	1,272	3,200	--	4,471	3.66
Total [4]	4	836	3	3,636	--	--	1,272	3,200	--	4,471	3.66
North Dakota (lignite):											
Adams	--	--	1	18	--	--	12	6	--	18	2.74
Bowman	--	--	W	W	--	--	W	W	--	W	W
Burke	--	--	W	W	--	--	W	W	--	W	W
Grant	--	--	2	10	--	--	--	10	--	10	3.47
McLean	--	--	W	W	--	--	--	W	--	W	W
Mercer	--	--	3	3,553	--	--	2,215	23	1,316	3,553	1.74
Morton	--	--	2	9	--	--	--	9	--	9	3.12
Oliver	--	--	1	3	--	--	--	3	--	3	3.00
Stark	--	--	W	W	--	--	--	W	--	W	W
Ward	--	--	W	W	--	--	W	W	W	W	W
Williams	--	--	1	5	--	--	--	--	5	5	3.00
Other counties	--	--	10	1,108	--	--	747	327	32	1,108	2.13
Total [4]	--	--	20	4,704	--	--	2,974	378	1,352	4,704	1.85
Ohio:											
Athens	3	48	4	65	--	--	--	113	--	113	4.07
Belmont	9	6,731	19	7,304	4	59	13,677	405	11	14,093	4.25
Carroll	--	--	W	W	W	W	43	322	--	365	3.93
Columbiana	4	44	25	860	5	255	255	904	--	1,159	3.47
Coshocton	W	W	11	2,245	W	W	592	924	1,254	2,770	4.57
Gallia	3	13	5	77	--	--	39	50	--	89	3.12
Guernsey	--	--	3	58	--	--	58	--	--	58	3.59
Harrison	5	6,126	18	4,761	2	51	10,360	534	44	10,938	4.34
Hocking	--	--	7	86	1	2	--	89	--	89	3.73
Holmes	--	--	4	288	--	--	--	288	--	288	3.50
Jackson	W	W	15	878	W	W	447	526	3	976	3.44
Jefferson	3	881	26	3,976	11	302	2,736	2,423	1	5,160	3.91
Lawrence	--	--	W	W	--	--	W	W	W	W	W
Mahoning	--	--	W	W	W	W	--	247	149	397	3.94
Meigs	1	13	--	--	--	--	--	13	--	13	4.00
Monroe	W	W	--	--	--	--	W	--	--	W	W
Morgan	--	--	2	825	--	--	--	41	784	825	W
Muskingum	3	53	7	2,681	1	62	--	520	2,276	2,796	3.45
Noble	--	--	8	2,441	5	315	581	2,047	129	2,757	3.55
Perry	W	W	9	621	W	W	2,137	1,173	--	3,310	4.33
Stark	--	--	W	W	W	W	--	359	--	359	3.43
Summit	--	--	W	W	--	--	--	W	--	W	W
Tuscarawas	W	W	28	1,984	W	W	297	2,213	4	2,514	3.73
Vinton	1	1	6	310	--	--	27	284	--	311	4.27
Washington	--	--	W	W	--	--	--	W	--	W	W
Wayne	--	--	1	26	--	--	--	26	--	26	3.00

See footnotes at end of table.

Table 16.—Production, shipments, and value at bituminous coal and lignite mines, in the United States, in 1969, by States and counties—Continued

(Thousand short tons)

State and county	Production						Shipments				Average value per ton [3]
	Underground		Strip		Auger						
	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Rail or water [1]	Truck	Used at mine [2]	Total	
Ohio—Continued											
Other counties	14	4,716	32	1,527	17	553	1,427	406	1	1,835	$4.58
Total [4]	46	18,625	230	31,014	46	1,602	32,675	13,909	4,657	51,242	4.10
Oklahoma:											
Craig			W	W			W	W		W	W
Haskell	W	W	W	W	W	W	W			W	W
LeFlore	W	W					W			W	W
Muskogee			W	W				W		W	W
Okmulgee			W	W			W			W	W
Rogers			W	W			W	W		W	W
Other counties	2	115	7	1,713	1	9	1,822	16		1,838	5.80
Total [4]	2	115	7	1,713	1	9	1,822	16		1,838	5.80
Pennsylvania:											
Allegheny	9	4,103	12	705			3,831	976	1	4,808	6.86
Armstrong	22	5,884	41	1,373	11	142	1,793	2,042	3,563	7,399	4.73
Beaver	W	W	5	60	W	W		267		267	4.61
Bedford	W	W	W	W				16		16	5.19
Blair	1	2						2		2	6.76
Butler	W	W	30	1,106	W	W	1,352	746		2,098	4.23
Cambria	40	6,254	24	808	1	4	6,301	750	15	7,066	6.60
Centre	2	505	20	545			662	388		1,050	3.99
Clarion			66	3,771			2,481	1,290	1	3,771	4.38
Clearfield	15	1,462	55	4,387	9	70	3,670	2,249		5,919	4.05
Clinton			16	551			433	118		551	4.46
Elk	4	45	10	232	7	90	184	184		367	4.41
Fayette	3	228	34	549	1	1	323	408	48	778	5.19
Greene	19	11,998	4	79			12,036	29	11	12,076	7.45
Huntingdon			W	W				W		W	W
Indiana	39	6,928	29	1,055	12	86	5,342	1,110	1,618	8,070	5.67
Jefferson	10	311	38	1,070	8	60	1,260	180	1	1,440	4.49
Lawrence			21	844	1	3		847		848	3.80
Lycoming			3	50				50		50	3.65
Mercer			4	182			20	162		182	4.02
Somerset	30	1,401	70	2,752	6	101	3,428	816	10	4,254	4.90
Tioga			8	743				743		743	4.19
Venango			12	504			161	342	1	504	3.70
Washington	12	13,357	18	412			12,413	1,347	9	13,769	6.90
Westmoreland	10	2,416	16	171	2	7	2,153	433	8	2,593	6.52

Other counties	12	1,145	5	22	3	59	--------	10	--------	10	3.91
Total [4]	228	56,039	541	21,970	61	622	57,842	15,504	5,285	78,631	5.87
Tennessee:											
Anderson	24	1,615	13	552	3	85	995	1,257	--------	2,252	3.55
Bledsoe	--------	--------	W	W	--------	--------	W	W	--------	W	W
Campbell	16	213	20	1,240	6	127	1,246	334	--------	1,580	3.60
Claiborne	6	1,060	W	W	W	W	1,427	15	--------	1,442	4.38
Cumberland	--------	--------	W	W	--------	--------	--------	W	--------	W	W
Fentress	5	33	--------	--------	--------	--------	--------	33	--------	33	5.00
Grundy	--------	--------	W	W	--------	--------	W	--------	--------	W	W
Hamilton	W	W	W	W	--------	--------	--------	36	--------	36	3.89
Marion	26	826	--------	--------	--------	--------	689	137	--------	826	3.96
Morgan	10	95	9	211	--------	--------	--------	305	--------	305	3.93
Overton	3	7	--------	--------	--------	--------	--------	7	--------	7	3.62
Putnam	W	W	--------	--------	--------	--------	W	W	--------	W	W
Rhea	1	2	--------	--------	--------	--------	--------	2	--------	2	3.79
Scott	8	425	W	W	W	W	643	180	--------	824	3.70
Sequatchie	W	W	W	W	--------	--------	174	55	--------	229	3.50
Van Buren	--------	--------	3	303	--------	--------	240	63	--------	303	3.99
Other counties	13	196	17	1,065	2	26	176	66	--------	243	3.42
Total [4]	112	4,473	62	3,371	11	238	5,590	2,491	--------	8,082	3.80
Utah:											
Carbon	10	3,367	--------	--------	--------	--------	3,218	131	18	3,367	6.30
Emery	7	1,200	--------	--------	--------	--------	1,021	173	6	1,200	6.38
Iron	1	4	--------	--------	--------	--------	--------	4	--------	4	5.00
Kane	1	2	--------	--------	--------	--------	--------	2	--------	2	6.00
Sevier	1	72	--------	--------	--------	--------	--------	72	--------	72	5.80
Summit	1	12	--------	--------	--------	--------	--------	12	--------	12	5.37
Total [4]	21	4,657	--------	--------	--------	--------	4,240	393	24	4,657	6.31
Virginia:											
Buchanan	402	13,670	19	500	39	578	14,378	367	3	14,748	5.64
Dickenson	54	7,176	6	939	8	285	8,014	385	--------	8,399	5.43
Lee	23	404	13	290	11	189	738	144	--------	883	4.19
Montgomery	W	W	--------	--------	--------	--------	--------	W	--------	W	W
Russell	19	2,002	1	16	1	8	1,931	95	--------	2,026	6.34
Scott	W	W	--------	--------	--------	--------	--------	W	--------	W	W
Tazewell	12	334	1	15	1	7	324	32	--------	356	5.55
Wise	86	6,785	36	1,802	22	554	8,663	290	187	9,141	4.97
Other counties	2	4	--------	--------	--------	--------	--------	4	--------	4	5.00
Total [4]	598	30,373	76	3,561	82	1,621	34,049	1,316	190	35,555	5.42
Washington:											
King	W	W	W	W	--------	--------	W	W	--------	W	W
Lewis	--------	--------	W	W	--------	--------	--------	W	--------	W	W

See footnotes at end of table.

Table 16.—Production, shipments, and value at bituminous coal and lignite mines, in the United States, in 1969, by States and counties—Continued

(Thousand short tons)

State and county	Production: Underground: Number of mines	Underground: Quantity	Strip: Number of mines	Strip: Quantity	Auger: Number of mines	Auger: Quantity	Shipments: Rail or water [1]	Truck	Used at mine [2]	Total	Average value per ton [3]
Washington—Continued											
Thurston	W	W	---	---	---	---	---	W	---	W	W
Other counties	3	53	2	5	---	---	10	48	---	58	$8.21
Total [4]	3	53	2	5	---	---	10	48	---	58	8.21
West Virginia:											
Barbour	23	2,131	14	1,533	1	43	3,706	2	---	3,708	4.58
Boone	41	8,320	12	1,226	17	1,041	10,545	35	8	10,587	5.30
Braxton	W	W	---	---	---	---	W	---	---	W	W
Brooke	2	651	6	212	---	---	19	199	645	863	4.43
Clay	W	W	---	---	---	---	W	---	---	W	W
Fayette	49	3,590	12	1,089	6	451	5,070	52	7	5,130	5.41
Gilmer	6	17	2	51	---	---	68	---	---	68	3.75
Grant	W	W	6	484	W	W	1,959	561	---	2,520	4.55
Greenbrier	18	476	1	7	---	---	464	18	---	482	4.11
Hancock	---	---	1	3	---	---	---	3	---	3	4.13
Harrison	15	6,268	25	850	1	56	7,114	61	---	7,175	4.91
Kanawha	55	9,402	18	1,370	20	618	11,255	130	5	11,390	5.36
Lewis	1	11	6	485	4	74	559	11	---	570	4.22
Logan	47	12,917	7	321	20	1,176	14,280	99	34	14,414	5.88
Marion	10	9,973	4	138	---	---	10,079	28	3	10,110	5.50
Marshall	4	4,328	---	---	---	---	2,501	126	1,702	4,328	4.63
Mason	4	338	---	---	---	---	336	1	---	338	4.02
McDowell	177	15,061	17	1,256	7	114	16,067	224	141	16,431	7.23
Mercer	13	1,028	5	182	2	23	1,229	1	3	1,232	7.14
Mineral	W	W	W	W	---	---	137	43	---	180	3.97
Mingo	43	3,407	5	37	8	424	3,600	267	---	3,867	5.85
Monongalia	24	10,499	13	421	---	---	10,509	410	---	10,919	4.93
Nicholas	67	6,311	W	W	W	W	6,702	65	---	6,767	6.02
Ohio	W	W	---	---	---	---	W	W	W	W	W
Pocahontas	6	54	---	---	---	---	50	4	---	54	4.35
Preston	45	1,147	23	1,354	---	---	1,699	802	---	2,501	3.92
Raleigh	67	7,110	16	1,560	11	217	8,708	148	30	8,886	6.95
Randolph	12	494	2	46	---	---	518	23	---	540	5.01
Taylor	8	44	3	132	---	---	175	1	---	176	4.40
Tucker	---	---	5	570	---	---	565	5	---	570	4.15
Upshur	7	302	4	189	1	14	502	3	---	505	3.60
Wayne	2	14	---	---	---	---	---	14	---	14	5.73
Webster	14	155	3	32	1	2	140	49	---	189	3.59
Wyoming	97	12,526	4	421	7	568	13,296	191	28	13,515	6.56

Other counties	10	5,050	15	496	5	105	2,922	48	8	2,979	4.90
Total [4]	867	121,623	229	14,464	111	4,924	134,774	3,625	2,612	141,011	5.73
Wyoming:											
Campbell	---------	---------	1	559	---------	---------	440	14	105	559	1.45
Carbon	---------	---------	1	615	---------	---------	615	---------	---------	615	W
Converse	---------	---------	W	W	---------	---------	---------	W	W	W	W
Hot Springs	W	W	---------	---------	---------	---------	W	W	---------	W	W
Lincoln	---------	---------	W	W	---------	---------	W	---------	W	W	W
Sheridan	---------	---------	2	346	---------	---------	323	23	---------	346	W
Sweetwater	W	W	---------	---------	---------	---------	W	W	W	W	W
Other counties	4	122	4	2,960	---------	---------	323	10	2,748	3,082	3.60
Total [4]	4	122	8	4,481	---------	---------	1,702	48	2,852	4,602	3.36
Total United States [4]	3,097	347,132	1,551	197,023	470	16,350	468,900	66,030	25,575	560,505	4.99

W Withheld to avoid disclosing individual company data; included with "Other counties."

[1] Includes coal loaded at mine directly into railroad cars or river barges, hauled by trucks to railroad sidings, and hauled by trucks to waterways.

[2] Includes coal used at mine for power and heat, made into beehive coke at mine, used by mine employees, used for all other purposes at mine, and transported from mine to point of use by conveyor, tram, or pipeline.

[3] Value received or charged for coal f.o.b. mine. Includes a value for coal not sold but used by producers, such as mine fuel and coal coked, as estimated by producers at average prices that might have been received if such coal had been sold commercially.

[4] Data may not add to totals shown because of independent rounding.

Table 17.—Number and production of bituminous coal and lignite strip mines and units of stripping and loading equipment in the United States, in 1969, by States

State	Number of strip mines	Production (thousand short tons)	Number of power shovels and dragline excavators: By type of power: Electric	Diesel electric	Diesel	Gasoline	By capacity of dipper or bucket, cubic yards: Less than 3	3–5	6–12	More than 12	By type of machine: Power shovels	Dragline excavators	Total	Number of carryall scrapers	Number of bulldozers
Alabama	64	8,130	12	3	114	3	46	31	35	20	95	37	132	4	111
Alaska	3	667	-------	-------	6	-------	4	2	-----	-----	5	1	6	5	8
Arkansas	6	167	-------	-------	6	-------	3	1	2	-----	3	3	6	-------	8
Colorado	9	1,915	7	1	6	-------	5	2	4	3	7	7	14	2	22
Illinois	37	34,640	84	11	19	-------	13	13	33	55	75	39	114	3	151
Indiana	32	17,976	54	6	47	4	35	24	27	25	65	46	111	2	107
Iowa	11	534	-------	-------	25	1	12	11	3	-----	11	15	26	2	18
Kansas	4	1,313	6	2	5	-------	4	3	2	4	6	7	13	-------	8
Kentucky:															
Eastern	113	9,885	-------	3	164	2	107	27	33	2	161	8	169	8	151
Western	50	27,618	55	10	73	1	31	33	40	35	106	33	139	6	130
Total [1]	163	37,503	55	13	237	3	138	60	73	37	267	41	308	14	281
Maryland	31	962	-------	-------	56	-------	49	5	2	-----	44	12	56	-------	43
Missouri	8	3,299	17	4	1	4	8	4	4	10	16	10	26	4	28
Montana:															
Bituminous	3	687	4	-------	-------	1	-------	1	1	3	4	1	5	-------	3
Lignite	2	308	1	-------	1	1	1	1	1	-----	2	1	3	2	2
Total [1]	5	995	5	-------	1	2	1	2	2	3	6	2	8	2	5
New Mexico	3	3,636	6	-------	3	-------	1	1	3	4	7	2	9	4	7
North Dakota (lignite)	20	4,704	18	4	16	8	22	10	8	6	34	12	46	16	33
Ohio	230	31,014	45	17	394	13	250	115	71	33	349	120	469	27	403
Oklahoma	7	1,713	6	4	3	-------	5	1	1	6	7	6	13	1	14
Pennsylvania	541	21,970	8	20	826	31	568	143	164	10	570	315	885	28	652
Tennessee	62	3,371	-------	4	100	1	75	7	22	1	95	10	105	-------	101
Virginia	76	3,561	-------	-------	47	2	31	17	1	-----	49	-------	49	2	62
Washington	2	5	-------	-------	1	2	1	-----	2	-----	2	1	3	-------	1
West Virginia	229	14,464	1	3	298	10	205	61	42	4	273	39	312	10	303
Wyoming	8	4,481	7	-------	5	3	8	2	3	2	11	4	15	24	22
Total [1]	1,551	197,023	331	92	2,216	87	1,484	515	504	223	1,997	729	2,726	150	2,388

[1] Data may not add to totals shown because of independent rounding.

Table 18.—Bituminous coal and lignite strip mines using power drills in bank or overburden in the United States, by States

State	Number of mines		Production: Quantity (thousand short tons)		Number of power drills: Horizontal		Vertical		Total	
	1968	1969	1968	1969	1968	1969	1968	1969	1968	1969
Alabama	33	47	5,264	7,169	7	5	32	48	39	53
Alaska	3	3	750	667	1	1	3	3	4	4
Arkansas	3	4	152	160	1	1	2	3	3	4
Colorado	4	7	1,764	1,905	2	2	5	7	7	9
Illinois	27	27	31,615	32,199	16	19	28	22	44	41
Indiana	23	24	15,851	17,823	12	9	30	33	42	42
Iowa	9	9	451	432	7	8	10	11	17	19
Kansas	4	4	1,268	1,313	9	7	2	1	11	8
Kentucky:										
Eastern	34	57	3,962	6,122	21	27	23	42	44	69
Western	29	31	27,965	22,713	8	11	48	47	56	58
Total [1]	63	88	31,927	28,835	29	38	71	89	100	127
Maryland	12	10	589	552	3	2	5	5	8	7
Missouri	10	8	3,199	3,299	12	10	5	5	17	15
Montana:										
Bituminous	1	2	2	166	----	----	1	2	1	2
Lignite	1	1	1	1	1	1	----	----	1	1
Total [1]	2	3	3	167	1	1	1	2	2	3
New Mexico	2	2	2,653	3,628	1	1	3	3	4	4
North Dakota (lignite)	1	1	2	1	1	1	----	----	1	1
Ohio	133	106	24,788	25,490	32	33	115	106	147	139
Oklahoma	4	5	999	1,048	5	4	4	8	9	12
Pennsylvania	193	214	12,828	13,348	61	46	133	134	194	180
Tennessee	32	30	1,934	2,050	27	18	14	25	41	43
Virginia	21	17	2,001	1,610	11	7	15	21	26	28
West Virginia	132	140	8,579	11,434	54	44	103	94	157	138
Wyoming	6	5	2,257	2,400	6	5	7	6	13	11
Total [1]	717	754	148,874	155,530	298	262	588	626	886	888

[1] Data may not add to totals shown because of independent rounding.

Table 19.—Method of haulage from bituminous coal and lignite strip mines to tipple or ramp, in the United States, in 1969, by States

State	Strip mines reporting method of haulage: Number of trucks	Average capacity per truck (short tons)	Average distance hauled (miles)	Production (thousand short tons)	Strip mines not reporting method of haulage production (thousand short tons)	Total strip production (thousand short tons)
Alabama	141	26.9	5.1	5,336	2,794	8,130
Alaska	13	42.8	6.4	667	--------	667
Arkansas	8	12.8	2.0	155	12	167
Colorado	16	39.3	2.2	1,284	631	1,915
Illinois	252	64.7	3.7	34,507	133	34,640
Indiana	145	52.3	3.8	17,831	145	17,976
Iowa	28	12.9	5.5	526	8	534
Kansas	19	53.6	5.1	1,313	--------	1,313
Kentucky	408	31.7	4.4	21,688	15,815	37,503
Maryland	31	20.1	5.6	603	359	962
Missouri	47	57.7	5.7	3,270	29	3,299
Montana:						
Bituminous	4	77.5	1.5	166	521	687
Lignite	4	15.8	2.0	308	--------	308
Total [1]	8	46.6	1.8	474	521	995
New Mexico	19	75.3	3.5	3,628	7	3,636
North Dakota (lignite)	85	24.6	3.5	4,635	71	4,704
Ohio	583	26.2	8.8	25,847	5,167	31,014
Oklahoma	33	32.4	4.0	1,049	664	1,713
Pennsylvania	1,010	17.3	7.3	15,651	6,319	21,970
Tennessee	127	20.9	9.0	1,386	1,985	3,371
Virginia	71	19.4	3.9	1,459	2,102	3,561
Washington	1	4.0	.7	3	2	5
West Virginia	482	21.8	5.9	10,720	3,744	14,464
Wyoming	34	45.5	1.4	4,481	--------	4,481
Total [1]	3,561	28.2	5.3	156,513	40,510	197,023

[1] Data may not add to totals shown because of independent rounding.

Table 20.—Equipment used at bituminous coal and lignite auger mines in the United States, number of units

State	Augers		Power shovels		Power drills		Bulldozers	
	1968	1969	1968	1969	1968	1969	1968	1969
Alabama	2	1	------	------	------	1	------	------
Illinois	1	------	------	------	------	------	------	------
Kentucky	150	146	2	19	5	8	99	86
Maryland	5	8	------	------	------	------	2	2
Ohio	41	40	1	1	1	1	22	14
Oklahoma	1	1	------	------	------	------	------	------
Pennsylvania	49	55	------	------	4	7	6	9
Tennessee	9	12	2	------	------	1	6	6
Virginia	68	85	------	1	6	2	49	73
West Virginia	107	105	18	13	16	15	109	94
Total	433	453	23	34	32	35	293	284

Table 21.—Bituminous coal and lignite mechanically loaded underground in the United States, by type of loading equipment

(Thousand short tons)

Type of loading equipment	1968	1969
Mobile loading machines:		
Direct into mine cars or onto conveyors	21,380	22,178
Into shuttle cars	138,320	133,222
Continuous-mining machines:		
Onto conveyors	17,433	17,574
Into shuttle cars	118,183	121,600
Onto bottom	24,196	29,125
Into rubber-tired mine cars	4,004	4,343
Longwall machines	4,633	6,344
Duckbills, scraper loaders, and hand-loaded conveyors	1,239	1,046
Total mechanically loaded [1]	329,387	335,431

[1] Data may not add to totals shown because of independent rounding.

Table 22.—Comparative changes in underground mechanical loading of bituminous coal and lignite by principal types of loading devices in the United States, by States

(Thousand short tons)

State	Mobile loading machines		Continuous-mining machines		Longwall machines	
	1968	1969	1968	1969	1968	1969
Alabama	8,418	8,215	382	652	--------	--------
Arkansas	--------	--------	--------	--------	--------	--------
Colorado	918	800	2,786	2,776	--------	--------
Illinois	12,221	12,208	14,168	17,832	--------	38
Indiana	1,989	1,952	179	158	--------	--------
Iowa	289	366	--------	--------	--------	--------
Kentucky	44,071	46,631	10,544	11,624	--------	--------
Maryland	161	150	95	87	--------	--------
Montana	17	19	--------	--------	--------	--------
New Mexico	--------	--------	763	832	--------	--------
Ohio	6,710	8,215	9,475	10,262	--------	--------
Oklahoma	--------	--------	31	115	--------	--------
Pennsylvania	9,068	8,441	43,391	45,228	1,615	1,967
Tennessee	3,246	3,484	606	502	--------	--------
Utah	871	507	3,149	3,693	282	441
Virginia	15,540	14,806	10,411	11,543	990	1,532
Washington	19	22	--------	--------	--------	--------
West Virginia	56,052	49,467	67,835	67,337	1,746	2,365
Wyoming	110	115	--------	--------	--------	--------
Total [1]	159,700	155,400	163,816	172,642	4,633	6,344

State	Duckbills, scraper loaders and hand-loaded conveyors		Total mechanically loaded		Total production at mines using mechanical loading devices	
	1968	1969	1968	1969	1968	1969
Alabama	165	231	8,966	9,098	8,966	9,098
Arkansas	59	61	59	61	59	61
Colorado	43	27	3,747	3,603	3,751	3,603
Illinois	--------	--------	26,389	30,079	26,389	30,079
Indiana	--------	--------	2,168	2,110	2,168	2,110
Iowa	--------	--------	289	366	289	366
Kentucky	37	33	54,653	58,288	55,042	58,555
Maryland	3	3	259	240	259	240
Montana	16	14	33	33	33	33
New Mexico	--------	--------	763	832	763	832
Ohio	10	4	16,195	18,481	16,197	18,481
Oklahoma	--------	--------	31	115	31	115
Pennsylvania	211	146	54,285	55,782	54,286	55,792
Tennessee	125	64	3,977	4,050	3,977	4,050
Utah	13	10	4,316	4,652	4,316	4,652
Virginia	87	72	27,028	27,953	27,156	27,971
Washington	31	31	50	53	50	53
West Virginia	433	343	126,066	119,512	126,159	119,531
Wyoming	7	7	117	122	117	122
Total [1]	1,239	1,046	329,387	335,431	330,005	335,744

[1] Data may not add to totals shown because of independent rounding.

Table 23.—Number of bituminous coal and lignite underground mines using mechanical loading devices and number of units in use in the United States, by States

State	Number of mines									
	Using mobile loading machines		Using continuous-mining machines only		Using duckbills, scraper loaders, and hand-loaded conveyors only		Using more than one type of loading device		Total	
	1968	1969	1968	1969	1968	1969	1968	1969	1968	1969
Alabama	10	10	-----	-----	19	19	4	5	33	34
Arkansas	-----	-----	-----	-----	2	2	-----	-----	2	2
Colorado	22	20	10	14	6	3	5	2	43	39
Illinois	14	10	10	8	-----	-----	8	9	32	27
Indiana	8	5	-----	-----	-----	-----	1	1	9	6
Iowa	2	2	-----	-----	-----	-----	-----	-----	2	2
Kentucky	425	421	41	38	2	5	11	14	479	478
Maryland	2	2	2	2	1	1	-----	-----	5	5
Montana	3	4	-----	-----	2	2	-----	-----	5	6
New Mexico	-----	-----	1	1	-----	-----	-----	-----	1	1
Ohio	14	13	12	13	2	1	5	5	33	32
Oklahoma	-----	-----	1	2	-----	-----	-----	-----	1	2
Pennsylvania	41	35	108	98	24	19	21	19	194	171
Tennessee	31	35	6	6	12	11	-----	1	49	53
Utah	10	8	7	8	1	-----	5	5	23	21
Virginia	269	310	40	51	6	4	18	11	333	376
Washington	2	2	-----	-----	1	1	-----	-----	3	3
West Virginia	341	331	147	144	15	9	103	96	606	580
Wyoming	4	2	-----	-----	-----	2	-----	-----	4	4
Total	1,198	1,210	385	385	93	79	181	168	1,857	1,842

State	Number of loading devices							
	Mobile loading machines		Continuous-mining machines		Longwall machines		Duckbills, scraper loaders, and hand-loaded conveyors	
	1968	1969	1968	1969	1968	1969	1968	1969
Alabama	77	75	7	8	------	------	28	37
Arkansas	-------	-------	-------	-------	------	------	4	4
Colorado	58	52	36	35	------	------	13	9
Illinois	77	69	76	85	------	1	-------	-------
Indiana	25	22	1	1	------	------	-------	-------
Iowa	5	4	-------	-------	------	------	-------	-------
Kentucky	643	643	108	114	------	------	3	9
Maryland	5	5	3	3	------	------	1	1
Montana	7	5	-------	-------	------	------	6	7
New Mexico	4	5	4	5	------	------	-------	-------
Ohio	56	57	75	79	------	------	3	2
Oklahoma	-------	2	1	5	------	------	-------	-------
Pennsylvania	222	187	429	458	8	9	53	40
Tennessee	56	59	10	11	------	------	23	12
Utah	32	27	27	29	2	2	2	3
Virginia	335	365	98	118	4	5	10	6
Washington	3	3	-------	-------	------	------	3	3
West Virginia	933	884	612	620	8	11	52	40
Wyoming	4	2	-------	-------	------	------	5	5
Total	2,542	2,466	1,487	1,571	22	28	206	178

Table 24.—Production at bituminous coal and lignite underground mines in the United States, by States and methods of loading

(Thousand short tons)

State	Hand loaded 1968	Hand loaded 1969	Mechanically loaded 1968	Mechanically loaded 1969	Total underground production 1968	Total underground production 1969
Alabama	286	188	8,966	9,098	9,252	9,287
Arkansas	----------	----------	59	61	59	61
Colorado	16	12	3,747	3,603	3,763	3,615
Illinois	3	3	26,389	30,079	26,392	30,082
Indiana	----------	----------	2,168	2,110	2,168	2,110
Iowa	4	2	289	366	293	368
Kentucky	6,041	6,048	54,653	58,288	60,694	64,336
Maryland	95	82	259	240	354	322
Missouri	----------	1	----------	----------	----------	1
Montana	3	1	33	33	36	35
New Mexico	5	4	763	832	768	836
Ohio	144	144	16,195	18,481	16,339	18,625
Oklahoma	----------	----------	31	115	31	115
Pennsylvania	337	257	54,285	55,782	54,622	56,039
Tennessee	647	423	3,977	4,050	4,624	4,473
Utah	----------	5	4,316	4,652	4,316	4,657
Virginia	4,372	2,420	27,028	27,953	31,400	30,373
Washington	----------	----------	50	53	50	53
West Virginia	2,800	2,111	126,066	119,512	128,866	121,623
Wyoming	----------	----------	117	122	117	122
Total [1]	14,755	11,700	329,387	335,431	344,142	347,132

[1] Data may not add to totals shown because of independent rounding.

Table 25.—Mechanical cleaning at bituminous coal and lignite mines in the United States, in 1969, by States

(Thousand short tons)

State	Total production	Mechanical cleaning: Number of cleaning plants	Mechanical cleaning: Raw coal	Mechanical cleaning: Cleaned coal	Mechanical cleaning: Refuse
Alabama	17,456	22	19,012	11,498	7,513
Alaska	667	3	64	34	30
Arkansas	228	1	53	49	4
Colorado	5,530	4	1,960	1,701	259
Illinois	64,722	43	68,190	54,911	13,280
Indiana	20,086	11	21,435	16,570	4,862
Kansas	1,313	3	1,893	1,308	585
Kentucky	109,049	52	58,744	47,149	11,595
Missouri	3,301	4	2,321	1,716	605
New Mexico	4,471	1	1,023	824	200
Ohio	51,242	19	20,610	15,567	5,042
Oklahoma	1,838	4	479	338	141
Pennsylvania	78,631	77	66,468	50,755	15,712
Tennessee	8,082	5	2,048	1,581	468
Utah	4,657	6	3,649	3,157	492
Virginia	35,555	33	27,233	21,176	6,057
Washington	58	3	65	53	11
West Virginia	141,011	143	140,033	106,297	33,735
Wyoming	4,602	1	78	77	2
Other States [1]	8,005	----------	----------	----------	----------
Total [2]	560,505	435	435,356	334,761	100,593

[1] Includes Iowa, Maryland, and bituminous coal and lignite from Montana, and North Dakota.
[2] Data may not add to totals shown because of independent rounding.

Table 26.—Mechanical cleaning of bituminous coal and lignite in the United States, by types of equipment

(Thousand short tons)

Type of equipment	1968	1969
Wet methods:		
Jigs	159,028	155,027
Concentrating tables	47,268	45,328
Classifiers	4,871	3,401
Launders	4,498	4,644
Dense medium processes:		
Magnetite	70,633	71,701
Sand	27,027	24,023
Calcium chloride	1,839	1,911
Total [1]	99,497	97,636
Flotation	8,961	9,560
Total, wet methods [1]	324,123	315,596
Pneumatic methods	16,804	19,163
Grand total [1]	340,923	334,761

[1] Data may not add to totals shown because of independent rounding.

Table 27.—Mechanical cleaning at bituminous coal and lignite mines in the United States, in 1969, by States and by underground, strip, and auger mining

(Thousand short tons)

State	Underground mines		Strip mines		Auger mines		Total, all mines [1]	
	Total production	Cleaned	Total production	Cleaned	Total production	Cleaned	Total production	Cleaned
Alabama	9,287	8,838	8,130	2,660	39	-------	17,456	11,498
Alaska	-------	-------	667	34	-------	-------	667	34
Arkansas	61	-------	167	49	-------	-------	228	49
Colorado	3,615	1,692	1,915	8	-------	-------	5,530	1,701
Illinois	30,082	24,090	34,640	30,820	-------	-------	64,722	54,911
Indiana	2,110	1,810	17,976	14,760	-------	-------	20,086	16,570
Kansas	-------	-------	1,313	1,308	-------	-------	1,313	1,308
Kentucky	64,336	31,276	37,503	15,861	7,211	12	109,049	47,149
Missouri	1	-------	3,299	1,716	-------	-------	3,301	1,716
New Mexico	836	824	3,636	-------	-------	-------	4,471	824
Ohio	18,625	12,299	31,014	3,193	1,602	75	51,242	15,567
Oklahoma	115	115	1,713	214	9	9	1,838	338
Pennsylvania	56,039	43,934	21,970	6,760	622	61	78,631	50,755
Tennessee	4,473	1,549	3,371	33	238	-------	8,082	1,581
Utah	4,657	3,157	-------	-------	-------	-------	4,657	3,157
Virginia	30,373	20,769	3,561	255	1,621	153	35,555	21,176
Washington	53	53	5	-------	-------	-------	58	53
West Virginia	121,623	99,683	14,464	4,460	4,924	2,153	141,011	106,297
Wyoming	122	77	4,481	-------	-------	-------	4,602	77
Other States [2]	725	-------	7,196	-------	83	-------	8,005	-------
Total [1]	347,132	250,166	197,023	82,131	16,350	2,463	560,505	334,761

[1] Data may not add to totals shown because of independent rounding.
[2] Includes Iowa, Maryland, and bituminous and lignite from Montana, and North Dakota.

Table 28.—Mechanical crushing of bituminous coal and lignite at mines in the United States, by States

State	Number of plants crushing coal		Coal crushed (thousand short tons)	
	1968	1969	1968	1969
Alabama	16	22	7,367	7,865
Alaska	3	3	750	667
Arkansas	6	6	189	206
Colorado	29	34	3,306	3,496
Illinois	63	56	37,998	41,291
Indiana	31	26	14,130	13,632
Iowa	13	12	701	757
Kansas	1	1	978	250
Kentucky	126	137	54,871	43,122
Maryland	6	9	591	594
Missouri	9	7	3,167	2,874
Montana:				
Bituminous	8	10	170	710
Lignite	2	2	328	306
Total [1]	10	12	499	1,016
New Mexico	4	4	3,421	4,464
North Dakota (lignite)	16	15	4,341	4,542
Ohio	107	95	25,278	26,128
Oklahoma	5	5	938	1,520
Pennsylvania	165	163	37,171	37,348
Tennessee	37	43	3,442	4,072
Utah	21	14	2,609	1,605
Virginia	55	54	13,452	16,189
Washington	3	3	9	11
West Virginia	226	217	53,064	51,227
Wyoming	9	8	1,768	2,477
Total [1]	961	946	270,040	265,353

[1] Data may not add to totals shown because of independent rounding.

Table 29.—Treatment of bituminous coal and lignite at mines for allaying dust in the United States

Treatment	Thousand short tons		Number of plants [1]	
	1968	1969	1968	1969
Calcium chloride	875	1,657	24	22
Oil	44,120	30,407	382	353
Calcium chloride and oil	1,893	2,196	14	11
All other materials	12,388	12,312	23	19
Total	59,276	46,572	443	405

[1] Because some mines used more than one method of treatment, this total may not necessarily be the sum of the individual items.

Table 30.—Treatment of bituminous coal and lignite at mines for allaying dust in the United States, by States

State	Number of mines treating coal		Coal treated (thousand short tons)	
	1968	1969	1968	1969
Alabama	1	1	2	3
Colorado	24	23	187	172
Illinois	43	38	3,502	3,786
Indiana	16	16	625	607
Iowa	3	3	4	2
Kansas	2	2	17	76
Kentucky	53	47	13,991	9,769
Missouri	2	2	11	12
Montana:				
Bituminous	7	8	19	24
Lignite	1	1	1	1
Total [1]	8	9	19	24
New Mexico	3	2	2,657	3,487
North Dakota (lignite)	16	15	452	660
Ohio	25	21	3,275	4,249
Oklahoma	2	1	11	6
Pennsylvania	48	42	10,753	11,143
Tennessee	1	2	22	23
Utah	17	16	827	632
Virginia	23	21	5,088	4,936
West Virginia	100	86	17,681	6,858
Wyoming	9	9	152	127
Total [1]	396	356	59,276	46,572

[1] Data may not add to totals shown because of independent rounding.

Table 31.—Thermal drying of bituminous coal and lignite in the United States, by type of drying equipment

Type of drier	Number of thermal drying units		Thermally dried (thousand short tons)	
	1968	1969	1968	1969
Fluidized-bed	77	80	38,153	40,639
Multilouver	42	29	13,831	10,067
Rotary	6	5	1,995	1,204
Screen	33	25	5,897	5,100
Suspension or flash	40	35	9,202	7,381
Vertical tray and cascade	23	18	4,225	2,691
Total	221	192	73,303	67,082

Table 32.—Comparison of thermal drying of bituminous coal and lignite with mechanical cleaning at mines in the United States, by States

(Thousand short tons)

State	Number of cleaning plants: Total 1968	Total 1969	With thermal drying 1968	With thermal drying 1969	Production mechanically cleaned 1968	Production mechanically cleaned 1969	Thermally dried 1968	Thermally dried 1969
Colorado	3	4	1	1	1,706	1,701	702	552
Illinois	48	43	25	21	53,881	54,911	11,848	10,717
Indiana	12	11	6	4	15,324	16,570	2,294	1,813
Kentucky	52	52	9	10	50,246	47,149	3,350	3,529
North Dakota (lignite)	------	------	2	2	--------	--------	135	112
Ohio	20	19	7	6	16,942	15,567	3,204	4,212
Pennsylvania	85	77	11	10	48,541	50,755	5,717	4,547
Utah	6	6	2	2	2,752	3,157	920	715
Virginia	33	33	7	8	19,663	21,176	9,633	10,121
West Virginia	149	143	55	55	114,900	106,297	35,500	30,764
Other States	46	47	------	------	16,968	17,478	--------	--------
Total [1]	454	435	125	119	340,923	334,761	73,303	67,082

[1] Data may not add to totals shown because of independent rounding.

Table 33.—Thermal drying of bituminous coal and lignite at mines in the United States, by States

(Thousand short tons)

State	Number of thermal drying units 1968	Number of thermal drying units 1969	Grand total production 1968	Grand total production 1969	Thermally dried 1968	Thermally dried 1969
Colorado	1	1	5,558	5,530	702	552
Illinois	46	39	62,441	64,722	11,848	10,717
Indiana	8	5	18,486	20,086	2,294	1,813
Kentucky	18	18	101,156	109,049	3,350	3,529
North Dakota (lignite)	2	2	4,487	4,704	135	112
Ohio	14	13	48,323	51,242	3,204	4,212
Pennsylvania	16	11	76,200	78,631	5,717	4,547
Utah	2	2	4,316	4,657	920	715
Virginia	19	19	36,966	35,555	9,633	10,121
West Virginia	95	82	145,921	141,011	35,500	30,764
Other States	----------	----------	41,389	45,317	----------	----------
Total [1]	221	192	545,245	560,505	73,303	67,082

[1] Data may not add to totals shown because of independent rounding.

Table 34.—Bituminous coal and lignite loaded for shipment by railroads and waterways in the United States, in 1969, as reported by mine operators

(Thousand short tons)

Route	State	By State	Total for route
RAILROAD			
Alaska	Alaska	663	663
Atchison, Topeka & Santa Fe	Illinois	134	1,406
	New Mexico	1,272	
Baltimore & Ohio	Illinois	493	35,489
	Ohio	10,402	
	Pennsylvania	2,609	
	West Virginia	21,985	
Bessemer & Lake Erie	Pennsylvania	2,183	2,183
Cambria & Indiana	do	4,974	4,974
Carbon County	Utah	843	843
Chesapeake & Ohio	Kentucky	17,597	56,961
	Ohio	27	
	West Virginia	39,337	
Cheswick & Harmar	Pennsylvania	317	317
Chicago, Burlington & Quincy	Illinois	11,493	13,345
	Iowa	331	
	Missouri	756	
	Wyoming	765	
Chicago & Eastern Illinois	Illinois	2,556	3,326
	Indiana	770	
Chicago & Illinois Midland	Illinois	4,223	4,223
Chicago, Milwaukee, St. Paul & Pacific	Indiana	3,194	3,301
	Montana	2	
	North Dakota (lig.)	105	
Chicago & North Western	Illinois	1,347	1,352
	Iowa	5	
Chicago, Rock Island & Pacific	Illinois	1,702	1,905
	Iowa	203	
Clinchfield	Kentucky	928	4,849
	Virginia	3,921	
Colorado & Wyoming	Colorado	764	764
Denver & Rio Grande Western	do	3,140	5,217
	Utah	2,077	
Erie-Lackawanna	Ohio	255	255
Great Northern	North Dakota (lig.)	229	229
Gulf, Mobile & Ohio	Illinois	7,152	7,152
Illinois Central	do	11,562	23,531
	Kentucky	11,969	
Interstate	Virginia	4,692	4,692
Kansas City Southern	Oklahoma	281	281
Kentucky & Tennessee	Kentucky	438	438
Lake Erie, Franklin & Clarion	Pennsylvania	346	346
Louisville & Nashville	Alabama	2,301	38,287
	Kentucky	34,392	
	Tennessee	1,441	
	Virginia	153	
Mary Lee	Alabama	871	871
Missouri-Kansas-Texas	Kansas	1,013	1,420
	Missouri	365	
	Oklahoma	42	
Missouri Pacific	Arkansas	221	5,952
	Illinois	5,462	
	Missouri	11	
	Oklahoma	258	
Monon	Indiana	93	93
Monongahela	West Virginia	7,286	7,286
Montour	Pennsylvania	2,601	2,601
Norfolk & Western	Iowa	56	79,582
	Kentucky	12,474	
	Missouri	309	
	Ohio	6,656	
	Virginia	22,794	
	West Virginia	37,293	
Northern Pacific	Montana (bit. and lig.)	991	3,206
	North Dakota (lig.)	2,215	
Pacific Coast	Washington	10	10
Penn Central (includes coal shipped over Kanawha & Michigan, Kelley's Creek, Toledo & Ohio Central, and Zanesville & Western)	Illinois	2,687	51,171
	Indiana	9,171	
	Ohio	11,227	
	Pennsylvania	21,654	
	West Virginia	6,432	
Pittsburgh & Shawmut	Pennsylvania	1,930	1,930
St. Louis-San Francisco	Alabama	303	1,819
	Arkansas	4	
	Kansas	271	
	Oklahoma	1,241	
Soo Line	North Dakota (lig.)	425	425

See footnotes at end of table.

Table 34.—Bituminous coal and lignite loaded for shipment by railroads and waterways in the United States, in 1969, as reported by mine operators—Continued

(Thousand short tons)

Route	State	By State	Total for route
Southern	Alabama	3,871	9,761
	Indiana	20	
	Kentucky	384	
	Tennessee	2,996	
	Virginia	2,490	
Tennessee	Tennessee	524	524
Tennessee Coal, Iron & Railroad Co.	Alabama	1,897	1,897
Toledo, Peoria & Western	Illinois	719	719
Union Pacific	Colorado	426	1,364
	Wyoming	938	
Unity	Pennsylvania	803	803
Utah	Utah	1,320	1,320
Western Maryland	Maryland	1,008	7,813
	Pennsylvania	440	
	West Virginia	6,365	
Woodward Iron Company	Alabama	968	968
Total railroad shipments [1]		397,863	397,863
WATERWAY			
Allegheny River	Pennsylvania	1,155	1,155
Black Warrior River	Alabama	3,108	3,108
Cumberland River	Kentucky	144	144
Green River	do	15,267	15,267
Illinois River	Illinois	2,777	2,777
Kanawha River	West Virginia	5,571	5,571
Monongahela River	Pennsylvania	18,829	26,680
	West Virginia	7,851	
Ohio River	Illinois	2,546	15,161
	Indiana	1,377	
	Kentucky	4,476	
	Ohio	4,108	
	West Virginia	2,654	
Tennessee River	Alabama	545	1,174
	Tennessee	629	
Total waterway shipments [1]		71,037	71,037
Total loaded at mines for shipment by railroads and waterways.		468,900	468,900
Shipped by truck from mine to final destination.		66,030	66,030
Used at mine [2]		25,575	25,575
Total production [1]		560,505	560,505

[1] Data may not add to totals shown because of independent rounding.
[2] Includes coal used at mine for power and heat, made into beehive coke at mine, used by mine employees, used for all other purposes at mine, and transported from mine to point of use by conveyor, tram, or pipeline.

Table 35.—Bituminous coal and lignite shipped by unit train in the United States

(Thousand short tons)

State	1968	1969
Colorado	731	1,336
Illinois	13,363	17,621
Kentucky:		
Eastern	8,537	7,420
Western	4,864	6,845
Total [1]	13,401	14,265
Maryland	(2)	150
Montana (bituminous)	1	(2)
Ohio	10,477	13,014
Pennsylvania	18,054	20,370
Virginia	5,372	5,067
West Virginia	42,289	40,733
Other States [3]	5,435	9,167
Total [1]	109,125	121,722

[1] Data may not add to totals shown because of independent rounding.
[2] Included in "Other States."
[3] Includes Alabama, Arkansas (1969), Indiana, Kansas, Maryland (1968), Missouri (1969), Montana (bituminous and lignite) (1969), New Mexico, North Dakota (lignite), Oklahoma (1969), Tennessee (1968), and Utah.

Table 36.—Consumption of bituminous coal and lignite, by consumer class, with retail deliveries in the United States

(Thousand short tons)

Year and month	Electric power utilities [1]	Bunker, lake vessel and foreign [2]	Manufacturing and mining industries					Retail deliveries to other consumers [5]	Total of classes shown [6]
			Beehive coke plants	Oven coke plants	Steel and rolling mills [3]	Cement mills	Other manufacturing and mining industries [4]		
1965	242,729	655	2,693	92,086	7,466	8,873	85,614	19,048	459,164
1966	264,202	609	2,369	93,523	7,117	9,149	89,332	19,965	486,266
1967	271,784	467	1,372	90,900	6,330	8,922	83,542	17,099	480,416
1968:									
January	26,646	1	120	7,975	645	754	8,423	2,780	47,344
February	25,115	------	113	7,634	611	803	7,867	2,380	44,523
March	24,346	3	131	8,082	571	702	7,623	1,730	43,188
April	21,929	43	134	7,870	492	754	6,739	773	38,734
May	22,574	57	135	8,122	476	856	6,584	471	39,275
June	23,209	49	118	7,840	407	747	6,011	475	38,856
July	25,126	46	103	7,835	381	741	5,819	465	40,516
August	26,530	61	97	7,198	336	748	5,807	681	41,458
September	22,850	54	85	6,561	325	771	5,882	943	37,471
October	23,764	48	76	6,524	390	777	6,700	1,357	39,636
November	24,781	41	78	6,632	449	828	7,209	1,339	41,357
December	27,869	14	78	7,224	574	910	7,973	1,830	46,472
Total	294,739	417	1,268	89,497	5,657	9,391	82,637	15,224	498,830
1969:									
January	29,041	1	73	7;379	633	712	8,132	2,597	48,568
February	24,771	------	70	6,937	563	710	7,246	2,007	42,304
March	26,304	3	86	7,579	608	880	7,442	1,509	44,411
April	22,383	28	97	7,581	477	810	6,705	530	38,611
May	23,142	36	88	7,866	411	771	6,316	374	39,004
June	24,391	31	87	7,656	374	731	5,861	335	39,466
July	27,173	41	78	7,755	348	681	5,557	442	42,075
August	26,794	40	111	7,729	332	711	5,573	538	41,828
September	24,544	39	120	7,594	361	695	5,545	748	39,646
October	25,226	44	111	7,981	414	770	6,122	1,074	41,742
November	25,735	36	105	7,664	476	807	6,477	1,122	42,422
December	28,957	14	132	8,022	563	853	7,267	1,390	47,198
Total	308,461	313	1,158	91,743	5,560	9,131	78,243	12,666	507,275

[1] Federal Power Commission.
[2] Bureau of the Census, U.S. Department of Commerce, Ore and Coal Exchange.
[3] Estimates based upon reports collected from a selected list of representative steel and rolling mills.
[4] Estimate based upon reports collected from a selected list of representative manufacturing plants.
[5] Estimates based upon reports collected from a selected list of representative retailers. Includes some coal shipped by truck from mine to final destination.
[6] The total of classes shown approximates total consumption. The calculation of consumption from production, imports, exports, and changes in stocks is not as accurate as the "Total of classes shown" because certain significant items of stocks are not included in year end stocks. These items are stocks on Lake and Tidewater docks, stocks at other intermediate storage piles between mine and consumer, and coal in transit.

Table 37.—Stocks of bituminous coal and lignite in the hands of commercial consumers and in the retail dealers' yards in the United States, in 1969

Date	Total stocks (thousand short tons)	Days' supply at current rate of consumption on date of stocktaking: Electric power utilities	Manufacturing and mining industries: Oven coke plants	Steel and rolling mills	Cement mills	Other manufacturing and mining industries	Retail dealers	Total
Jan. 31	78,156	63	36	17	44	35	2	50
Feb. 28	76,056	64	33	18	41	36	2	50
Mar. 31	72,416	65	30	17	28	38	2	51
Apr. 30	77,054	78	32	21	33	42	5	60
May 31	82,084	83	34	27	39	48	9	65
June 30	82,763	77	35	29	43	52	13	63
July 31	74,480	65	26	28	49	54	11	55
Aug. 31	75,128	66	27	34	53	54	10	56
Sept. 30	78,712	72	29	30	57	57	7	60
Oct. 31	83,545	77	33	27	56	55	5	62
Nov. 30	83,322	72	34	24	52	48	6	59
Dec. 31	80,482	65	35	21	51	38	4	53

Table 38.—Distribution of bituminous coal and lignite, in 1969, by method of movement and consumer use

(Thousand short tons)

Shipments	Electric utilities	Coke and gas plants	Retail dealers	All others	Railroad fuel	Used at mines and sales to employees
Total shipments to all destinations in the United States, Canada, and Mexico, by all methods of movements and consumer use, and overseas exports	311,992	98,661	15,628	90,989	855	1,450
Shipments to all destinations in the United States, Canada, and Mexico by specific method of movement and consumer use:						
Method of movement:						
All-rail	163,566	52,556	8,391	54,618	------	---------
River and ex-river	70,176	26,015	919	6,325	------	---------
Great Lakes [1]	18,762	13,460	3,344	10,519	------	---------
Tidewater [2]	8,493	5,119	------	389	------	---------
Truck	31,571	1,479	2,974	19,138	------	---------
Tramway, conveyor, and private railroad	19,424	32	------	------	------	---------
Method of movement and/or consumer uses unknown	-------	------	------	------	855	1,450
Total	311,992	98,661	15,628	90,989	855	1,450

Shipments	Canadian Great Lakes commercial docks [3]	U.S. Great Lakes dock storage[3]	U.S. tidewater dock storage[3]	Overseas exports[4]	Net change in mine inventory	Total
Total shipments to all destinations in the United States, Canada, and Mexico, by all methods of movements and consumer use, and overseas exports	500	−446	------	39,361	890	559,880
Shipments to all destinations in the United States, Canada, and Mexico by specific method of movement and consumer use:						
Method of movement:						
All-rail	-------	------	------	------	------	279,131
River and ex-river	-------	------	------	------	------	103,435
Great Lakes [1]	-------	------	------	------	------	46,085
Tidewater [2]	-------	------	------	------	------	14,001
Truck	-------	------	------	------	------	55,162
Tramway, conveyor, and private railroad	-------	------	------	------		19,456
Method of movement and/or consumer uses unknown	500	−446	------	39,361	890	42,610
Total	500	−446	------	39,361	890	559,880

[1] Excludes shipments to Canadian Great Lakes commercial docks and U.S. dock storage for which consumer uses are not available; however, includes vessel fuel, the destinations of which are not available.

[2] Excludes overseas exports for which consumer uses are not available.

[3] Consumer use unknown.

[4] Excludes Canada; consumer use unknown.

Table 39.—Distribution of bituminous coal and lignite, in 1969, by district of origin and consumer use

(Thousand short tons)

District of origin [1]	Electric utilities	Coke and gas plants	Retail dealers	All others	Railroad fuel	Used at mines and sales to employees
1	30,722	3,727	402	7,100	117	274
2	9,150	23,553	481	6,539	3	31
3 and 6	35,669	5,913	306	6,240	33	18
4	37,411	--------	1,366	12,062	127	37
7	1,449	16,784	820	1,084	101	593
8	60,385	33,464	7,742	29,278	240	332
9	41,197	196	1,129	4,793	55	--------
10	49,046	3,376	1,454	12,821	98	52
11	13,718	125	230	6,068	24	7
12	776	--------	--------	108	--------	--------
13	11,067	5,917	255	1,349	--------	2
14	--------	532	--------	84	--------	--------
15 [2]	5,298	150	80	320	1	--------
16	514	--------	32	40	--------	2
17	2,149	2,978	368	363	--------	--------
18	3,687	--------	2	33	--------	--------
19	3,868	32	106	631	21	4
20	1,046	1,914	650	711	2	32
21	3,938	--------	165	795	28	66
22 and 23	902	--------	40	570	5	--------
Total	311,992	98,661	15,628	90,989	855	1,450

District of origin [1]	Canadian Great Lakes commercial docks [3]	U.S. Great Lakes dock storage [3]	U.S. tidewater dock storage [3]	Overseas exports [4]	Net change in mine inventory	Total
1	--------	−2	--------	1,404	55	43,799
2	43	−24	--------	--------	−66	39,710
3 and 6	162	48	--------	1,131	112	49,632
4	85	−168	--------	--------	183	51,103
7	--------	−19	1	15,580	69	36,462
8	210	−172	−1	21,096	−31	152,543
9	--------	−26	--------	--------	141	47,485
10	--------	−83	--------	--------	236	67,000
11	--------	--------	--------	--------	−12	20,160
12	--------	--------	--------	--------	--------	884
13	--------	--------	--------	--------	−67	18,523
14	--------	--------	--------	74	--------	690
15 [2]	--------	--------	--------	--------	20	5,869
16	--------	--------	--------	--------	3	591
17	--------	--------	--------	--------	−15	5,843
18	--------	--------	--------	--------	312	4,034
19	--------	--------	--------	--------	--------	4,662
20	--------	--------	--------	76	30	4,461
21	--------	--------	--------	--------	−80	4,912
22 and 23	--------	--------	--------	--------	--------	1,517
Total	500	−446	--------	39,361	890	559,880

[1] Producing districts are defined in: Bureau of Mines. Bituminous Coal and Lignite Distribution Calendar Year 1969. Mineral Industry Survey, April 1970, 39 pp.
[2] Excludes Texas.
[3] Consumer use unknown.
[4] Excludes Canada; consumer use unknown.

Table 40.—Distribution of bituminous coal and lignite, in 1969, by destination and consumer use

(Thousand short tons)

Destination	Total	Electric utilities	Coke and gas plants	Retail dealers	All others [1]
New England:					
Massachusetts	2,225	1,861	--------	58	306
Connecticut	2,295	2,032	--------	1	262
Maine, New Hampshire, Vermont, Rhode Island	1,139	982	--------	16	141
Middle Atlantic:					
New York	24,324	12,891	5,449	90	5,894
New Jersey	5,500	4,583	434	14	469
Pennsylvania	59,661	26,187	24,828	613	8,033
East North Central:					
Ohio	62,160	32,669	12,625	1,660	15,206
Indiana	41,299	22,389	11,566	656	6,688
Illinois	45,244	30,393	3,713	3,077	8,061
Michigan	35,674	21,432	4,823	1,166	8,253
Wisconsin	14,972	8,531	433	1,740	4,268
West North Central:					
Minnesota	8,100	4,591	991	868	1,650
Iowa	5,673	3,676	--------	232	1,765
Missouri	11,098	8,928	365	122	1,683
North Dakota and South Dakota	3,996	3,273	--------	230	493
Nebraska and Kansas	1,470	1,139	--------	94	237
South Atlantic:					
Delaware and Maryland	15,008	8,344	5,368	79	1,217
District of Columbia	1,235	764	--------	80	391
Virginia	12,994	8,240	12	576	4,166
West Virginia	24,356	13,847	5,102	265	5,142
North Carolina	18,711	16,071	--------	556	2,084
South Carolina	5,319	3,660	--------	304	1,355
Georgia and Florida	11,951	11,239	--------	163	549
East South Central:					
Kentucky	20,355	15,696	1,827	540	2,292
Tennessee	16,793	13,638	177	656	2,322
Alabama and Mississippi	25,582	15,375	8,235	131	1,841
West South Central: Arkansas, Louisiana, Oklahoma, Texas	929	--------	921	7	1
Mountain:					
Colorado	4,687	2,986	919	322	460
Utah	2,978	409	1,929	166	474
Montana and Idaho	1,063	599	--------	296	168
Wyoming	3,324	3,077	--------	26	221
New Mexico	3,263	3,249	--------	2	12
Arizona and Nevada	1,103	1,072	--------	10	21
Pacific:					
Washington and Oregon	452	--------	--------	131	321
California	2,231	--------	2,113	103	15
Alaska	672	139	--------	33	500
Canada [2]	16,224	6,577	6,449	410	2,788
Mexico	84	--------	--------	--------	84
Destinations not revealable	2,175	1,453	382	135	205
Destinations and/or consumer uses not available:					
Great Lakes movement:					
Canadian commercial docks	500	--------	--------	--------	--------
Vessel fuel	951	--------	--------	--------	--------
U.S. dock storage	−446	--------	--------	--------	--------
Tidewater movement:					
Overseas exports (except Canada)	39,361	--------	--------	--------	--------
Bunker fuel	--------	--------	--------	--------	--------
U.S. dock storage	--------	--------	--------	--------	--------
Railroad fuel:					
U.S. companies	827	--------	--------	--------	--------
Canadian companies	28	--------	--------	--------	--------
Coal used at mines and sales to employees	1,450	--------	--------	--------	--------
Net change in mine inventory	890	--------	--------	--------	--------
Total	559,880	--------	--------	--------	--------

[1] Excludes vessel fuel and bunker fuel, the destinations of which are not available.
[2] Excludes shipments to Canadian Great Lakes commercial docks and Canadian railroad companies.

Table 41.—Total bituminous coal and lignite shipments and percent of grand total shipments, by geographic division and State of destination

Geographic division and State of destination	Thousand short tons					Percent of total				
	1965	1966	1967	1968	1969	1965	1966	1967	1968	1969
Total	512,525	532,366	552,647	545,319	559,880	100.0	100.0	100.0	100.0	100.0
New England	10,640	10,877	9,741	6,956	5,659	2.1	2.0	1.8	1.3	1.0
Massachusetts	4,681	4,415	4,022	2,872	2,225	.9	.8	.7	.5	.4
Connecticut	4,870	5,434	4,793	3,013	2,295	1.0	1.0	.9	.6	.4
Maine, New Hampshire, Vermont, Rhode Island	1,089	1,028	926	1,071	1,139	.2	.2	.2	.2	.2
Middle Atlantic	95,721	93,913	96,362	91,289	89,485	18.7	17.6	17.4	16.7	16.0
New York	27,025	25,314	27,300	24,562	24,324	5.3	4.8	4.9	4.5	4.3
New Jersey	9,000	8,692	7,865	6,837	5,500	1.8	1.6	1.4	1.2	1.0
Pennsylvania	59,696	59,907	61,197	59,890	59,661	11.6	11.2	11.1	11.0	10.7
East North Central	182,072	192,251	196,417	195,484	199,349	35.5	36.1	35.5	35.8	35.6
Ohio	52,756	57,622	58,726	59,912	62,160	10.3	10.8	10.6	11.0	11.1
Indiana	36,885	38,424	40,441	40,245	41,299	7.2	7.2	7.3	7.4	7.4
Illinois	44,356	46,382	46,710	43,465	45,244	8.6	8.7	8.5	8.0	8.1
Michigan	33,411	34,770	34,959	36,787	35,674	6.5	6.6	6.3	6.7	6.3
Wisconsin	14,664	15,053	15,581	15,075	14,972	2.9	2.8	2.8	2.7	2.7
West North Central	24,978	25,977	26,761	27,350	30,337	4.9	4.9	4.8	5.0	5.4
Minnesota	7,406	7,680	7,142	7,332	8,100	1.5	1.4	1.3	1.3	1.4
Iowa	5,508	5,440	5,549	5,477	5,673	1.1	1.0	1.0	1.0	1.0
Missouri	8,243	8,494	9,389	9,400	11,098	1.6	1.6	1.7	1.7	2.0
North Dakota and South Dakota	2,211	2,996	3,427	3,781	3,996	.4	.6	.6	.7	.7
Nebraska and Kansas	1,610	1,367	1,254	1,360	1,470	.3	.3	.2	.3	.3
South Atlantic	72,052	80,491	88,499	88,413	89,574	14.1	15.1	16.0	16.2	16.0
Delaware and Maryland	13,288	14,082	14,954	14,777	15,008	2.6	2.6	2.7	2.7	2.7
District of Columbia	[1] 541	[1] 897	[1] 886	[1] 887	1,235	[1] .1	[1] .2	[1] .1	[1] .2	.2
Virginia	13,887	14,279	14,854	14,526	12,994	2.7	2.7	2.7	2.7	2.3
West Virginia	19,337	20,159	23,244	24,564	24,356	3.8	3.8	4.2	4.5	4.4
North Carolina	12,376	15,352	17,515	16,912	18,711	2.4	2.9	3.2	3.1	3.3
South Carolina	4,301	5,118	5,554	4,695	5,319	.9	.9	1.0	.8	1.0
Georgia and Florida	8,322	10,604	11,492	12,052	11,951	1.6	2.0	2.1	2.2	2.1
East South Central	52,103	54,929	61,312	60,487	62,730	10.2	10.3	11.1	11.1	11.2
Kentucky	16,834	17,644	19,046	18,811	20,355	3.3	3.3	3.4	3.4	3.6
Tennessee	13,896	14,811	18,185	16,833	16,793	2.7	2.8	3.3	3.1	3.0
Alabama and Mississippi	21,373	22,474	24,081	24,843	25,582	4.2	4.2	4.4	4.6	4.6
West South Central: Arkansas, Louisiana, Oklahoma, Texas	1,166	1,084	955	976	929	.2	.2	.2	.2	.2
Mountain	13,866	14,098	14,261	14,868	16,418	2.7	2.7	2.6	2.7	2.9
Colorado	4,500	4,705	4,720	4,967	4,687	.9	.9	.9	.9	.8
Utah	2,868	2,974	2,853	2,836	2,978	.6	.6	.5	.5	.5
Montana and Idaho	1,075	995	968	1,042	1,063	.2	.2	.2	.2	.2
Wyoming	2,196	2,601	2,494	2,702	3,324	.4	.5	.4	.5	.6
New Mexico	2,505	2,084	2,526	2,392	3,263	.5	.4	.5	.4	.6
Arizona and Nevada	722	739	700	929	1,103	.1	.1	.1	.2	.2
Pacific	3,176	2,575	2,592	2,546	2,683	.6	.5	.5	.5	.5
Washington and Oregon	798	687	541	449	452	.2	.1	.1	.1	.1
California	2,378	1,888	2,051	2,097	2,231	.4	.4	.4	.4	.4

Alaska	789	858	952	804	672	.1	.2	.2	.1	.1
Canada [3]	15,634	15,807	15,257	16,746	16,752	3.0	3.0	2.8	3.1	3.0
Mexico	60	54	62	74	84	(2)	(2)	(2)	(2)	(2)
Destinations not revealable	1,385	1,211	994	2,138	2,175	.3	.2	.2	.4	.4
U.S. railroad fuel	1,241	1,260	1,146	976	827	.2	.2	.2	.2	.1
U.S. Great Lakes dock storage	−252	−6	−62	−239	−446	−(2)	−(2)	−(2)	−(2)	−.1
U.S. tidewater dock storage	10	4	---	−5	---	(2)	(2)	---	−(2)	---
Vessel fuel	1,004	1,054	878	879	951	.2	.2	.1	.2	.2
Bunker fuel	13	13	5	---	---	(2)	(2)	(2)	---	---
Overseas exports	34,746	33,527	34,174	33,998	39,361	6.8	6.3	6.2	6.2	7.0
Coal used at mines and sales to employees	1,969	2,098	1,678	1,496	1,450	.4	.4	.3	.3	.3
Net change in mine inventory	152	291	663	83	890	(2)	.1	.1	(2)	.2

[1] A considerable block of tonnage is included under "Destinations not revealable."
[2] Less than 0.1 percent.
[3] Includes shipments to Canadian Great Lakes commercial docks and Canadian railroad companies.

Table 42.—The changing levels of bituminous coal and lignite markets—indexes of physical volumes shipped to markets, by geographic division, State of destination, and consumer use

Geographic division, State of destination, and consumer use	1957 (thousand short tons)	Index 1957 = 100 (except where noted)				
		1965	1966	1967	1968	1969
Total	493,895	103.8	107.8	111.9	110.4	113.4
Electric utilities	160,754	155.1	169.0	184.2	185.0	194.1
Coke and gas plants	112,901	89.0	89.1	88.4	85.5	87.4
Retail dealers	39,230	58.2	52.7	47.9	45.1	39.8
All others (includes vessel and bunker fuel)	108,711	92.8	93.7	91.9	89.2	83.7
Railroad fuel (U.S. and Canada)	9,581	13.7	13.7	12.3	10.5	8.9
Canadian Great Lakes commercial docks (consumer use not available)	2,785	38.6	15.4	13.2	16.2	18.0
U.S. Great Lakes dock storage (consumer use not available) [1]	NA	−182.9	−102.0	−120.4	−178.6	−246.7
U.S. tidewater dock storage (consumer use not available) [2]	NA	38.5	15.4	.0	−119.2	.0
Coal used at mines and sales to employees	3,125	63.0	67.1	53.7	47.9	46.4
Net change in mine inventory	1,142	13.3	25.5	58.1	7.3	77.9
Overseas exports (excludes Canada—consumer use not available)	55,666	62.4	60.2	61.4	61.1	70.7
New England	11,909	89.3	91.3	81.8	58.4	47.5
Electric utilities	6,012	149.8	157.3	135.8	97.1	81.1
Coke and gas plants	1,345	35.1	33.8	35.9	11.7	.0
Retailer dealers	1,279	16.7	14.5	12.8	10.7	5.9
All others	3,273	29.1	23.8	28.3	25.2	21.7
Massachusetts	5,354	87.4	82.5	75.1	53.6	41.6
Electric utilities	2,575	159.5	156.1	132.7	94.0	72.3
Coke and gas plants	751	.0	.0	.0	.0	.0
Retail dealers	755	16.0	14.4	14.6	15.1	7.7
All others	1,273	35.7	22.5	38.8	26.5	24.0
Connecticut	4,105	118.6	132.4	116.8	73.4	55.9
Electric utilities	2,567	159.8	182.1	157.0	97.7	79.2
Coke and gas plants	594	79.5	76.4	81.3	26.6	.0
Retail dealers	139	9.4	8.6	8.6	0.7	0.7
All others	805	35.3	36.4	33.3	43.0	32.5
Maine, New Hampshire, Vermont, Rhode Island	2,450	44.4	42.0	37.8	43.7	46.5
Electric utilities	870	91.5	87.8	82.6	104.4	112.9
Retail dealers	385	20.5	16.9	10.9	5.7	4.2
All others	1,195	17.9	16.7	13.8	11.8	11.8
Middle Atlantic	92,596	103.4	101.4	104.1	98.6	96.6
Electric utilities	31,662	134.0	132.8	140.0	131.4	137.9
Coke and gas plants	38,448	90.1	87.1	88.0	83.2	79.9
Retail dealers	2,498	53.0	43.8	38.5	34.4	28.7
All others	19,988	86.8	86.5	86.2	84.3	72.0
New York	26,753	101.0	94.6	102.0	91.8	90.9
Electric utilities	12,335	112.2	101.2	116.2	101.9	104.5
Coke and gas plants	5,693	109.7	103.3	105.0	89.7	95.7
Retail dealers	769	47.9	33.8	21.5	19.9	11.7
All others	7,956	82.7	84.0	85.8	84.6	74.1
New Jersey	7,814	115.2	111.2	100.7	87.5	70.4
Electric utilities	4,284	168.2	166.9	149.5	127.8	107.0
Coke and gas plants	1,249	35.0	40.9	39.2	38.0	34.7
Retail dealers	130	31.5	12.3	11.5	5.4	10.8
All others	2,151	61.3	47.1	44.5	40.8	21.8
Pennsylvania	58,029	102.9	103.2	105.5	103.2	102.8
Electric utilities	15,043	142.1	148.9	156.9	156.6	174.1
Coke and gas plants	31,506	88.7	86.0	86.9	83.8	78.8
Retail dealers	1,599	57.2	51.1	48.8	43.7	38.3
All others	9,881	95.6	97.0	95.7	93.6	81.3
East North Central	[3] 170,697	106.7	112.6	115.1	114.5	116.8
Electric utilities	66,436	138.2	151.7	162.8	166.1	173.7
Coke and gas plants	38,757	83.1	86.6	83.8	80.8	85.6
Retail dealers	21,321	59.8	54.9	50.3	46.0	38.9
All others	[3] 44,183	102.5	104.5	102.0	99.6	96.1
Ohio	55,612	94.9	103.6	105.6	107.7	111.8
Electric utilities	20,193	122.8	140.3	149.0	155.8	161.8
Coke and gas plants	15,661	69.1	78.1	74.1	73.2	80.6
Retail dealers	5,077	50.6	45.9	43.2	40.0	32.7
All others	14,681	99.1	100.4	101.1	101.8	103.6
Indiana	34,938	105.6	110.0	115.8	115.2	118.2
Electric utilities	12,853	139.7	144.7	160.5	167.3	174.2
Coke and gas plants	13,736	86.8	89.2	89.7	84.0	84.2
Retail dealers	2,796	44.6	41.6	38.3	35.7	23.5
All others	5,553	103.7	115.5	115.7	111.7	120.4

See footnotes at end of table.

Table 42.—The changing levels of bituminous coal and lignite markets—indexes of physical volumes shipped to markets, by geographic division, State of destination, and consumer use—Continued

Geographic division, State of destination, and consumer use	1957 (thousand short tons)	Index 1957 = 100 (except where noted)				
		1965	1966	1967	1968	1969
East North Central—Continued						
Illinois	[3] 42,718	103.8	108.6	109.3	101.7	**105.9**
Electric utilities	18,584	135.5	149.6	158.7	151.9	**163.5**
Coke and gas plants	3,925	91.9	92.4	87.9	78.2	**94.6**
Retail dealers	8,623	52.9	49.4	47.2	38.4	**35.7**
All others	[3] 11,586	95.0	92.2	83.6	76.5	**69.6**
Michigan	26,255	127.3	132.4	133.2	140.1	**135.9**
Electric utilities	9,839	172.4	187.7	199.3	211.7	**217.8**
Coke and gas plants	4,877	109.5	102.8	94.1	100.8	**98.9**
Retail dealers	3,368	60.3	54.4	44.1	43.8	**34.6**
All others	8,171	111.1	115.8	113.5	117.1	**101.0**
Wisconsin	11,174	131.2	134.7	139.4	134.9	**134.0**
Electric utilities	4,967	139.3	152.7	168.3	167.6	**171.8**
Coke and gas plants	558	92.8	83.0	89.1	60.8	**77.6**
Retail dealers	1,457	160.1	145.2	131.4	136.9	**119.4**
All others	4,192	116.7	116.6	114.8	105.4	**101.8**
West North Central	[3] 20,824	119.9	124.7	128.5	131.3	**145.7**
Electric utilities	8,278	178.3	198.8	214.9	238.8	**261.0**
Coke and gas plants	1,518	75.0	76.5	75.6	40.5	**89.3**
Retail dealers	4,079	52.8	46.3	40.3	38.5	**37.9**
All others	[3] 6,949	99.6	93.2	88.9	77.7	**83.9**
Minnesota	5,332	138.9	144.0	133.9	137.5	**151.9**
Electric utilities	1,810	223.4	255.5	228.6	277.6	**253.6**
Coke and gas plants	1,206	78.9	78.9	77.0	32.3	**82.2**
Retail dealers	553	128.9	128.8	123.9	143.8	**157.0**
All others	1,763	96.3	79.0	78.9	63.7	**93.6**
Iowa	[3] 4,878	112.9	111.5	113.8	112.3	**116.3**
Electric utilities	1,846	149.7	157.9	174.8	185.6	**199.1**
Retail dealers	1,254	45.1	35.2	28.3	21.0	**18.5**
All others	[3] 1,778	122.6	117.2	110.6	100.6	**99.3**
Missouri	6,862	120.1	123.8	136.8	137.0	**161.7**
Electric utilities	2,605	212.7	228.3	266.6	272.3	**342.7**
Coke and gas plants	312	59.6	67.0	70.2	72.1	**117.0**
Retail dealers	1,495	23.3	18.5	12.6	10.0	**8.2**
All others	2,450	88.5	84.2	83.1	78.9	**68.7**
North Dakota and South Dakota	2,416	91.5	124.0	141.8	156.5	**165.4**
Electric utilities	1,378	98.5	157.7	190.3	227.0	**237.5**
Retail dealers	517	84.5	77.0	71.0	60.3	**44.5**
All others	521	80.0	81.6	84.1	65.5	**94.6**
Nebraska and Kansas	1,336	120.5	102.3	93.9	101.8	**110.0**
Electric utilities	639	165.6	124.6	134.7	171.4	**178.2**
Retail dealers	260	34.6	23.1	17.7	19.6	**36.2**
All others	437	105.7	116.9	79.4	49.0	**54.2**
South Atlantic	52,560	137.1	153.1	168.4	168.2	**170.4**
Electric utilities	22,251	192.5	231.5	267.7	272.1	**279.4**
Coke and gas plants	11,321	95.5	92.0	91.4	88.1	**92.6**
Retail dealers	4,765	55.5	52.6	50.6	50.7	**42.5**
All others	14,223	110.8	112.9	113.7	108.9	**104.8**
Delaware and Maryland	10,358	128.3	136.0	144.4	142.7	**144.9**
Electric utilities	3,000	233.1	270.3	290.4	286.5	**278.1**
Coke and gas plants	5,414	94.5	91.7	99.6	93.2	**99.2**
Retail dealers	420	53.3	26.4	22.1	21.4	**18.8**
All others	1,524	62.6	58.8	49.5	68.6	**79.9**
District of Columbia	1,097	[4] 49.3	[4] 81.8	[4] 80.8	[4] 80.9	**112.6**
Electric utilities	609	49.4	81.6	89.7	110.5	**125.5**
Retail dealers	188	63.8	53.7	47.3	44.1	**42.6**
All others	300	[4] 40.0	[4] 99.7	[4] 83.7	[4] 43.7	**130.3**
Virginia	10,553	131.6	135.3	140.8	137.6	**123.1**
Electric utilities	4,435	170.8	185.9	200.6	204.3	**185.8**
Coke and gas plants	165	161.2	157.6	43.6	2.4	**7.3**
Retail dealers	1,756	51.8	47.3	42.9	41.0	**32.8**
All others	4,197	122.4	117.8	122.3	112.9	**99.3**
West Virginia	15,771	122.6	127.8	147.4	155.8	**154.4**
Electric utilities	6,290	138.3	152.5	201.4	218.0	**220.1**
Coke and gas plants	5,742	94.6	90.4	85.1	85.8	**88.9**
Retail dealers	302	92.4	101.7	129.8	140.7	**87.7**
All others	3,437	143.3	147.4	154.1	160.2	**149.6**
North Carolina	8,716	142.0	176.1	210.0	194.0	**214.7**
Electric utilities	4,953	189.1	246.8	289.7	281.8	**324.5**
Retail dealers	1,248	50.2	51.2	51.0	49.6	**44.6**
All others	2,515	94.7	98.9	100.6	92.8	**82.9**
South Carolina	3,050	141.0	167.8	182.1	153.9	**174.4**
Electric utilities	856	278.9	378.5	452.9	381.0	**427.6**
Retail dealers	321	82.2	92.2	83.8	85.7	**94.7**
All others	1,873	88.1	84.5	75.2	61.9	**72.3**

See footnotes at end of table.

Table 42.—The changing levels of bituminous coal and lignite markets—indexes of physical volumes shipped to markets, by geographic division, State of destination, and consumer use—Continued

Geographic division, State of destination, and consumer use	1957 (thousand short tons)	Index 1957 = 100 (except where noted)				
		1965	1966	1967	1968	1969
South Atlantic—Continued						
Georgia and Florida	3,015	276.0	351.7	381.2	399.7	396.4
Electric utilities	2,108	356.4	455.3	499.0	534.8	533.2
Retail dealers	530	42.1	42.1	33.4	38.7	30.8
All others	377	155.4	208.0	211.1	152.0	145.6
East South Central	43,283	120.4	126.9	141.7	139.7	144.9
Electric utilities	23,572	149.5	159.8	184.2	180.7	189.7
Coke and gas plants	10,380	88.6	90.0	97.0	92.1	98.6
Retail dealers	2,494	56.0	50.7	46.1	50.1	53.2
All others	6,837	91.5	97.3	97.8	103.5	94.4
Kentucky	11,167	150.7	158.0	170.6	168.5	182.3
Electric utilities	6,758	176.6	187.6	208.4	208.6	232.3
Coke and gas plants	1,683	114.0	104.0	116.3	108.8	108.6
Retail dealers	834	62.4	66.2	59.7	67.1	64.7
All others	1,892	129.9	140.0	132.3	122.9	121.1
Tennessee	15,104	92.0	98.1	120.4	111.4	111.2
Electric utilities	9,876	107.6	115.7	149.6	133.8	138.1
Coke and gas plants	258	70.2	69.8	67.4	71.3	68.6
Retail dealers	1,206	63.2	50.4	46.0	48.4	54.4
All others	3,764	61.9	69.0	71.2	75.8	61.7
Alabama and Mississippi	17,012	125.6	132.1	141.6	146.0	150.4
Electric utilities	6,938	182.9	195.3	209.7	220.4	221.6
Coke and gas plants	8,439	84.1	87.8	94.0	89.4	97.6
Retail dealers	454	25.1	22.9	21.4	23.1	28.9
All others	1,181	124.4	119.5	127.2	160.5	155.9
West South Central: Arkansas, Louisiana, Oklahoma, Texas	1,868	62.4	58.0	51.1	52.2	49.7
Electric utilities [5]	65	.0	.0	.0	.0	.0
Coke and gas plants	1,050	94.9	90.3	78.3	80.8	87.7
Retail dealers	161	17.4	17.4	14.3	8.1	4.3
All others	592	24.0	18.2	18.6	19.4	0.2
Mountain	8,779	157.9	160.6	162.4	169.4	187.0
Electric utilities	1,437	572.5	605.0	639.0	674.2	792.8
Coke and gas plants	3,772	85.3	83.9	77.5	79.7	75.5
Retail dealers	1,350	85.0	77.3	71.6	63.2	60.9
All others	2,220	57.3	53.9	53.6	59.5	61.1
Colorado	3,264	137.9	144.1	144.6	152.2	143.6
Electric utilities	687	357.5	401.5	424.9	439.8	434.6
Coke and gas plants	1,324	99.8	93.1	79.8	85.3	69.4
Retail dealers	326	113.2	105.2	88.7	96.9	98.8
All others	927	38.1	40.1	49.1	54.0	49.6
Utah	3,748	76.5	79.3	76.1	75.7	79.5
Electric utilities	367	102.7	132.4	130.5	132.7	111.4
Coke and gas plants	2,448	77.5	78.9	76.2	76.7	78.8
Retail dealers	334	62.6	55.7	57.8	40.1	49.7
All others	599	64.3	61.9	52.8	56.4	79.1
Montana and Idaho	923	116.5	107.8	104.9	112.9	115.2
Electric utilities [6]	1	165.9	181.6	183.3	265.4	334.6
Retail dealers	593	72.8	63.6	72.0	59.2	49.9
All others	329	105.2	89.1	64.7	65.7	51.1
Wyoming	607	361.8	428.5	410.9	445.1	547.6
Electric utilities	340	597.4	716.8	673.8	717.1	905.0
Retail dealers	61	82.0	63.9	45.9	49.2	42.6
All others	206	55.8	60.7	85.0	113.6	107.3
New Mexico [7]	92	221.3	184.1	223.1	211.3	288.3
Electric utilities [7]	37	227.8	190.2	230.8	218.6	299.4
Retail dealers	12	108.3	58.3	41.7	33.3	16.7
All others	43	46.5	30.2	39.5	37.2	27.9
Arizona and Nevada	145	497.9	509.7	482.8	640.7	760.7
Electric utilities [8]	5	177.3	186.3	197.3	267.2	320.0
Retail dealers	24	308.3	383.3	104.2	75.0	41.7
All others	116	46.6	19.8	12.1	13.8	18.1
Pacific	3,142	101.1	82.0	82.5	81.0	85.4
Electric utilities	4	.0	.0	.0	.0	.0
Coke and gas plants	1,708	137.1	107.7	118.1	121.3	123.7
Retail dealers	377	87.8	71.1	54.4	40.8	62.1
All others	1,053	47.9	44.4	35.1	30.4	31.9
Washington and Oregon	1,324	60.3	51.9	40.9	33.9	34.1
Electric utilities	3	.0	.0	.0	.0	.0
Retail dealers	367	86.6	69.2	52.0	39.0	35.7
All others	954	50.3	45.4	36.7	32.1	33.6
California	1,818	130.8	103.9	112.8	115.3	122.7
Electric utilities	1	.0	.0	.0	.0	.0
Coke and gas plants	1,708	137.1	107.7	118.1	121.3	123.7
Retail dealers	10	130.0	140.0	140.0	110.0	1,030.0
All others	99	24.2	35.4	20.2	14.1	15.2

See footnotes at end of table.

Table 42.—The changing levels of bituminous coal and lignite markets—indexes of physical volumes shipped to markets, by geographic division, State of destination, and consumer use—Continued

Geographic division, State of destination, and consumer use	1957 (thousand short tons)	Index 1957 = 100 (except where noted)				
		1965	1966	1967	1968	1969
Pacific—Continued						
Alaska	829	95.2	103.5	114.8	97.0	81.1
Electric utilities	470	92.3	43.4	28.7	28.1	29.6
Retail dealers	49	81.6	89.8	87.8	75.5	67.3
All others	310	101.6	196.8	249.7	204.8	161.3
Canada [9]	17,878	87.4	88.4	85.3	93.7	93.7
Electric utilities	567	705.6	794.7	869.8	998.4	1,160.0
Coke and gas plants	4,602	115.0	127.2	119.8	145.5	140.1
Retail dealers	857	83.8	65.1	51.6	60.2	47.8
All others	7,183	62.2	61.4	55.3	47.2	38.8
Canadian Great Lakes commercial docks (consumer use not available)	2,785	38.6	15.4	13.2	16.2	18.0
Canadian railroad companies	1,884	4.0	2.5	1.8	1.6	1.5
Mexico [10]	NA	105.3	94.7	108.8	129.8	147.4
All others [10]	NA	105.3	94.7	108.8	129.8	147.4
Destinations not revealable [11]	--------	100.4	87.8	72.0	154.9	157.6
Electric utilities [11]	--------	105.0	62.0	98.0	237.4	292.4
Coke and gas plants [11]	--------	54.8	83.4	42.8	78.3	102.1
Retail dealers [11]	--------	89.8	80.8	49.5	59.6	136.4
All others [11]	--------	138.8	124.6	72.7	147.8	50.0
Destinations not available:						
Great Lakes vessel fuel [12]	1,859	54.0	56.7	47.2	47.3	51.2
Tidewater bunker fuel [12]	41	31.7	31.7	12.2	.0	.0
Railroad fuel, United States companies [13]	7,697	16.1	16.4	14.9	12.7	10.7

NA Not available.

1 For Great Lakes dock storage the annual base period is 1959 = 100. The 1959 annual tonnage was 304,000 tons.

2 For tidewater dock storage the annual base period is 1959 = 100. The 1959 annual tonnage was 26,000 tons.

3 District 15 shipments to Illinois included with Iowa.

4 A considerable block of tonnage is included under "Destinations not revealable."

5 For electric utilities in Arkansas, Louisiana, Oklahoma, and Texas the annual base period is 1963 = 100. The 1963 tonnage shipped to electric utilities was 24,000 tons.

6 For electric utilities in Montana and Idaho the annual base period is 1959 = 100. The 1959 tonnage shipped to electric utilities was 179,000 tons.

7 For total shipments and electric utilities to New Mexico the annual base period is 1963 = 100. Total shipments to New Mexico were 1,132,000 tons and for electric utilities 1,085,000 tons.

8 For electric utilities in Arizona and Nevada the annual base period is 1962 = 100. The 1962 annual tonnage shipped to electric utilities was 335,000 tons.

9 Includes shipments to Canadian Great Lakes commercial docks and Canadian railroad companies.

10 Since tonnages for Mexico were first published in 1960, yearly indexes are based on 1960 = 100. 1960 tons were total 57,000, all others 57,000.

11 Since "Destinations not revealable" were first published during 1960, the calendar year indexes are based on 1960 = 100. These figures are as follows: Calendar year 1960 total not revealable 1,380,000, electric utilities 497,000, coke and gas plants 374,000, retail dealers 99,000, all others 410,000.

12 Included in summary at beginning of table in "All others."

13 Included in summary at beginning of table in "Railroad fuel."

Table 43.—Average value per ton, f.o.b. mines, of bituminous coal and lignite produced in the United States, by States

State	1968				1969			
	Underground	Strip	Auger	Total	Underground	Strip	Auger	Total
Alabama	$8.78	$4.79	$8.16	$7.04	$9.44	$5.23	$5.55	$7.47
Alaska	------	6.00	------	6.00	------	6.54	------	6.54
Arkansas	7.82	7.33	------	7.47	8.43	7.71	------	7.90
Colorado	5.48	3.43	------	4.82	6.15	3.59	------	5.27
Illinois	4.14	3.92	3.25	4.01	4.43	4.23	------	4.32
Indiana	4.38	3.81	------	3.88	4.77	4.05	------	4.13
Iowa	3.83	3.71	------	3.75	3.77	3.75	------	3.76
Kansas	------	5.15	------	5.15	------	5.42	------	5.42
Kentucky	4.30	3.35	3.06	3.91	4.57	3.53	3.39	4.14
Maryland	4.25	3.64	2.00	3.67	3.77	4.01	2.30	3.85
Missouri	------	4.20	------	4.20	4.33	4.33	------	4.33
Montana:								
Bituminous	8.53	1.86	------	3.12	9.17	1.83	------	2.18
Lignite	------	1.89	------	1.89	------	2.03	------	2.03
Total	8.53	1.88	------	2.34	9.17	1.89	------	2.13
New Mexico	8.38	2.66	------	3.94	8.37	2.58	------	3.66
North Dakota (lignite)	------	1.78	------	1.78	------	1.85	------	1.85
Ohio	4.46	3.72	3.39	3.96	4.65	3.79	3.63	4.10
Oklahoma	6.46	5.85	8.16	5.88	7.83	5.65	8.43	5.80
Pennsylvania	5.97	3.84	4.05	5.37	6.53	4.24	4.04	5.87
Tennessee	3.66	3.61	3.60	3.64	3.94	3.65	3.27	3.80
Utah	5.77	------	------	5.77	6.31	------	------	6.31
Virginia	5.07	3.55	3.48	4.84	5.73	3.64	3.43	5.42
Washington	9.07	2.91	------	4.63	8.40	6.26	------	8.21
West Virginia	5.46	4.31	4.06	5.32	5.90	4.77	4.61	5.73
Wyoming	6.34	3.06	------	3.16	6.40	3.27	------	3.36
Total	5.22	3.75	3.53	4.67	5.62	3.98	3.81	4.99

Table 44.—Production and average value per ton, f.o.b. mines, of bituminous coal and lignite sold in open market and not sold in open market, in 1969, by States

(Thousand short tons)

State	Production			Average value per ton, f.o.b. mines		
	Sold in open market	Not sold in open market	Total [1]	Sold in open market	Not sold in open market	Total
Alabama	10,267	7,188	17,456	$6.03	$9.52	$7.47
Alaska	667	--------	667	6.54	--------	6.54
Arkansas	228	--------	228	7.90	--------	7.90
Colorado	4,024	1,506	5,530	4.41	7.56	5.27
Illinois	63,891	831	64,722	4.30	5.62	4.32
Indiana	20,086	--------	20,086	4.13	--------	4.13
Iowa	903	--------	903	3.76	--------	3.76
Kansas	1,313	--------	1,313	5.42	--------	5.42
Kentucky	101,574	7,475	109,049	3.96	6.56	4.14
Maryland	1,368	--------	1,368	3.85	--------	3.85
Missouri	3,301	--------	3,301	4.33	--------	4.33
Montana:						
Bituminous	721	1	722	2.18	2.02	2.18
Lignite	308	--------	308	2.03	5.60	2.03
Total [1]	1,029	1	1,030	2.14	2.05	2.13
New Mexico	3,660	812	4,471	2.59	8.50	3.66
North Dakota (lignite)	4,580	125	4,704	1.84	2.00	1.85
Ohio	44,879	6,363	51,242	4.14	3.82	4.10
Oklahoma	1,838	--------	1,838	5.80	--------	5.80
Pennsylvania	49,689	28,943	78,631	4.89	7.56	5.87
Tennessee	8,082	--------	8,082	3.80	--------	3.80
Utah	2,614	2,044	4,657	4.77	8.28	6.31
Virginia	34,856	699	35,555	5.39	7.02	5.42
Washington	58	--------	58	8.21	--------	8.21
West Virginia	121,231	19,780	141,011	5.53	6.95	5.73
Wyoming	2,545	2,057	4,602	3.84	2.75	3.36
Total [1]	482,682	77,823	560,505	4.65	7.05	4.99

[1] Data may not add to totals shown because of independent rounding.

Table 45.—Summary of operations at lignite mines [1] in the United States, in 1968, by States [2]

Item	Montana	North Dakota	Total [3]
Number of mines	2	22	24
Production (thousand short tons):			
Shipped by rail [4]	329	2,950	3,279
Shipped by truck	1	315	316
Used at mines [5]	---------	1,221	1,221
Total [3]	330	4,487	4,817
Average value per ton	$1.89	$1.78	$1.79
Number of shovels and draglines	3	45	48
Average number of men working daily	16	297	313
Average number of days worked	242	217	218
Number of man-days worked (thousands)	4	64	68
Average tons per man per day	85.13	69.65	70.53

[1] All strip.
[2] Exclusive of Texas (lignite).
[3] Data may not add to totals shown because of independent rounding.
[4] Includes coal loaded at mines directly into railroad cars and hauled by trucks to railroad sidings.
[5] Includes coal used at mine for power and heat, used by mine employees, used for all other purposes at mine, and transported from mine to point of use by conveyor or tram.

Table 46.—Summary of operations at lignite mines [1] in the United States, in 1969, by States [2]

Item	Montana	North Dakota	Total [3]
Number of mines	2	20	22
Production (thousand short tons):			
Shipped by rail [4]	306	2,974	3,280
Shipped by truck	2	378	380
Used at mines [5]	---------	1,352	1,352
Total [3]	308	4,704	5,012
Average value per ton	$2.03	$1.85	$1.86
Number of shovels and draglines	3	46	49

[1] All strip.
[2] Exclusive of Texas (lignite).
[3] Data may not add to totals shown because of independent rounding.
[4] Includes coal loaded at mines directly into railroad cars and hauled by trucks to railroad sidings.
[5] Includes coal used at mine for power and heat, used by mine employees, used for all other purposes at mine, and transported from mine to point of use by conveyor or tram.

Table 47.—Exports of bituminous coal, by country groups

(Thousand short tons and thousand dollars)

Country group	1967		1968		1969	
	Quantity	Value	Quantity	Value	Quantity	Value
Canada (including Newfoundland and Mexico	15,370	$128,482	16,822	$143,021	16,905	$147,312
Overseas (all other countries):						
West Indies and Central America	2	21	1	11	1	8
Bermuda, Greenland, Miquelon and St. Pierre Islands	6	69	3	30	3	41
South America	2,562	26,240	2,569	26,401	2,869	30,904
Europe	19,362	189,526	15,403	154,991	15,088	163,415
Asia	12,220	130,622	15,839	171,525	21,368	243,765
Africa	6	55	(1)	1	-------	-------
Oceania	-------	-------	-------	-------	(1)	7
Total	34,158	346,533	33,815	352,959	39,329	438,140
Grand total	49,528	475,015	50,637	495,980	56,234	585,452

[1] Less than ½ unit.

Table 48.—Bituminous coal exported from the United States, by countries [1]

(Thousand short tons and thousand dollars)

Country	1967		1968		1969	
	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	590	$6,188	441	$4,450	477	$5,017
Belgium-Luxembourg	1,422	13,732	1,052	10,843	943	10,394
Brazil	1,735	17,529	1,787	18,227	1,843	19,818
Canada	15,308	127,736	16,748	142,156	16,789	145,710
Chile	193	2,050	306	3,343	519	5,697
Ecuador	-------	-------	-------	-------	20	253
France	2,131	19,737	1,459	13,787	2,253	24,192
Germany:						
East	77	868	101	1,171	87	1,111
West	4,694	44,414	3,785	36,273	3,451	34,942
Ireland	267	2,618	168	1,707	83	918
Italy	5,815	59,004	4,254	43,576	3,679	40,824
Japan	12,215	130,525	15,822	171,418	21,367	243,753
Mexico	62	746	74	865	116	1,602
Miquelon and St. Pierre Islands	6	69	3	30	3	41
Netherlands	2,228	21,219	1,491	14,904	1,622	17,544
Norway	246	2,410	305	3,043	248	2,726
Portugal	86	1,031	-------	-------	15	230
Rumania	-------	-------	83	953	72	891
Spain	1,012	10,381	1,480	15,923	1,825	20,910
Sweden	813	8,344	761	8,003	668	7,365
Switzerland	39	411	28	303	-------	-------
Uruguay	43	466	34	373	10	114
Yugoslavia	532	5,358	436	4,504	141	1,366
Other	14	179	19	128	3	34
Total	49,528	475,015	50,637	495,980	56,234	585,452

[1] Amounts stated do not include fuel or bunker coal on vessels engaged in foreign trade, which aggregated 145,497 tons ($1,490,974) in 1967, 107,749 tons ($1,097,120) in 1968 and 59,152 tons ($738,409) in 1969.

Table 49.—Bituminous coal exported from the United States, by customs districts

(Thousand short tons and thousand dollars)

Customs district	1967		1968		1969	
	Quantity	Value	Quantity	Value	Quantity	Value
Baltimore, Md	1,944	$17,597	2,436	$22,501	2,654	$24,746
Boston, Mass	-------	-------	-------	-------	1	10
Buffalo, N.Y	558	4,365	425	3,371	444	3,653
Chicago, Ill	63	438	29	203	43	298
Cleveland, Ohio	14,061	116,592	15,540	131,031	15,656	134,975
Detroit, Mich	66	771	92	914	70	728
Duluth, Minn	3	46	3	32	5	54
El Paso, Tex	47	607	44	559	45	616
Houston, Tex	(1)	2	-------	-------	-------	-------
Laredo, Tex	15	138	29	304	70	981
Los Angeles, Calif	(1)	2	8	80	93	1,073
Milwaukee, Wis	-------	-------	10	73	-------	-------
Mobile, Ala	(1)	3	1	7	1	6
New Orleans, La	6	57	31	354	79	852
New York City	(1)	2	85	873	-------	-------
Norfolk, Va	32,607	332,780	31,820	334,781	37,023	416,918
Ogdensburg, N.Y	129	1,314	64	682	40	442
Pembina, N. Dak	1	8	9	86	-------	-------
Philadelphia, Pa	(1)	2	-------	-------	6	53
Portland, Maine	-------	-------	1	17	1	9
Providence, R.I	-------	-------	5	44	-------	-------
St. Albans, Vt	25	264	5	64	1	14
San Diego, Calif	(1)	1	(1)	2	(1)	5
San Francisco, Calif	3	26	-------	-------	-------	-------
Savannah, Ga	-------	-------	(1)	2	-------	-------
Seattle, Wash	-------	-------	-------	-------	2	19
Tampa, Fla	(1)	(1)	-------	-------	(1)	(1)
Total	49,528	475,015	50,637	495,980	56,234	585,452

[1] Less than ½ unit.

Table 50.—Bituminous coal[1] imported for consumption in the United States, by countries and customs districts

Country and customs district	1967		1968		1969	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Country:						
Australia	-------	-------	90	$2	-------	-------
Canada	175,070	$1,584	224,298	1,897	108,867	$1,074
Germany, West	51,548	374	-------	-------	-------	-------
India	-------	-------	-------	-------	30	3
Ireland	180	3	-------	-------	-------	-------
Netherlands	-------	-------	-------	-------	11	2
Norway	540	31	-------	-------	-------	-------
South Africa, Republic of	-------	-------	-------	-------	6	2
United Kingdom	-------	-------	6	1	-------	-------
Total	227,338	1,992	224,394	1,900	108,914	1,081
Customs district:						
Boston, Mass	51,548	374	-------	-------	-------	-------
Buffalo, N.Y	3,089	43	1,344	26	2,297	34
Chicago, Ill	-------	-------	36,525	237	98	2
Detroit, Mich	37	1	129	3	18	2
Duluth, Minn	1,265	19	10,212	153	4,371	65
El Paso, Tex	74	1	-------	-------	-------	-------
Galveston, Tex	540	31	-------	-------	-------	-------
Great Falls, Mont	19,983	179	10,103	100	35,845	304
Minneapolis, Minn	-------	-------	6	1	-------	-------
Ogdensburg, N.Y	-------	-------	-------	-------	10	1
New York City	-------	-------	-------	-------	41	5
Pembina, N.D	2,837	40	12,430	177	12,796	185
Philadelphia, Pa	-------	-------	90	2	6	2
Portland, Maine	147,965	1,304	153,555	1,201	43,779	401
Seattle, Wash	-------	-------	-------	-------	9,653	80
Total	227,338	1,992	224,394	1,900	108,914	1,081

[1] Includes slack, culm, and lignite.

Table 51.—World production of bituminous coal, anthracite, and lignite, by countries

(Thousand short tons)

Country [1]	1967	1968	1969 [p]
North America:			
Canada:			
Bituminous	9,387	8,758	8,652
Lignite	2,008	2,250	2,021
Greenland: Bituminous	35	30	[e] 33
Mexico: Bituminous	2,632	2,871	2,709
United States:			
Anthracite (Pennsylvania)	12,256	11,461	10,473
Bituminous	548,136	540,428	555,493
Lignite [2]	4,490	4,817	5,012
South America:			
Argentina: Bituminous	[r] 453	520	575
Brazil: Bituminous (marketable)	2,530	2,606	2,685
Chile: Bituminous	1,649	1,776	1,878
Colombia: Bituminous	3,417	3,417	3,656
Peru: Bituminous and anthracite	[r] 184	177	169
Venezuela: Bituminous	38	34	35
Europe:			
Albania: Lignite	478	[e] 638	[e] 705
Austria:			
Bituminous	15	---------	---------
Lignite	5,075	4,621	4,233
Belgium: Bituminous and anthracite	18,116	16,321	14,550
Bulgaria:			
Bituminous and anthracite	515	484	474
Lignite	29,475	31,175	31,526
Czechoslovakia:			
Bituminous	28,601	28,579	29,994
Lignite	78,663	82,546	87,448
Denmark: Lignite	[r] 1,375	838	[e] 551
France:			
Bituminous and anthracite	52,498	46,199	44,736
Lignite	3,230	3,551	3,252
Germany:			
Bituminous and anthracite:			
East	1,972	[e] 2,205	[e] 2,205
West	123,506	123,472	123,051
Lignite:			
East	266,789	272,393	272,271
West	106,666	111,902	118,415
Pech coal: West	981	919	841
Greece: Lignite	5,769	6,283	7,496
Hungary:			
Bituminous	4,468	4,676	4,550
Lignite	25,327	25,321	24,656
Ireland: Bituminous and anthracite	201	183	169
Italy:			
Bituminous and anthracite	452	402	334
Lignite	2,426	1,905	2,131
Netherlands: Bituminous and anthracite	8,890	7,345	6,122
Poland:			
Bituminous	136,576	141,757	147,910
Lignite	26,369	29,652	34,061
Portugal:			
Anthracite	488	438	398
Lignite	43	34	9
Rumania:			
Bituminous and anthracite [3]	7,403	7,919	8,416
Lignite	9,152	10,842	12,695
Spain:			
Bituminous and anthracite	13,608	13,485	12,769
Lignite	2,961	3,097	3,016
Svalbard (Spitzbergen): Bituminous:			
Controlled by Norway	471	364	432
Controlled by U.S.S.R. (shipments) [e]	440	440	441
Sweden: Bituminous	12	22	24
U.S.S.R.: [4] [5]			
Bituminous and anthracite	[r] 497,602	502,286	[e] 515,881
Lignite	158,529	152,447	[e] 154,323
United Kingdom: Bituminous and anthracite	192,792	183,759	168,621
Yugoslavia:			
Bituminous	1,001	920	752
Lignite	28,173	28,546	28,456

See footnotes at end of table.

Table 51.—World production of bituminous coal, anthracite, and lignite, by countries—Continued

(Thousand short tons)

Country [1]	1967	1968	1969 p
Africa:			
Algeria: Bituminous and anthracite	r 12	(6)	30
Congo: (Kinshasa): Bituminous	147	78	73
Malagasy Republic: Bituminous	2	---------	NA
Morocco: Anthracite	531	517	456
Mozambique: Bituminous	311	346	305
Nigeria: Bituminous	r 105	e 4	28
Rhodesia, Southern: Bituminous	r 7 3,373	7 3,608	r 7 3,673
South Africa, Republic of: Bituminous and anthracite (marketable)	54,344	56,940	58,149
Swaziland: Bituminous	86	107	115
Tanzania: Bituminous	2	3	3
United Arab Republic: Bituminous	122	---------	---------
Zambia: Bituminous	433	633	438
Asia:			
Afghanistan: Bituminous [8]	168	220	220
Burma: Bituminous	19	10	14
China, mainland: Bituminous, anthracite, and lignite e	250,000	330,000	364,000
India:			
Bituminous	75,184	78,058	80,633
Lignite	3,230	4,548	4,614
Indonesia: Bituminous	229	194	211
Iran: Bituminous [8]	320	331	276
Japan:			
Bituminous and anthracite	51,859	51,332	48,928
Lignite	403	369	277
Korea:			
North: Anthracite, bituminous, and lignite e	23,590	25,353	27,558
South: Anthracite	13,708	11,290	11,324
Mongolia, Outer: Lignite and bituminous e	1,170	1,378	1,543
Pakistan: Bituminous and lignite	r 1,477	1,404	e 1,433
Philippines: Bituminous	72	35	58
Taiwan: Bituminous	5,598	5,527	5,120
Thailand: Lignite	369	336	384
Turkey (salable):			
Bituminous	5,546	5 8,274	5 8,522
Lignite	4,925	5 7,039	5 9,335
Vietnam, North: Anthracite [9]	r 3,307	3,307	3,307
Oceania:			
Australia:			
Bituminous	38,875	45,102	50,851
Lignite	26,193	25,731	25,602
New Zealand:			
Bituminous and anthracite	2,467	2,302	2,417
Lignite	186	190	188
Lignite [10]	792,304	811,071	832,677
Bituminous and anthracite [10]	1,927,164	1,921,503	1,944,771
Mixed grades [10]	277,218	359,103	393,942
Total, all grades [10]	2,996,686	3,091,677	3,171,390

e Estimate. p Preliminary. r Revised. NA Not Available.
[1] In addition to countries listed, Ecuador produces a negligible amount of coal.
[2] Excludes production in State of Texas.
[3] Includes a preponderant share of low-grade bituminous.
[4] Output from U.S.S.R. in Asia (including Sakhalin) included with U.S.S.R. in Europe.
[5] Run of mine.
[6] Less than ½ unit.
[7] Sales.
[8] Year ended March 20 of year following that stated.
[9] Figures denote only estimated pre-war general output levels.
[10] Totals are of listed figures only.

Coal—Pennsylvania Anthracite

By Walter C. Lorenz [1]

Production of anthracite in 1969 was from 234 underground mines, 174 strip pits, 109 culm banks, six river dredges, and 111 preparation plants, in 13 northeastern Pennsylvania counties. The anthracite producing area is divided into four fields, the Northern, the Eastern Middle, Western Middle, and Southern. The area is further divided into three trade regions, the Wyoming, the Lehigh, and the Schuylkill (fig. 1).

The 1969 production statistics indicated a general decline of about 9 percent from the 1968 output; the average per-ton sales price trended upward about 13 percent from the 1968 sales price. The output per man-day decreased about 2 percent in 1969.

The Federal Government continued to purchase Pennsylvania anthracite as a portion of the solid fuel needs of the U.S. Armed Forces in West Germany. The shipments for 1969 were about 27 percent greater than those for 1968.

[1] Chemical engineer, Bureau of Mines, Pittsburgh, Pa.

Table 1.—Salient statistics of the Pennsylvania anthracite industry

	1965	1966	1967	1968	1969
Production:					
Preparation plants ------ short tons --	14,023,269	12,139,106	11,481,582	10,799,260	9,920,130
Dredges ---------- do ----	699,857	661,017	631,660	605,920	535,369
Used at collieries for power and heat ---------- do ----	142,829	141,141	142,821	55,653	17,417
Total production ----- short tons --	14,865,955	12,941,264	12,256,063	11,460,833	10,472,916
Value ---------- thousands --	$122,021	$100,663	$96,160	$97,245	$100,770
Average sales realization per short ton on preparation plant shipments (excludes dredge coal):					
Pea and larger ----------	$11.70	$11.11	$11.53	$12.40	$13.56
Buckwheat No. 1 and smaller -------	$6.48	$6.40	$6.35	$6.87	$7.93
All sizes ----------	$8.51	$8.08	$8.15	$8.78	$9.91
Percentage of total preparation plant shipment (excludes dredge coal):					
Pea and larger ----------	39.0	35.6	34.8	34.6	35.1
Buckwheat No. 1 and smaller -------	61.0	64.4	65.2	65.4	64.9
Exports [1] ---------- short tons --	850,630	766,025	594,797	518,159	627,492
Consumption apparent [2] ---------- do ----	12,900,000	11,400,000	10,800,000	10,160,000	8,809,000
Average number of days worked ----------	204	203	219	217	221
Average number of men working daily ---	11,132	9,292	7,750	6,932	6,300
Output per man per day ----- short tons --	6.55	6.87	7.21	7.62	7.49
Output per man per year ---------- do ----	1,336	1,395	1,579	1,654	1,655
Quantity cut by machines ---------- do ----	329,328	246,658	146,908	61,245	6,830
Quantity mined by stripping ------ do ----	5,938,982	5,253,408	4,740,187	4,696,163	4,578,732
Quantity loaded by machines under ground ---------- do ----	3,246,034	2,590,547	1,997,806	1,475,000	1,326,598
Distribution:					
Receipts in New England [3] --- do ----	241,638	[4] 149,010	----------	----------	----------
Exports to Canada [1] ---------- do ----	642,657	624,280	448,744	401,314	472,763
Loaded into vessels at Lake Erie [5] do ----	224,460	208,432	206,975	204,682	209,000
Receipts at Duluth-Superior [6] do ----	11,560	----------	----------	----------	----------

[1] U.S. Department of Commerce, 1965–69 export data does not include shipments to U.S. military forces. See NOTE, tables 3 and 28.
[2] Beginning with 1961 exports to the U.S. military forces in West Germany were taken into consideration. See NOTE, tables 3 and 28.
[3] Commonwealth of Massachusetts, Division on the Necessaries of Life.
[4] Data discontinued with September, 1966.
[5] Ore and Coal Exchange, Cleveland, Ohio.
[6] Lake Superior area office, Corps of Engineers, U.S. Army, Duluth, Minn.

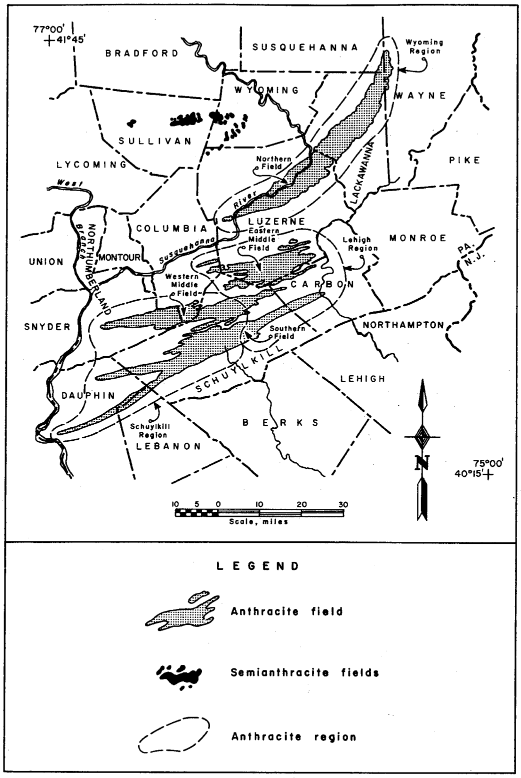

Figure 1.—Coalfields, regions, and counties of the Pennsylvania anthracite area.

Legislation and Government Programs.—State and Federal Government programs for various environmental activities, including underground-mine-fire control, surface subsidence, refuse-or culm-bank-fire control, mine-water-drainage control, and reclamation of old strip pits, continued through 1969 as funds became available. The rate of funding for research projects and for advances in mining techniques continued to decline.

The current problems in the anthracite area are an aftermath of more than 200 years of unregulated mining. These problems are essentially social in nature; surface subsidence and underground mine fires have forced many of the individuals affected to abandon their homes. Pollution by acid coal mine water and sewage is serious. State and Federal cooperative projects are correcting some of the immediate problems, while the State has been making long range plans to prevent future stream contamination.

Work has continued toward filling abandoned strip pits with existing spoil banks. Long-range plans were projected toward completely eliminating the pits, which are both unsightly and unsafe. Large culm banks, a land use pollution problem, are gradually being eliminated by leveling and by slushing the mine refuse underground to correct surface subsidence. Fires in culm banks and underground coalbeds are gradually being brought under control and quenched.

Appalachian projects are being used to control surface subsidence caused by underground mine voids and fires in underground coalbeds as measures to protect life and property. The Federal Government's usual contribution for Applachian environmental control activities in the anthracite area has been 75 percent of the funds used, and the State's contribution has been 25 percent. The work progress of various environmental control projects continued from previous starts or starting in 1969 is as follows:

Project location	Project description	Sponsor	Status of report
ACID COAL MINE DRAINAGE			
Anthracite fields	Monthly measurements of mine water levels and overflows.	U.S. Geological Survey	Continuous.
Luzerne County-Sandy Run	Lime neutralization stream treatment plant	Commonwealth of Pennsylvania	Work in progress 1969.
Luzerne County-Wyoming Valley	Demineralization plant (distillation)	do	Do.
Luzerne County-Plymouth Borough	Abatement of mine water and reclamation	do	Work started in 1969.
Luzerne County-Catawissa Creek, Hazle Township.	Channel relocations to control acid water	do	Work in progress 1969.
Carbon County, Buck Mountain	Lime neutralization stream treatment plant	do	Do.
Schuylkill County, Rausch Creek	Lime neutralizing mine discharge treatment plant	do	Do.
Schuylkill County, Catawissa Creek	Plugging of abandoned Audenried Tunnel	do	Do.
Schuylkill County, Swatara Creek Watershed	Survey of Swatara Creek Watershed to evaluate abatement measures needed on Panther and Black Creeks.	do	Do.
Schuylkill County, Swatara Creek Watershed	Survey to evaluate abatement measures needed on Middle and Goodspring Creeks, and Gebhard and Coal Runs.	do	Do.
Schuylkill County-Frailey Township	Installation of flumes, drainage ditches, and sealing strip pits and reconditioning stream beds.	do	Do.
Schuylkill County, Frailey and Reilly Townships.	Installation of flumes, drainage ditches and reconditioning of stream beds of Bailey and Gebhard Runs.	do	Do.
Schuylkill County, Swatara Creek Watershed	Survey to determine pollution abatement measures needed on Lower Rausch Creek and Lorberry Creek.	do	Do.
Lackawanna County, Jermyn Borough	Abatement of acid mine drainage	do	Project completed 1969.
Schuylkill County, Hegins Township	Rehabilitation of surface area of Rausch Creek Watershed.	do	Project started 1969.
Lackawanna, Wayne and Susquehanna Counties, Upper Lackawanna River.	Abatement and gravity discharge, design and specifications project.	do	Work in progress 1969.
Northumberland County, Shamokin Creek	Engineering study to determine pollution abatement measures needed.	do	Do.
Northumberland County, Shamokin Creek	Design, supervision of construction and operation of treatment plants.	do	Do.
STRIP MINE REHABILITATION			
Schuylkill County, Delano Township	Appalachia strip mine rehabilitation on 80 acres abandoned strip.	Commonwealth of Pennsylvania and U.S. Bureau of Mines.	Project completed 1969.
BURNING AND NONBURNING CULM BANKS			
Lackawanna County, City of Scranton	Air pollution control by extinguishing fire in burning culm bank at Marvine Colliery.	Commonwealth of Pennsylvania and U.S. Public Health Service.	Project completed 1969.
Lackawanna County, Taylor Borough	Elimination of air pollution by extinguishing fire in burning culm bank at Taylor Colliery.	Commonwealth of Pennsylvania and U.S. Bureau of Mines.	Work in progress 1969.
Lackawanna County, City of Scranton	Elimination of air pollution by extinguishing fire in burning culm bank at South Bank Marvine Colliery.	Commonwealth of Pennsylvania	Do.
Luzerne County, Fairview Township	Elimination of air pollution by extinguishing fire in burning Huber culm bank at Huber Colliery.	do	Do.

SURFACE SUBSIDENCE			
Luzerne County, Ashley Borough	Surface stabilization by filling selected underground mine voids with fly ash.	Commonwealth of Pennsylvania	Project completed 1969.
Luzerne County, Wilkes-Barre, East End Section.	Appalachia project for hydraulic backfill of abandoned Blue Coal Corp mine voids on Spring Street.	Commonwealth of Pennsylvania and U.S. Bureau of Mines.	Do.
Luzerne County, Wilkes-Barre, West Heights	Appalachia project for hydraulic backfill of abandoned Stanton Co. mine voids.	do	Do.
Schuylkill County, Coaldale	Appalachia project for hydraulic backfilling of abandoned underground mine voids.	do	Do.
Lackawanna County, Scranton, Central City West.	Appalachia project for hydraulic backfill of mine voids in top three coalbeds of abandoned Pine Brook Co. mine.	do	Work in progress 1969.
Lackawanna County, Scranton, Central City East.	Appalachia project for hydraulic backfill of mine voids in Pine Brook Co. mine adjacent to previous backfill project.	do	Do.
Lackawanna County, Scranton	Filling voids in the abandoned Tripp Slope Mine, Diamond Colliery.	Commonwealth of Pennsylvania	Project completed 1969.
UNDERGROUND MINE FIRES			
Luzerne County, Laurel Run Borough	Appalachia mine fire control, which included Phase I exploratory drilling, Phase II (1) preparation to seal, Phase II (2) seal blocking with sand, Phase II (3) additional sand barrier seals.	Commonwealth of Pennsylvania and U.S. Bureau of Mines.	Phase I work completed 1967; Phase II (1) work completed 1968; Phase II (2) work completed 1969; Phase II (3) work in progress 1969.
Luzerne County, Hazleton Borough	Appalachia mine fire control at site of former Hill mine property, which includes Phase I exploratory drilling and Phase II seal blocking with sand.	do	Phase I work completed 1969; Phase II work in progress 1969.
Luzerne County, Swoyersville Borough	Appalachia mine fire control at site of former Forty Fort Mine property, which includes Phase I exploratory drilling and Phase II seal blocking with sand.	do	Do.
Lackawanna County, Troup Borough	Appalachia mine fire control at site in southern part of the Borough, which includes Phase I exploratory drilling and Phase II seal blocking with sand.	do	Phase I work completed 1968; Phase II work completed 1969.
Lackawanna County, Scranton, Cedar Avenue.	Appalachia mine fire control at site under Cedar Avenue section, which includes Phase I exploratory drilling, Phase II (1) sand seal blocking of top bed, and Phase II (2) sand seal blocking lower bed.	do	Phase I work completed 1967; Phase II (1) work completed 1968; Phase II (2) work in progress 1969.
Schuylkill County, Shenandoah Borough	Appalachia mine fire control at site of former Kehleg Run Mine, which includes Phase I exploratory drilling and Phase II sand seal blocking of fire area.	Commonwealth of Pennsylvania and Phase I-U.S. Bureau of Mines.	Phase I work completed 1968; Phase II work in progress.
Lackawanna County, Carbondale Township	Appalachia mine fire control at site of former mine in the southwest part of the city of Carbondale, includes stripping out fire in the city and Phase I exploratory drilling, Phase II sand seal barrier.	Carbondale Redevelopment Authority, Commonwealth of Pennsylvania, and U.S. Bureau of Mines.	Containment of fire, continuing 1969; Phase I work completed 1969; Phase II work in progress 1969.
Columbia County, Centralia Borough	Appalachia mine fire control, which includes Phase I exploratory drilling and Phase II seal blocking with fly ash.	Commonwealth of Pennsylvania and U.S. Bureau of Mines.	Phase I work completed 1968; Phase II work in progress 1969.
Northumberland County, Mt. Carmel Township.	Control of mine fire, which includes Phase I exploratory drilling and Phase II seal blocking for fire control.	Commonwealth of Pennsylvania	Phase I work completed 1969; Phase II work completed 1969.

DOMESTIC PRODUCTION

Anthracite production was 10.5 million tons in 1969, some 987,917 tons, or 9 percent, below the 1968 output. About 5 percent of the anthracite was produced by river dredging, 44 percent by strip mining, 31 percent from the reworking of refuse or culm banks, and the remaining 20 percent from underground mines. About 15 percent of the production came from the Eastern Middle field, 27 percent from the Western Middle field, 35 percent from the Southern field, and the remaining 23 percent from the Northern field. Production by the three trade regions was as follows: Lehigh region, 23 percent; Schuylkill region, 54 percent; and the Wyoming region, 23 percent.

The total 1969 production was valued at $100.8 million, an average of $9.62 per ton. The average value of anthracite sold, by sizes, varied from about $3.00 per ton for the smallest sizes to over $16.00 per ton for the large sizes, which were generally used as domestic fuel.

CONSUMPTION AND USES

The apparent domestic consumption of anthracite (production minus exports and shipments to U.S. Armed Forces, West Germany) was about 1,270,000 tons below the 1968 consumption. The decrease reflected a slight decline in sales for residential and commercial heating purposes, though export coal sales increased. Overall consumption of anthracite in 1969 was about as follows: 6 percent for export; 10 percent for the U.S. Armed Forces, West Germany; 40 percent for residential and commercial heating purposes; 18 percent for electric power generation; 11 percent for the iron and steel industry; and the remaining 15 percent divided between other industrial uses.

FOREIGN TRADE

Shipments to foreign markets, other than the U.S. Armed Forces, West Germany, during 1969 were about 21 percent greater than in 1968. Increased shipments to the U.S. Armed Forces, West Germany, were about 26 percent over that for 1968. The shipments to foreign consumers were usually the larger sizes, such as, lump, egg, stove, chestnut, and pea and were generally made by the larger coal operators, because of their ability to supply the quantities of coal needed to meet boat schedules.

WORLD REVIEW

The production of anthracite in the Communist countries in 1969 was estimated to have increased about 2 percent over that for 1968. In other countries, the trend for production in 1969 was slightly downward compared with the 1968 totals. The total world production including the United States in 1969 was down about 2 percent.

TECHNOLOGY

No significant progress has been made during the past several years in improving anthracite underground mining techniques. The Pennsylvania Department of Mines and Mineral Industries has continued research and started development work on an automated anthracite mining system with semilongwall and pitch capabilities, Coal Research Board's Projects No.'s 89-U and 89-C.

A new use for anthracite coal developed by Melpar, Inc. (Div. American Standard Inc.), as U.S. Patent No. 3,460,925 combined sodium hydroxide, anthracite, and steam to produce sodium carbide.[2]

The preparation characteristics of the Kidney Seam in the Northern field were studied by the U.S. Bureau of Mines. The

[2] Coal Mining & Processing. V. 7, January 1970, p. 16.

coal used in the tests was generally low-ash anthracite, but the ash content could be further reduced by 90 percent with the removal of the sink 1.70 specific gravity material.

Maps of abandoned underground mines in the Lackawanna Basin Northern Anthracite field were microfilmed as part of a Bureau of Mines continuing program to preserve old mine maps for future studies of subsidence, for mine-fire control, and for evaluating building sites.

Table 2.—Standard anthracite specifications approved and adopted by the Anthracite Committee, effective July 28, 1947

Size	Round test mesh (inches)	Percent					
		Oversize maximum	Undersize		Maximum impurities [1]		
			Maximum	Minimum	Slate	Bone	Ash [2]
Broken	Through 4⅜	------	------	------	1½	2	11
	Over 3¼ to 3	------	15	7½	------	------	------
Egg	Through 3¼ to 3	5	------	------	1½	2	11
	Over 2 7/16	------	15	7½	------	3	11
Stove	Through 2 7/16	7½	------	------	2	3	11
	Over 1⅝	------	15	7½	------	------	------
Chestnut	Through 1⅝	7½	------	------	3	4	11
	Over 13/16	------	15	7½	------	------	------
Pea	Through 13/16	10	------	------	4	5	12
	Over 9/16	------	15	7½	------	------	------
Buckwheat No. 1	Through 9/16	10	------	------	------	------	13
	Over 5/16	------	15	7½	------	------	------
Buckwheat No. 2 (rice)	Through 5/16	10	------	------	------	------	13
	Over 3/16	------	17	7½	------	------	------
Buckwheat No. 3 (barley)	Through 3/16	10	------	------	------	------	15
	Over 3/32	------	20	10	------	------	------
Buckwheat No. 4	Through 3/32	20	------	------	------	------	15
	Over 3/64	------	30	10	------	------	------
Buckwheat No. 5	Through 3/64	30	No limit		------	------	16

[1] When slate content in sizes from broken to chestnut, inclusive, is less than above standards, bone content may be increased by 1½ times the decrease in slate content under the allowable limits, but slate content specified above shall not be exceeded in any event.

A tolerance of 1 percent is allowed on maximum percentage of undersize and maximum percentage of ash content.

Maximum percentage of undersize is applicable only to anthracite as it is produced at preparation plant.

Slate is defined as any material that has less than 40 percent fixed carbon.

Bone is defined as any material that has 40 percent or more, but less than 75 percent, fixed carbon.

[2] Ash determinations are on a dry basis.

Table 3.—Summary of monthly developments in the Pennsylvania anthracite industry in 1969

(Thousand short tons, except as otherwise indicated)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year 1969	Change from 1968 (percent)	Year 1968
Production (including mine fuel, local sales, and dredge coal)	973	911	898	916	869	812	704	877	947	985	831	750	10,473	−8.6	11,461
Shipments (breakers and washeries only, all sizes):															
By rail [1]	295	279	333	437	468	403	340	493	422	400	358	290	4,518	−5.3	4,770
By truck [2]	544	509	463	396	333	360	261	336	363	430	393	433	4,821	−6.9	5,181
Carloadings [3]	5	5	6	8	8	8	7	8	8	8	7	5	83	−8.8	91
Distribution:															
Lake Erie loadings [4]	-----	-----	-----	15	32	26	19	32	20	29	29	7	209	+2.0	205
Upper Lake dock trade: [5]															
Receipts:															
Lake Superior	-----	-----	-----	6	-----	15	-----	9	3	3	9	-----	45	−2.2	46
Lake Michigan	(6)	(6)	(6)	(6)	2	1	(6)	(6)	(6)	(6)	(6)	(6)	4	−33.3	6
Deliveries (reloadings):															
Lake Superior	4	2	4	4	-----	3	3	4	4	5	3	7	43	−20.4	54
Lake Michigan	1	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	1	(6)	(6)	5	−28.6	7
Exports [7]	17	14	18	39	76	59	47	111	41	70	63	70	[8] 627	+20.7	518
Industrial consumption and stocks by:															
Electric utilities: [9]															
Consumption	166	142	147	151	139	160	173	172	153	137	146	163	1,849	−16.1	2,203
Stocks	1,298	1,272	1,255	1,269	1,289	1,304	1,310	1,318	1,233	1,337	1,340	1,297	1,297	−2.1	1,325
Coke plants:															
Used for carbonizing	49	46	46	43	44	41	40	40	49	48	44	53	543	+2.1	532
Stocks	125	95	74	73	85	100	99	110	119	122	137	130	130	−15.6	154
Stocks on Upper Lake docks: [5]															
Lake Superior	14	12	8	10	10	22	19	24	22	21	27	20	20	+11.1	18
Lake Michigan	2	2	2	1	3	3	3	3	2	2	2	1	1	−50.0	2
Stocks in retail dealer yards: [10]															
Chestnut and larger	141	120	97	81	95	112	104	112	109	100	97	81	81	−53.4	174
Pea	17	15	13	12	14	14	13	12	12	12	12	9	9	−66.7	27
Buckwheat No. 1 and rice	82	72	55	46	55	73	62	61	60	61	63	52	52	−51.9	108
Total	240	207	165	139	164	199	179	185	181	173	172	142	142	−54.0	309
Retail dealer deliveries: [10]															
Chestnut and larger	227	187	149	52	30	33	36	37	68	105	58	70	1,052	−37.0	1,670
Pea	25	23	18	10	5	5	4	6	9	10	7	11	133	−68.1	417
Buckwheat No. 1 and rice	60	50	45	25	17	11	15	24	27	33	25	41	373	−30.0	533
Total	312	260	212	87	52	49	55	67	104	148	90	122	1,558	−40.5	2,620

Wholesale price indexes (1957–59 = 100):[11]															
F.o.b. car at mines:															
Chestnut	101.6	102.0	102.0	100.0	96.6	96.6	100.4	100.4	103.8	103.8	107.1	110.4	102.1	+6.8	95.6
Buckwheat No. 1	105.5	105.9	105.9	106.0	106.0	106.0	109.5	109.5	112.7	112.7	116.0	119.6	109.6	+12.3	97.6

[1] Furnished by initial carriers.
[2] Pennsylvania Department of Mines and Mineral Industries.
[3] Association of American Railroads.
[4] Ore and Coal Exchange, Cleveland, Ohio.
[5] Data furnished by Lake dock operators.
[6] Less than ½ unit.
[7] U.S. Department of Commerce. Does not include shipments to the U.S. military forces.
[8] Data may not add to totals shown because of independent rounding.
[9] Federal Power Commission.
[10] Estimated from reports submitted by a selected list of retail dealers located outside the producing region.
[11] Furnished by the Bureau of Labor Statistics from data obtained from authorized trade publications.

NOTE: According to the Association of American Railroads, 1,106,409 short tons of anthracite was exported to Europe during 1969 compared with 880,076 tons for 1968. Of this total 1,037,470 tons was consigned to West Germany and Netherlands, including exports to the U.S. military forces. This compares with 819,824 tons for 1968.

Table 4.—Commercial production of Pennsylvania

Size	From preparation plants					
	Lehigh region			Schuylkill region		
	Rail	Truck	Total [2]	Rail	Truck	Total [2]
Quantity, thousand short tons:						
Egg	109	4	113	59	2	61
Stove	186	60	245	259	241	500
Chestnut	146	175	321	197	382	580
Pea	95	167	261	106	274	380
Total pea and larger [2]	535	405	941	621	900	1,521
Buckwheat No. 1	130	155	285	216	357	573
Buckwheat No. 2 (rice)	59	214	273	99	371	470
Buckwheat No. 3 (barley)	89	174	263	242	499	740
Buckwheat No. 4	162	33	195	193	165	358
Buckwheat No. 5	368	47	415	565	108	674
Other [3]	9	65	74	366	412	778
Total buckwheat No. 1 and smaller [2]	817	687	1,504	1,680	1,912	3,592
Grand total [2]	1,353	1,093	2,445	2,302	2,812	5,113
Value, thousands:						
Egg	$1,547	$55	$1,602	$812	$24	$836
Stove	2,595	854	3,450	3,612	3,349	6,961
Chestnut	2,035	2,480	4,515	2,744	5,281	8,025
Pea	1,096	1,976	3,072	1,280	3,248	4,527
Total pea and larger [2]	7,273	5,367	12,639	8,447	11,901	20,348
Buckwheat No. 1	1,463	1,728	3,191	2,494	4,128	6,622
Buckwheat No. 2 (rice)	670	2,466	3,136	1,109	4,200	5,309
Buckwheat No. 3 (barley)	830	1,647	2,477	2,239	4,821	7,060
Buckwheat No. 4	961	191	1,153	1,339	1,047	2,387
Buckwheat No. 5	2,142	264	2,407	3,074	522	3,596
Other [3]	31	230	261	1,338	1,560	2,898
Total buckwheat No. 1 and smaller [2]	6,098	6,526	12,624	11,594	16,279	27,872
Grand total [2]	13,371	11,893	25,264	20,041	28,180	48,220
Average value per ton:						
Egg	$14.16	$14.14	$14.16	$13.67	$13.42	$13.66
Stove	13.98	14.27	14.05	13.97	13.88	13.92
Chestnut	13.95	14.19	14.08	13.91	13.81	13.84
Pea	11.58	11.85	11.75	12.08	11.84	11.91
Total pea and larger	13.58	13.24	13.43	13.60	13.23	13.38
Buckwheat No. 1	11.21	11.15	11.18	11.54	11.58	11.56
Buckwheat No. 2 (rice)	11.35	11.53	11.49	11.22	11.32	11.30
Buckwheat No. 3 (barley)	9.34	9.45	9.42	9.26	9.67	9.54
Buckwheat No. 4	5.94	5.86	5.92	6.96	6.33	6.67
Buckwheat No. 5	5.82	5.66	5.80	5.44	4.82	5.34
Other [3]	3.50	3.55	3.55	3.66	3.79	3.73
Total buckwheat No. 1 and smaller	7.46	9.50	8.39	6.90	8.51	7.76
Grand total	9.89	10.89	10.33	8.71	10.02	9.43

[1] Includes Sullivan County.
[2] Data may not add to totals shown because of independent rounding.
[3] Includes various mixtures of buckwheat Nos. 2 to 5 and coal of relatively low dollar value.

anthracite in 1969, by regions and sizes

From preparation plants											
Wyoming region [1]			Total preparation plants			From river dredging			Total		
Rail	Truck	Total [2]	Rail	Truck	Total [2]	Rail	Truck	Total [2]	Rail	Truck	Total [2]
71	1	73	240	7	247	------	------	------	240	7	247
184	101	284	628	402	1,030	------	------	------	628	402	1,030
129	246	375	472	803	1,275	------	------	------	472	303	1,275
56	231	288	257	672	929	------	------	------	257	672	929
441	579	1,020	1,597	1,884	3,482	------	------	------	1,597	1,884	3,482
76	271	347	423	782	1,205	------	------	------	423	782	1,205
48	173	222	206	758	964	------	------	------	206	758	964
75	155	230	405	828	1,233	------	------	------	405	828	1,233
62	24	86	416	222	638	------	12	12	416	234	650
29	32	61	962	187	1,150	------	3	3	962	191	1,153
45	351	397	420	828	1,248	474	46	520	895	873	1,768
335	1,007	1,342	2,833	3,606	6,439	474	61	535	3,307	3,667	6,974
776	1,586	2,362	4,430	5,490	9,920	474	61	535	4,905	5,551	10,455
$990	$16	$1,006	$3,349	$95	$3,444	------	------	------	$3,349	$95	$3,444
2,636	1,437	4,073	8,843	5,641	14,484	------	------	------	8,843	5,641	14,484
1,890	3,579	5,469	6,669	11,340	18,009	------	------	------	6,669	11,340	18,009
721	2,964	3,685	3,096	8,188	11,284	------	------	------	3,096	8,188	11,284
6,237	7,996	14,233	21,957	25,264	47,221	------	------	------	21,957	25,264	47,221
897	3,187	4,083	4,854	9,043	13,896	------	------	------	4,854	9,043	13,896
561	2,051	2,612	2,341	8,716	11,056	------	------	------	2,341	8,916	11,056
706	1,461	2,166	3,775	7,928	11,704	------	------	------	3,775	7,928	11,704
460	187	647	2,761	1,425	4,186	------	46	46	2,761	1,472	4,232
167	119	286	5,383	905	6,289	------	14	14	5,383	919	6,303
182	604	787	1,551	2,395	3,946	2,056	159	2,215	3,607	2,554	6,161
2,973	7,608	10,581	20,665	30,412	51,077	2,056	220	2,276	22,720	30,632	53,353
9,210	15,604	24,814	42,622	55,676	98,298	2,056	220	2,276	44,678	55,896	100,574
$13.86	$13.73	$13.86	$13.95	$13.88	$13.95	------	------	------	$13.95	$13.88	$13.95
14.35	14.25	14.32	14.08	14.03	14.06	------	------	------	14.08	14.03	14.06
14.62	14.56	14.58	14.12	14.12	14.12	------	------	------	14.12	14.12	14.12
12.76	12.82	12.81	12.05	12.18	12.14	------	------	------	12.05	12.18	12.14
14.15	13.81	13.96	13.74	13.41	13.56	------	------	------	13.74	13.41	13.56
11.79	11.77	11.77	11.48	11.56	11.53	------	------	------	11.48	11.56	11.53
11.59	11.85	11.79	11.34	11.50	11.47	------	------	------	11.34	11.50	11.47
9.48	9.41	9.43	9.32	9.57	9.49	------	------	------	9.32	9.57	9.49
7.46	7.77	7.55	6.63	6.42	6.56	------	3.88	3.88	6.63	6.29	6.51
5.73	3.68	4.65	5.59	4.83	5.47	------	4.00	4.00	5.59	4.82	5.47
4.01	1.72	1.98	3.69	2.89	3.16	4.33	3.50	4.26	4.03	2.92	3.48
8.87	7.56	7.88	7.29	8.43	7.93	4.33	3.60	4.25	6.87	8.35	7.65
11.87	9.84	10.51	9.62	10.14	9.91	4.33	3.60	4.25	9.11	10.07	9.62

Table 5.—Sizes of Pennsylvania anthracite (excluding dredge coal) prepared at plants in 1969, by regions

(Percent)

Size	Lehigh region			Schuylkill region		
	Shipped by rail	Shipped by truck	Total	Shipped by rail	Shipped by truck	Total
Egg	8.1	0.3	4.6	2.6	0.1	1.2
Stove	13.7	5.5	10.0	11.2	8.6	9.8
Chestnut	10.8	16.0	13.1	8.6	13.6	11.3
Pea	7.0	15.3	10.7	4.6	9.7	7.4
Total pea and larger	39.6	37.1	38.4	27.0	32.0	29.7
Buckwheat No. 1	9.6	14.2	11.7	9.4	12.7	11.2
Buckwheat No. 2 (rice)	4.4	19.6	11.2	4.3	13.2	9.2
Buckwheat No. 3 (barley)	6.6	15.9	10.8	10.5	17.7	14.5
Buckwheat No. 4	12.0	3.0	8.0	8.4	5.9	7.0
Buckwheat No. 5	27.2	4.3	16.9	24.5	3.9	13.2
Other [1]	.6	5.9	3.0	15.9	14.6	15.2
Total buckwheat No. 1 and smaller	60.4	62.9	61.6	73.0	68.0	70.3
	Wyoming region [2]			Total		
Egg	9.2	0.1	3.1	5.4	0.1	2.5
Stove	23.7	6.3	12.0	14.2	7.3	10.4
Chestnut	16.6	15.5	15.9	10.7	14.6	12.8
Pea	7.3	14.6	12.2	5.8	12.3	9.4
Total pea and larger	56.8	36.5	43.2	36.1	34.3	35.1
Buckwheat No. 1	9.8	17.1	14.7	9.5	14.3	12.2
Buckwheat No. 2 (rice)	6.2	10.9	9.4	4.7	13.8	9.7
Buckwheat No. 3 (barley)	9.6	9.8	9.7	9.1	15.1	12.4
Buckwheat No. 4	7.9	1.5	3.6	9.4	4.0	6.4
Buckwheat No. 5	3.8	2.0	2.6	21.7	3.4	11.6
Other [1]	5.9	22.2	16.8	9.5	15.1	12.6
Total buckwheat No. 1 and smaller	43.2	63.5	56.8	63.9	65.7	64.9

[1] Includes various mixtures of buckwheat Nos. 2 to 5 and coal of relatively low dollar value.
[2] Includes Sullivan County.

Table 6.—Sizes of Pennsylvania anthracite (excluding dredge coal) prepared at plants, by regions

(Percent)

Size	Lehigh region					Schuylkill region				
	1965	1966	1967	1968	1969	1965	1966	1967	1968	1969
Lump [1] and broken	----	----	----	----	----	----	----	----	----	----
Egg	3.9	2.7	4.6	4.5	4.6	1.0	0.9	1.2	1.2	1.2
Stove	11.8	11.1	11.0	10.3	10.0	10.3	9.3	9.4	9.4	9.8
Chestnut	14.9	12.4	12.1	12.0	13.1	12.0	12.0	10.7	11.1	11.3
Pea	9.4	7.4	9.0	10.9	10.7	8.4	8.3	8.0	7.7	7.4
Total pea and larger	40.0	33.6	36.7	37.7	38.4	31.7	30.5	29.3	29.4	29.7
Buckwheat No. 1	10.5	11.3	10.5	11.0	11.7	11.9	12.1	11.0	11.0	11.2
Buckwheat No. 2 (rice)	9.5	9.9	8.9	9.6	11.2	10.1	10.2	9.2	9.5	9.2
Buckwheat No. 3 (barley)	10.2	9.1	9.1	10.3	10.8	13.5	13.3	11.1	11.8	14.5
Buckwheat No. 4	5.5	6.2	6.0	6.6	8.0	6.5	7.0	6.7	6.5	7.0
Buckwheat No. 5	12.5	14.8	15.9	16.9	16.9	14.7	14.1	12.8	13.0	13.2
Other [3]	11.8	15.1	12.9	7.9	3.0	11.6	12.8	19.9	18.8	15.2
Total buckwheat No. 1 and smaller	60.0	66.4	63.3	62.3	61.6	68.3	69.5	70.7	70.6	70.3
	Wyoming region [4]					Total				
Lump [1] and broken	(2)	(2)	(2)	(2)	----	(2)	(2)	(2)	(2)	----
Egg	4.7	3.4	3.0	1.9	3.1	2.8	2.0	2.6	2.2	2.5
Stove	15.0	13.1	12.0	11.7	12.0	12.1	10.8	10.5	10.2	10.4
Chestnut	16.6	17.2	15.8	15.6	15.9	14.1	13.5	12.4	12.5	12.8
Pea	12.9	12.6	12.1	12.2	12.2	10.0	9.3	9.3	9.7	9.4
Total pea and larger	49.2	46.3	42.9	41.4	43.2	39.0	35.6	34.8	34.6	35.1
Buckwheat No. 1	13.8	15.0	13.3	14.4	14.7	12.2	12.7	11.5	11.9	12.2
Buckwheat No. 2 (rice)	9.2	9.7	9.4	9.2	9.4	9.7	9.9	9.2	9.4	9.7
Buckwheat No. 3 (barley)	10.7	10.8	10.6	10.3	9.7	11.9	11.6	10.4	11.1	12.4
Buckwheat No. 4	3.8	4.7	2.6	2.6	3.6	5.4	6.2	5.4	5.5	6.4
Buckwheat No. 5	2.9	4.3	6.0	5.1	2.6	10.5	11.6	11.9	11.8	11.6
Other [3]	10.4	9.2	15.2	17.0	16.8	11.3	12.4	16.8	15.7	12.6
Total buckwheat No. 1 and smaller	50.8	53.7	57.1	58.6	56.8	61.0	64.4	65.2	65.4	64.9

[1] Quantity of lump included is insignificant.
[2] Less than 0.05 percent.
[3] Includes various mixtures of buckwheat Nos. 2 to 5 and coal of relatively low dollar value.
[4] Includes Sullivan County.

Table 7.—Production of Pennsylvania anthracite in 1969, by regions and counties

(Thousand short tons and thousand dollars)

Source	Rail shipments		Truck shipments		Colliery fuel		Total production [1]	
	Quantity	Value [2]	Quantity	Value [2]	Quantity	Value	Quantity	Value [2]
REGIONS								
Lehigh:								
Preparation plants	1,353	$13,371	1,093	$11,893	7	$82	2,452	$25,345
Schuylkill:								
Preparation plants	2,302	20,041	2,812	28,180	6	70	5,119	48,290
Dredges	474	2,056	61	220	------	------	535	2,276
Total Schuylkill [1]	2,776	22,096	2,873	28,400	6	70	5,655	50,566
Wyoming:								
Preparation plants [3]	776	9,210	1,586	15,604	4	44	2,366	24,858
Total: [1]								
Preparation plants	4,430	42,622	5,490	55,676	17	196	9,938	98,494
Dredges	474	2,056	61	220	------	------	535	2,276
Grand total [1]	4,905	44,678	5,551	55,896	17	196	10,473	100,770
COUNTIES								
Berks, Lancaster, and Snyder	474	$2,056	51	$174	------	------	525	$2,230
Carbon	395	3,754	87	496	------	------	482	4,250
Columbia	238	2,846	50	507	------	------	288	3,354
Dauphin	7	68	49	228	------	------	56	296
Lackawanna	156	1,806	180	2,117	1	$7	338	3,929
Luzerne	1,403	15,586	1,958	20,093	9	115	3,371	35,794
Northumberland	470	2,656	843	7,734	1	7	1,314	10,398
Schuylkill	1,761	15,905	2,304	24,386	6	66	4,072	40,358
Sullivan	------	------	29	160	------	------	29	160
Total [1]	4,905	44,678	5,551	55,896	17	196	10,473	100,770

[1] Data may not add to totals shown because of independent rounding.
[2] Value given for shipments is that at which coal left possession of producing company; does not include selling expenses.
[3] Includes Sullivan County.

Table 8.—Pennsylvania anthracite produced, by fields

(Thousand short tons)

Field	1965	1966	1967	1968	1969
Eastern Middle: Breakers and washeries	2,027	2,009	2,039	1,559	1,583
Western Middle:					
Breakers and washeries	3,428	3,025	2,893	2,840	2,806
Dredges	36	26	27	17	5
Total [1]	3,464	3,051	2,920	2,857	2,811
Southern:					
Breakers and washeries	4,160	3,781	3,604	3,557	3,183
Dredges	664	635	605	589	530
Total [1]	4,824	4,416	4,209	4,146	3,713
Northern: Breakers and washeries [2]	4,551	3,465	3,088	2,899	2,366
Total [1]					
Breakers and washeries	14,165	12,280	11,624	10,855	9,938
Dredges	700	662	632	606	535
Grand total [1]	14,866	12,941	12,256	11,461	10,473

[1] Data may not add to totals shown because of independent rounding.
[2] Includes Sullivan County.

Table 9.—Pennsylvania anthracite produced in 1969, classified as fresh-mined, culm-bank and river coal, by fields and regions

(Thousand short tons)

Source	Fresh-mined coal: Underground mines: Mechanically loaded	Hand loaded	Total [1]	Strip pits	From culm banks	From river dredging	Total [1]
FIELDS							
Eastern Middle	14	15	29	1,063	491	------	1,583
Western Middle	108	273	381	1,052	1,372	5	2,811
Southern	410	491	901	1,554	728	530	3,713
Northern [2]	795	------	795	909	662	------	2,366
Total [1]	1,327	779	2,106	4,579	3,253	535	10,473
REGIONS							
Lehigh	14	36	50	1,627	775	------	2,452
Schuylkill	518	743	1,261	2,043	1,815	535	5,655
Wyoming [2]	795	------	795	909	662	------	2,366
Total	1,327	779	2,106	4,579	3,253	535	10,473

[1] Data may not add to totals shown because of independent rounding.
[2] Includes Sullivan County.

Table 10.—Production of Pennsylvania anthracite from strip pits

	Mined by stripping (thousand short tons)	Percent of fresh-mined total	Number of men employed	Average number of days worked
1965	5,939	52.9	2,349	217
1966	5,253	56.2	2,085	225
1967	4,740	59.3	1,883	237
1968	4,696	65.7	1,891	239
1969:				
Lehigh region	1,627	97.0	582	220
Schuylkill region	2,043	61.8	722	202
Wyoming region [1]	909	53.3	414	252
Total [2] or average	4,579	68.5	p 1,718	p 221

p Preliminary.
[1] Includes Sullivan County.
[2] Data may not add to totals shown because of independent rounding.

Table 11.—Power shovels and draglines used in recovering coal from culm banks and stripping Pennsylvania anthracite, by type of power

Type of power	1967: Number of power shovels	1967: Number of drag-lines	1967: Total	1968: Number of power shovels	1968: Number of drag-lines	1968: Total	1968: Number of power shovels	1968: Number of drag-lines	1968: Total
Gasoline	4	6	10	6	5	11	3	3	6
Electric	27	43	70	26	40	66	27	37	64
Diesel	93	140	233	81	144	225	74	124	198
Diesel-electric	1	1	2	----	1	1	----	1	1
Total	125	190	315	113	190	303	104	165	269

Table 12.—Production of Pennsylvania anthracite from culm banks, by regions

(Thousand short tons)

Year	Lehigh region	Schuylkill region	Wyoming region	Total[1]
1965	833	1,380	716	2,930
1966	971	1,390	578	2,938
1967	1,134	1,710	782	3,627
1968	958	1,868	883	3,709
1969	775	1,815	662	3,253

[1] Data may not add to totals shown because of independent rounding.

Table 13.—Pennsylvania anthracite produced by dredges, by rivers, including tributaries

(Thousand short tons and thousand dollars)

Year	Schuylkill River			Susquehanna River			Total[1]		
	Quantity	Value	Average value (per ton)	Quantity	Value	Average value (per ton)	Quantity	Value	Average value (per ton)
1965	86	$289	$3.36	614	$2,048	$3.33	700	$2,337	$3.34
1966	57	180	3.16	605	2,107	3.48	662	2,287	3.46
1967	39	116	3.00	593	2,140	3.61	632	2,257	3.57
1968	45	157	3.50	561	2,066	3.68	606	2,224	3.67
1969	53.	185	3.50	483	2,091	4.33	535	2,276	4.25

[1] Data may not add to totals shown because of independent rounding.

Table 14.—Estimated production of Pennsylvania anthracite, by weeks, in 1969[1]

Week ended—	Thousand short tons	Week ended—	Thousand short tons	Week ended—	Thousand short tons
Jan. 4	186	May 10	172	Sept. 13	209
11	243	17	175	20	299
18	282	24	179	27	253
25	262	31	160	Oct. 4	243
Feb. 1	233	June 7	208	11	237
8	217	14	206	18	265
15	212	21	195	25	240
22	249	28	203	Nov. 1	150
Mar. 1	193	July 5	98	8	157
8	198	12	108	15	172
15	108	19	239	22	165
22	195	26	259	29	187
29	204	Aug. 2	167	Dec. 6	189
Apr. 5	230	9	189	13	199
12	219	16	191	20	202
19	242	23	185	27	160
26	225	30	145		
May 3	183	Sept. 6	186	Total	10,473

[1] Estimated from weekly carloadings as reported by the Association of American Railroads and other factors; adjusted to annual production from Bureau of Mines canvass.

Table 15.—Estimated monthly production of Pennsylvania anthracite [1]

(Thousand short tons)

Month	1965	1966	1967	1968	1969
January	1,215	1,108	1,101	965	973
February	1,006	1,091	939	962	911
March	1,256	1,033	979	960	898
April	1,127	1,058	952	926	916
May	1,264	1,103	1,102	986	869
June	1,565	998	995	824	812
July	1,209	745	899	853	704
August	1,244	1,191	1,132	1,016	877
September	1,313	1,145	1,071	953	947
October	1,221	1,221	1,073	1,136	985
November	1,208	1,145	1,017	994	831
December	1,238	1,103	996	886	750
Total	14,866	12,941	12,256	11,461	10,473

[1] Production is estimated from weekly carloadings, as reported by the Association of American Railroads, and includes mine fuel, coal sold locally, and dredge coal.

Table 16.—Pennsylvania anthracite loaded mechanically underground, by fields

(Thousand short tons)

Field	Scraper loaders [1]		Pit-car loaders		Hand-loaded face conveyors, all types [2]		Total mechanically loaded [3]	
	1968	1969	1968	1969	1968	1969	1968	1969
Northern	606	452	18	14	345	329	970	795
Eastern Middle	14	4	-----	-----	6	10	21	14
Western Middle	14	24	-----	-----	125	83	139	108
Southern	197	276	-----	-----	148	134	345	410
Total [3]	831	757	18	14	625	556	1,475	1,327

[1] Includes mobile loaders.
[2] Shaker chutes, including those equipped with duckbills.
[3] Data may not add to totals shown because of independent rounding.

Table 17.—Pennsylvania anthracite loaded mechnically underground

(Thousand short tons)

Year	Scraper loaders		Mobile loaders		Conveyor [1] and pit-car loaders		Total [2] loaded mechanically	
	Number of units	Quantity loaded	Number of units	Quantity loaded	Number of units	Quantity loaded	Number of units	Quantity loaded
1965	155	907	25	393	403	1,946	583	3,246
1966	151	788	30	328	383	1,474	564	2,591
1967	119	707	21	201	228	1,090	368	1,998
1968	131	710	26	121	184	643	341	1,475
1969	106	567	25	190	158	570	289	1,327

[1] Includes duckbills and other self-loading conveyors.
[2] Data may not add to totals shown because of independent rounding.

Table 18.—Trends in mechanical loading,[1] hand loading, and stripping of Pennsylvania anthracite

(Thousand short tons)

Year	Fresh-mined coal							
	Underground					Strip pits		
	Mechanical loading	Percent of total underground	Hand loading	Percent of total underground	Total [2]	Quantity	Percent of total fresh-mined	Total [2]
1965	3,246	61.3	2,051	38.7	5,297	5,939	52.9	11,236
1966	2,591	63.4	1,498	36.6	4,088	5,253	56.2	9,342
1967	1,998	61.3	1,260	38.7	3,258	4,740	59.3	7,998
1968	1,475	60.2	975	39.8	2,450	4,696	65.7	7,146
1969	1,327	63.0	779	37.0	2,106	4,579	68.5	6,685

[1] Mechanical loading includes coal handled on pit-car loaders and hand-loaded face conveyors.
[2] Data may not add to totals shown because of independent rounding.

Table 19.—Average sales realization of Pennsylvania anthracite (excluding dredge coal) at preparation plants, by regions and sizes

(Per short ton)

Size	Lehigh region					Schuylkill region				
	1965	1966	1967	1968	1969	1965	1966	1967	1968	1969
Lump [1] and broken	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Egg	$12.95	$12.46	$12.68	$12.99	$14.16	$12.65	$12.42	$12.49	$13.26	$13.66
Stove	12.62	12.03	12.51	12.93	14.05	11.73	11.30	11.80	12.82	13.92
Chestnut	12.50	11.95	12.46	12.93	14.08	11.68	11.04	11.53	12.66	13.84
Pea	10.09	9.00	9.42	10.33	11.75	9.37	8.66	9.15	10.44	11.91
Total pea and larger	12.01	11.37	11.76	12.18	13.43	11.11	10.51	11.00	12.15	13.38
Buckwheat No. 1	9.28	8.45	9.01	9.70	11.18	8.69	8.68	9.02	10.03	11.56
Buckwheat No. 2 (rice)	9.66	9.32	9.62	10.24	11.49	8.53	8.28	8.67	9.80	11.30
Buckwheat No. 3 (barley)	7.57	7.53	7.78	8.29	9.42	7.12	7.19	7.43	8.13	9.54
Buckwheat No. 4	5.57	5.59	5.48	5.72	5.92	5.26	5.32	5.50	5.91	6.67
Buckwheat No. 5	5.36	5.38	5.46	5.54	5.80	4.31	4.61	4.70	4.95	5.34
Other [2]	2.98	2.99	3.13	3.36	3.55	3.44	3.57	3.95	3.56	3.73
Total buckwheat No. 1 and smaller	6.66	6.26	6.49	7.20	8.39	6.19	6.23	6.18	6.65	7.76
Total all sizes	8.80	7.98	8.42	9.08	10.33	7.75	7.53	7.60	8.26	9.43
	Wyoming region [3]					Total				
Lump [1] and broken	$12.39	$12.50	$14.96	$14.80	-----	$12.39	$12.50	$14.96	$14.80	-----
Egg	13.12	12.51	12.74	13.24	$13.86	12.99	12.48	12.65	13.12	$13.95
Stove	12.58	12.17	12.66	13.40	14.32	12.25	11.77	12.25	13.02	14.06
Chestnut	12.51	12.04	12.31	13.58	14.58	12.17	11.59	12.03	13.02	14.12
Pea	10.62	10.34	10.73	11.61	12.81	10.02	9.35	9.75	10.80	12.14
Total pea and larger	12.09	11.65	11.99	12.93	13.96	11.70	11.11	11.53	12.40	13.56
Buckwheat No. 1	9.34	9.01	9.60	10.56	11.77	9.03	8.74	9.19	10.13	11.53
Buckwheat No. 2 (rice)	9.42	9.18	9.59	10.59	11.79	9.03	8.77	9.16	10.11	11.47
Buckwheat No. 3 (barley)	7.42	7.30	7.44	8.26	9.43	7.28	7.28	7.51	8.20	9.49
Buckwheat No. 4	5.82	6.16	5.65	5.80	7.55	5.45	5.56	5.51	5.84	6.56
Buckwheat No. 5	5.08	5.43	4.55	4.17	4.65	4.64	4.93	4.95	5.06	5.47
Other [2]	1.80	2.04	2.45	2.45	1.98	2.86	3.09	3.43	3.22	3.16
Total buckwheat No. 1 and smaller	6.91	6.96	6.58	7.04	7.88	6.48	6.40	6.35	6.87	7.93
Total all sizes	9.46	9.13	8.91	9.48	10.51	8.51	8.08	8.15	8.78	9.91

[1] Quantity of lump included is insignificant.
[2] Includes various mixtures of buckwheat Nos. 2 to 5 and coal of relatively low dollar value.
[3] Includes Sullivan County.

Table 20.—Average value of Pennsylvania anthracite from all sources, by regions[1]

(Per short ton)

Region	1968 Shipped by rail	1968 Shipped by truck	1968 Colliery fuel	1968 Total	1969 Shipped by rail	1969 Shipped by truck	1969 Colliery fuel	1969 Total
Lehigh	$8.95	$9.21	$9.63	$9.08	$9.89	$10.89	$12.05	$10.34
Schuylkill	6.74	8.68	9.03	7.80	7.96	9.89	11.11	8.94
Wyoming[2]	10.92	8.86	1.77	9.37	11.87	9.84	10.11	10.51
Total	8.06	8.84	3.83	8.48	9.11	10.07	11.23	9.62

[1] Value given for shipments is that at which coal left possession of producing company; does not include selling expenses.
[2] Includes Sullivan County.

Table 21.—Wholesale prices of Pennsylvania anthracite, in 1969, by sizes[1]

(Per short ton)

Size	Winter	Spring discount	Summer-fall	End of year
Egg and Stove	$15.45–$15.60	$14.70–$15.60	$15.25	$15.75–$16.70
Chestnut	15.25– 15.30	14.50– 15.30	15.00	15.20– 16.40
Pea	12.25– 12.45	12.25– 12.45	12.50	12.80– 14.00
Buckwheat No. 1	11.60– 11.75	11.60– 11.95	$11.90– 12.00	12.30– 13.60
Buckwheat No. 2 (rice)	11.60– 11.75	11.60– 11.95	11.90– 12.00	12.30– 13.60
Buckwheat No. 3 (barley)	10.00– 10.25	10.00– 10.75	10.75– 11.00	11.00– 12.10

[1] As quoted in The Black Diamond Magazine. All prices are per short ton f.o.b. at mines.

Table 22.—Employment at operations producing Pennsylvania anthracite (including strip contractors) in 1969

	Lehigh region	Schuylkill region	Wyoming region[1]	Total 1969[p]	Total 1968
Average number of men working daily:					
Underground	33	848	648	1,529	1,683
In strip pits	582	722	414	1,718	1,891
At culm banks	152	261	135	548	603
At preparation plants	452	804	356	1,612	1,773
Other surface	33	261	537	831	914
Total excluding dredge operations	1,252	2,896	2,090	6,238	6,864
Dredge operations	---------	62	---------	62	68
Total	1,252	2,958	2,090	6,300	6,932
Average number of days active:					
All operations except dredges	218	222	223	221	217
Dredge operations	---------	275	---------	275	269
Average, all operations	218	223	223	221	217
Man-days of labor:					
All operations except dredges	272,925	643,412	465,595	1,381,932	1,489,314
Dredge operations	---------	17,068	---------	17,068	18,264
Total, all operations	272,925	660,480	465,595	1,399,000	1,507,578
Average tons per man-day:					
All operations except dredges	9.04	8.01	5.11	7.24	7.31
Dredge operations	---------	31.56	---------	31.56	33.18
Average, all operations	9.04	8.61	5.11	7.49	7.62

[p] Preliminary.
[1] Includes Sullivan County.

Table 23.—Employment at operations producing Pennsylvania anthracite (including strip contractors) by counties

County	1968	1969 p	County	1968	1969 p
Berks, Lancaster, Lebanon,[1] and Snyder	55	50	Northumberland	771	699
Carbon	230	208	Schuylkill	2,588	2,350
Columbia	211	195	Sullivan	14	13
Dauphin	89	82	Susquehanna	7	6
Lackawanna	433	391	Total	6,932	6,300
Luzerne	2,534	2,306			

p Preliminary.
[1] None employed in Lebanon in 1968.

Table 24.—Distribution of Pennsylvania anthracite, April 1, 1968 to March 31, 1969, by States, Provinces, and countries of destination

(Short tons)

Destination	Pea and larger: Broken and egg	Pea and larger: Stove	Pea and larger: Chestnut	Pea and larger: Pea	Pea and larger: Total	Buckwheat No. 1 and smaller: Buckwheat No. 1	Buckwheat No. 1 and smaller: Buckwheat No. 2 (Rice)	Buckwheat No. 1 and smaller: Buckwheat No. 3 (Barley)	Buckwheat No. 1 and smaller: Other	Buckwheat No. 1 and smaller: Total	Total all sizes	Percent of total
United States:												
New England States:												
Connecticut	600	8,106	11,004	359	20,069	1,063	1,983	3,706	36	6,788	26,857	0.3
Maine	-------	8,324	7,374	65	15,763	754	3,521	1	---------	4,276	20,039	.2
Massachusetts	944	24,827	16,677	2,256	44,704	7,097	13,677	6	1,053	21,833	66,537	.7
New Hampshire	57	4,765	3,862	207	8,891	2,016	2,720	---------	70	4,806	13,697	.1
Rhode Island	67	2,109	2,260	---------	4,436	---------	438	---------	40	478	4,914	.1
Vermont	28	9,544	5,986	1,621	17,179	4,207	10,922	---------	3	15,132	32,311	.3
Total	1,696	57,675	47,163	4,508	111,042	15,137	33,261	3,713	1,202	53,313	164,355	1.7
Middle Atlantic States:												
New Jersey	2,681	43,672	97,738	29,087	173,178	54,920	31,257	111,251	303,220	500,648	673,826	6.8
New York	12,165	161,118	124,303	272,241	569,827	149,848	78,274	88,330	191,791	508,243	1,078,070	11.0
Pennsylvania [1]	7,284	340,765	747,641	649,039	1,744,729	840,451	801,134	947,773	1,062,930	3,652,288	5,397,017	54.9
Total	22,130	545,555	969,682	950,367	2,487,734	1,045,219	910,665	1,147,354	1,557,941	4,661,179	7,148,913	72.7
South Atlantic States: [2]												
Delaware	1,542	11,083	11,389	4,948	28,962	1,796	528	3,022	44	5,390	34,352	.4
District of Columbia	57	3,249	3,558	332	7,196	3,616	557	---------	---------	4,173	11,369	.1
Maryland	121	17,927	11,716	719	30,483	39,306	1,523	3	153,975	194,807	225,290	2.3
Virginia	-------	3,345	955	227	4,527	127	66	5	8,624	8,822	13,349	.1
Total	1,720	35,604	27,618	6,226	71,168	44,845	2,674	3,030	162,643	213,192	284,360	2.9
Lake States:												
Illinois	-------	144	726	4,981	5,851	56,345	16,847	1,753	40,082	115,027	120,878	1.2
Indiana	-------	---------	1,526	17,335	18,861	41	151	316	120,956	121,464	140,325	1.4
Michigan	-------	796	919	54	1,769	5,616	1,194	26	86,881	93,717	95,486	1.0
Minnesota	-------	33	5	3	41	6	1	5	24,222	24,234	24,275	.2
Ohio	-------	12,530	528	79	13,137	19,520	8,534	14,417	113,314	155,785	168,922	1.7
Wisconsin	-------	3,584	4,391	207	8,182	142	1,515	36	6,478	8,171	16,353	.2
Total	-------	17,087	8,095	22,659	47,841	81,670	28,242	16,553	391,933	518,398	566,239	5.7
Other States	798	11	537	25,269	26,615	50,112	5,445	18,933	193,468	267,958	294,573	3.0
Total United States	26,344	655,932	1,053,095	1,009,029	2,744,400	1,236,983	980,287	1,189,583	2,307,187	5,714,040	8,458,440	86.0
Canada:												
Ontario	185	62,555	47,566	13,547	123,853	24,007	11,769	2,566	6,220	44,562	168,415	1.7
Quebec	85	5,720	4,646	599	11,050	19,636	25,441	81,650	28,874	155,601	166,651	1.7
Other Provinces	59	2,009	874	65	3,007	142	65	554	201	962	3,969	(3)
Total Canada	329	70,284	53,086	14,211	137,910	43,785	37,275	84,770	35,295	201,125	339,035	3.4
Other countries	232,217	465,573	250,320	12,362	960,472	20,544	46	117	58,759	79,466	1,039,938	10.6
Grand total	258,890	1,191,789	1,356,501	1,035,602	3,842,782	1,301,312	1,017,608	1,274,470	2,401,241	5,994,631	9,837,413	100.0

[1] Includes "Local Sales."
[2] Shipments to other States in the South Atlantic area are included in "Other States."
[3] Less than 0.05 percent.

Table 25.—Truck shipments of Pennsylvania anthracite in 1969, by months, and by State of destination[1]

(Thousand short tons)

Destination	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total[2]	Percent of total trucked
Pennsylvania:														
Within region	209	198	208	168	130	117	105	138	154	162	164	167	1,918	39.8
Outside region	238	234	191	175	154	182	107	144	155	200	166	207	2,151	44.6
New York	39	37	31	28	23	30	29	29	29	34	31	30	369	7.7
New Jersey	23	26	23	17	22	23	15	18	18	23	20	18	247	5.1
Delaware	3	3	2	1	1	2	1	3	2	2	2	2	22	.5
Maryland	30	10	7	6	3	5	3	3	4	7	8	7	94	1.9
District of Columbia	(3)	(3)	(3)	(3)	---	---	---	---	(3)	(3)	(3)	(3)	2	.1
Other States	2	2	1	1	1	1	(3)	1	1	2	2	2	17	.3
Total:[2] 1969	544	509	463	396	333	360	261	336	363	430	393	433	4,821	100.0
1968	620	545	470	343	394	358	319	388	365	450	449	480	5,181	100.0

[1] Compiled from reports of Pennsylvania Department of Mines and Mineral Industries; does not include dredge coal.
[2] Data may not add to totals shown because of independent rounding.
[3] Less than ½ unit.

Table 26.—Shipments of Pennsylvania anthracite, by destinations [1]

(Thousand short tons)

Destination	1965	1966	1967	1968	1969
TRUCK SHIPMENTS					
Pennsylvania:					
Within region	2,712	2,343	1,986	2,021	1,918
Outside region	3,015	2,685	2,485	2,269	2,151
New York	521	477	418	409	369
New Jersey	440	392	286	248	247
Delaware	30	26	23	26	22
Maryland	63	69	89	188	94
District of Columbia	7	8	6	2	2
Other States	24	21	20	18	17
Total [2]	6,812	6,021	5,312	5,181	4,821
RAIL SHIPMENTS					
New England States	298	221	174	163	107
New York	1,056	957	703	606	645
New Jersey	654	399	323	263	291
Pennsylvania	1,780	1,247	1,052	846	940
Delaware	6	4	5	1	(3)
Maryland	184	210	83	32	34
District of Columbia	12	9	10	9	4
Virginia	39	29	13	6	6
Ohio	142	121	85	98	215
Indiana	80	67	51	43	70
Illinois	121	103	114	108	102
Wisconsin	21	19	16	14	6
Minnesota	39	25	22	13	25
Michigan	84	54	41	42	33
Other States	272	305	244	233	312
Total United States [2]	4,788	3,768	2,936	2,476	2,792
Canada	464	434	306	308	373
Other foreign countries	1,170	741	894	697	853
Grand total [2]	6,422	4,943	4,136	3,481	4,018

[1] Compiled from reports of Pennsylvania Department of Mines and Mineral Industries; does not include dredge coal.
[2] Data may not add to totals shown because of independent rounding.
[3] Less than ½ unit.

Table 27.—Consumption of Pennsylvania anthracite in the United States, by consumer categories

(Thousand short tons)

Year	Residential and commercial heating [1]	Colliery fuel	Electric utilities [2]	Cement plants	Iron and steel industry: Coke making	Iron and steel industry: Sintering and pelletizing [3]	Other industrial [1]	Unaccounted for [1]
1965	6,628	143	2,158	269	507	966	2,071	158
1966	5,622	141	2,192	187	515	897	1,715	131
1967	5,085	143	2,186	239	528	819	1,800	50
1968	4,759	56	2,203	181	532	748	1,635	46
1969	4,209	17	1,849	213	543	623	1,355	---

[1] Estimated.
[2] Federal Power Commission.
[3] Annual Statistical Report, American Iron and Steel Institute.

Table 28.—U.S. exports of anthracite by countries and customs districts

(Thousand short tons and thousand dollars)

	1968		1969	
	Quantity	Value	Quantity	Value
COUNTRY				
Argentina	2	$33	(1)	$1
Australia	4	99	5	105
Brazil	3	73	4	197
Canada	401	4,979	473	6,117
Chile	1	13	1	17
France	(1)	6	1	14
Germany, West	(1)	1	41	423
India	(1)	1	3	36
Italy	59	585	40	419
Japan	2	24	-----	-----
Mexico	12	157	8	123
Netherlands	(1)	1	23	454
Peru	(1)	2	3	49
Philippines	1	17	1	22
Surinam	1	14	(1)	6
Venezuela	9	151	9	197
Vietnam, South	22	365	-----	-----
Yugoslavia	1	11	14	183
Other	(1)	21	1	57
Total	518	6,553	627	8,420
CUSTOMS DISTRICT				
Baltimore	1	$8	2	$78
Buffalo	137	1,982	137	2,120
Detroit	7	103	20	399
Houston	4	132	2	86
Laredo	12	157	8	123
Los Angeles	(1)	1	2	24
Mobile	1	13	(1)	4
New Orleans	-----	-----	3	75
New York City	4	49	3	78
Norfolk	1	16	2	40
Ogdensburg	54	654	68	855
Philadelphia	295	3,418	377	4,485
San Francisco	-----	-----	1	19
St. Albans	2	20	1	17
Seattle	-----	-----	1	7
Other	-----	-----	(1)	10
Total	518	6,553	627	8,420

[1] Less than ½ unit.

Note: According to the Association of American Railroads, 1,106,409 short tons was exported to Europe during 1969 compared with 880,076 tons in 1968. Of this total 1,037,470 tons was consigned to West Germany and Netherlands, including exports to the U.S. military forces. This compares with 819,824 tons in 1968.

Table 29.—World production of anthracite by countries

(Thousand short tons)

Country	1967	1968	1969 [p]
Belgium	[r] 5,459	5,409	[e] 4,630
Bulgaria	[r] 207	194	198
China, mainland [e]	19,842	22,046	22,046
France	13,263	11,688	[e] 11,795
Germany, West	12,103	11,759	[e] 10,688
Ireland	122	114	[e] 110
Japan	1,669	1,641	1,350
Korea:			
North [e]	18,739	20,393	22,156
South	13,708	11,290	11,324
Morocco	531	497	456
Netherlands [1]	4,248	7,344	6,122
Peru	[r] 14	NA	NA
Portugal	488	438	[e] 398
Rumania [e]	17	17	17
South Africa, Republic of	1,411	1,505	1,699
Spain	[r] 3,052	3,155	3,050
U.S.S.R.	85,031	85,429	[e] 85,760
United Kingdom	4,533	4,345	[e] 4,023
United States (Pennsylvania)	12,256	11,461	10,473
Vietnam, North [e]	3,086	3,307	3,307
Total	[r] 199,779	202,032	199,602

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.
[1] Less than 10 percent volatile matter.
NOTE: Insignificant quantities produced in New Zealand, South Vietnam, and possibly other countries. An undetermined amount of semi-anthracite is included in figures for some countries.

Cobalt

By Gilbert L. DeHuff [1]

The serious shortage of nickel, which resulted from protracted strikes in Canada and the United Kingdom in the last half of the year, increased demand for cobalt at a time when consumption already was at a substantially high rate. In spite of continued Government sales of surplus stockpile cobalt at the rate of 1 million pounds per quarter through September and 2 million pounds per month after that, a tightness in cobalt supply was experienced and two increases in the producer price followed.

Table 1.—Salient cobalt statistics
(Thousand pounds of contained cobalt)

	1965	1966	1967	1968	1969
United States:					
Consumption	13,595	14,205	13,976	13,000	15,390
Imports for consumption	15,408	18,823	8,215	9,068	11,975
Stocks, Dec. 31: Consumer	1,590	1,996	2,471	2,139	2,191
Price: Metal, per pound	$1.50	$1.65	$1.85	$1.85	$1.85–$2.20
World: Production	40,624	46,782	44,028	45,412	44,592

Legislation and Government Programs.—The Office of Emergency Preparedness (OEP) on March 27 revised the conventional-war stockpile objective for cobalt to 38.2 million pounds (cobalt content) from 42 million pounds.

Government sales of cobalt through September totaled 2,849,469 pounds as a result of competitive bidding on quarterly offerings of approximately 1 million pounds each. The fourth quarter offering was increased to 2 million pounds and competitive bids were opened in October. In each of the 2 following months offerings of 2 million pounds were made on an off-the-shelf basis. Sales of the three fourth-quarter offerings totaled 6,049,731 pounds. Total sales for the year were 8,899,200 pounds of cobalt metal. The sales in November and December consisted of granules only and were restricted for domestic consumption. The earlier sales comprised granules and broken cathodes, and were unrestricted except as to quantity. All metal sold was from the Defense Production Act inventory.

As of December 31, 1969, the total U.S. Government stockpile inventory was 84,289,302 pounds of cobalt. Of this quantity, 75,715,194 pounds was stockpile grade.

DOMESTIC PRODUCTION

Cobalt continued to be produced in the United States as a byproduct of iron ore mining. Further drilling in Idaho at the Blackbird cobalt-copper deposit of The Hanna Mining Co. increased reserves, and pilot plant investigation of treatment methods for the ore was completed. Evaluation of the findings continued.

[1] Physical scientist, Division of Ferrous Metals.

CONSUMPTION AND USES

Consumption of cobalt in the United States in 1969 was at a rate well in excess of that of the previous year, even before the Canadian nickel work stoppages brought an increased demand for cobalt as a partial substitute for nickel in some of the latter's uses. The most important of these uses was electroplating. The increase in consumption of cobalt in salts and driers, as reported to the Bureau of Mines and shown in tables 4 and 5, reflects this substitution. However, the data in these tables do not account for all the cobalt used for this purpose, either as salts or as metal, and the missing portion may be as much as 3 million pounds. This would put total U.S. cobalt consumption at approximately 18 million pounds for 1969.

Harshaw Chemical Co., M&T Chemicals Inc., and Udylite Corp., all important suppliers to electroplaters, provided processes wherein cobalt substituted for a large part of the nickel used in plating. Two of these processes featured anodes of 50 percent cobalt-50 percent nickel alloy used in conjunction with special plating baths.

The superalloy (Stellite, Hastelloy, etc.) operations of Union Carbide Corp. at Kokomo, Ind., were to be acquired December 31 by Cabot Corp., according to an agreement reached by the two companies.

Table 2.—Cobalt materials consumed by refiners or processors in the United States
(Thousand pounds of contained cobalt)

Form [1]	1965	1966	1967	1968	1969
Alloy and concentrate	1,188	1,214	1,168	1,184	1,004
Metal	1,669	1,699	1,618	1,831	2,819
Hydrate	32	35	18	14	25
Other	3	6	2	11	1

[1] Total consumption is not shown because some metal and hydrate originated from alloy and concentrate, and a total would involve duplication.

Table 3.—Cobalt products [1] produced and shipped by refiners and processors in the United States
(Thousand pounds)

	1968				1969			
	Production		Shipments		Production		Shipments	
	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content
Oxide	399	280	365	256	604	425	590	415
Hydrate	658	318	559	264	759	421	576	316
Salts:								
Acetate	1,480	355	1,482	355	1,490	375	1,477	372
Carbonate	524	244	556	258	1,293	574	1,270	570
Sulfate	1,166	239	1,087	226	1,976	418	1,974	418
Other	437	118	422	95	1,131	291	1,115	294
Driers	9,697	650	9,541	628	9,017	631	8,662	607
Total	14,361	2,204	14,012	2,082	16,270	3,135	15,664	2,992

[1] Figures on metal withheld to avoid disclosing individual company confidential data.

Table 4.—Cobalt consumed in the United States, by end uses
(Thousand pounds of contained cobalt)

Use	1969
Steel:	
Carbon	5
Stainless and heat-resisting	73
Alloy (excludes stainless and tool)	282
Tool	570
Cast irons	W
Superalloys	3,675
Alloys (exclude alloy steels and superalloys):	
Cutting and wear-resistant materials [1]	1,747
Welding and alloy hard-facing rods and materials	302
Magnetic alloys	2,560
Nonferrous alloys	660
Other alloys	1,108
Mill products made from metal powder	39
Chemical and ceramic uses:	
Pigments	191
Catalysts	286
Ground coat frit	133
Glass decolorizer	74
Other	5
Miscellaneous and unspecified	1,104
Total [2]	12,813
Salts and driers: Lacquers, varnishes, paints, inks, pigments, enamels, glazes, feed, electroplating, etc. (est.)	2,577
Grand total [2]	15,390

W Withheld to avoid disclosing individual company confidential data; included in "miscellaneous and unspecified."
[1] Includes cemented and sintered carbides and cast carbide dies or parts.
[2] Data may not add to totals shown because of independent rounding.

Table 5.—Cobalt consumed in the United States, by forms
(Thousand pounds of contained cobalt)

Form	1965	1966	1967	1968	1969
Metal	10,872	11,768	11,610	10,456	11,839
Oxide	961	768	654	573	646
Purchased scrap	87	48	120	145	328
Salts and driers	1,675	1,621	1,592	1,826	2,577
Total [1]	13,595	14,205	13,976	13,000	15,390

[1] Data may not add to totals shown because of independent rounding.

PRICES

The producer price for metal granules (shot) containing 99 percent or more cobalt in 500-pound kegs, and that for electrolytic cathodes (broken) containing approximately 99.9 percent cobalt in 551-pound (250-kg) drums, remained at $1.85 per pound, f.o.b. New York or Chicago, until October 20. The price for both granules and cathodes was then raised to $2 per pound, both in 551-pound drums, f.o.b. New York or Chicago. Effective November 17 this price was raised to $2.20 per pound and remained unchanged for the balance of the year.

An open market for cobalt metal developed in the last half of the year with prices reportedly as high as $3 per pound domestically and as much as $3.15 to $3.50 per pound abroad.

Prices obtained by General Services Administration in its sales of surplus Government stocks of cobalt metal by competitive bidding advanced sequentially in the following ranges: $1.634 to $1.7765, $1.644 to $1.80, $1.6153 to $1.85, and $1.84 to $2.60, per pound. The cobalt metal sold off-the-shelf in November was priced at $2 per pound of contained cobalt. The price for the December sale was $2.20. All prices were f.o.b. carrier's conveyance at Government storage locations.

FOREIGN TRADE

Exports of unwrought cobalt metal and alloys and of waste and scrap totaled 2,352,628 pounds, gross weight, with a value of $2,769,116. These exports went to 17 countries. West Germany, Japan, and the United Kingdom took the largest quantities—690,933 pounds ($410,730), 542,971 pounds ($560,276), and 455,003 ($862,804), respectively. Exports of wrought cobalt metal and alloys were 904,190 pounds, gross weight, valued at $3,182,396, which went to 29 countries. The imports of cobalt salts and compounds totaled in table 7 came from the United Kingdom and West Germany.

Table 6.—U.S. imports for consumption of cobalt metal and oxide, by countries
(Thousand pounds and thousand dollars)

Country	Metal				Oxide			
	1968		1969		1968		1969	
	Gross weight	Value	Gross weight	Value	Gross weight	Value	Gross weight	Value
Belgium-Luxembourg	3,404	$6,146	3,047	$6,001	1,184	$2,108	1,152	$1,980
Canada	1,032	1,909	814	1,505	2	5	------	------
Congo (Kinshasa)	2,649	4,630	5,832	9,937	------	------	8	16
Finland	------	------	383	724	------	------	------	------
France	776	1,418	163	340	------	------	------	------
Germany, West	23	51	12	19	------	------	15	26
Japan	8	9	5	6	(1)	(1)	(1)	(1)
Netherlands	30	32	10	11	------	------	------	------
Norway	741	1,370	1,686	3,084	------	------	------	------
Switzerland	(1)	(1)	------	------	------	------	------	------
United Kingdom	398	447	85	98	------	------	(1)	1
Western Africa, n.e.c.	158	273	------	------	------	------	------	------
Total	9,219	16,285	12,037	21,725	1,186	2,113	1,175	2,023

[1] Less than ½ unit.

Table 7.—U.S. imports for consumption of cobalt, by classes
(Thousand pounds and thousand dollars)

Year	Metal		Oxide		Salts and compounds		Total	
	Gross weight	Value	Gross weight	Value	Gross weight	Value	Gross weight	Cobalt content [e]
1967	7,946	$14,420	1,044	$1,670	167	$200	9,157	8,215
1968	9,219	16,285	1,186	2,113	107	90	10,512	9,068
1969	12,037	21,725	1,175	2,023	131	67	13,343	11,975

[e] Estimate.

WORLD REVIEW

Canada.—Although lengthy strikes at the Ontario operations of The International Nickel Company of Canada, Ltd. (Inco), and Falconbridge Nickel Mines Ltd. caused a drop in cobalt production, both companies reported an increase in cobalt deliveries. Sherritt Gordon Mines Ltd. also had lower cobalt production in 1969, even though its operations were not affected by strikes. Inco reported cobalt deliveries of 1,870,000 pounds in 1969 compared with 1,790,000 pounds in 1968. Falconbridge stated that its "cobalt deliveries rose substantially in 1969, reflecting unusually high demand for the metal." Cobalt production by Sherritt Gordon was 668,000 pounds in 1969 and 894,000 pounds in 1968; sales were 725,000 pounds and 985,000 pounds respectively. The Cobalt Refinery Division, Kam–Kotia Mines Ltd., reported 290 tons of speiss produced at its Cobalt, Ontario, smelter in 1969 compared with 551 tons in 1968. All speiss was shipped to Belgium for treatment, and an agreement was reached to continue these shipments in 1970 at improved terms.

Table 8.—World production of cobalt by countries [1]

(Short tons of contained cobalt)

Country	1967	1968	1969 p
Australia (in nickel and zinc concentrates)	164	237	e 330
Canada [2]	1,802	2,015	1,602
Congo (Kinshasa)	[3] 10,712	11,628	e 11,000
Cuba (recoverable from sulfide) e	1,150	1,400	1,700
Finland [4] e	1,984	1,875	1,800
Germany, West (metal)	973	892	e 864
Morocco (content of concentrate)	2,125	e 1,840	e 1,700
U.S.S.R. (metal) e	1,500	1,500	1,650
Zambia (cathode metal and other products)	1,604	1,319	1,650
Total [5]	22,014	22,706	22,296

e Estimate. p Preliminary.

[1] Cobalt was produced in Bulgaria, East Germany, and Poland, but production data are not available. U.S. figure is withheld to avoid disclosing individual company confidential data. Cobaltous pyrite concentrates continued to be produced and stockpiled in Uganda.

[2] Cobalt in all forms. Excludes the cobalt content of nickel-oxide sinter shipped to the United Kingdom by International Nickel, but includes the cobalt content of Falconbridge shipments of nickel-copper matte to Norway.

[3] Includes 7,126 short tons in cathodes and 3,586 short tons in granules.

[4] Content of cobaltous sulfides.

[5] Total is of listed figures only.

Congo (Kinshasa).—Union Minière S.A. reported that agreement had been reached with the Congo (Kinshasa) Government giving the company satisfactory compensation for the nationalization of its properties, which occurred at the beginning of 1967. The agreement was part of a 25-year extension of the technical cooperation agreement signed in 1967 between the company's affiliate, Société Générale des Minerais (SGM), and the Government company, La Générale Congolais des Minerais (GECOMIN).

Finland.—Outokumpu Oy used Sherritt Gordon's hydrogen reduction process at Kokkola to recover cobalt metal from cobalt sulfate solution as powder or briquets analyzing 99.8 plus percent cobalt. The raw materials for the plant consisted of pyrite concentrate, from the Outokumpu mine, containing nickel, copper, zinc, and approximately 0.7 percent cobalt, and dead-roasted calcine having a cobalt content of 0.8 to 0.9 percent cobalt.[2] Cobalt metal production was 858 short tons in 1969, compared with 557 tons in 1968. There were 234 tons of cobalt hydroxide produced in 1969.

Japan.—Because of the shortage of cobalt, SGM notified Japanese consumers in December that its shipments to them would be reduced by half.

Morocco.—Concentrates from the Bou Azzer mine, Morocco's only cobalt producer, have been exported to France, Belgium, and China.[3] Depletion of reserves suggested that the mine would close by the end of the year or in 1971 at the latest.

Uganda.—Kilembe Mines Ltd., a subsidiary of Kilembe Copper Cobalt Ltd., which is in turn a subsidiary of Falconbridge Nickel Mines Ltd., announced that it planned to build a plant to produce annually 1,000 tons of a cobalt compound at its copper property at Kilembe in western Uganda. Construction was to start by mid-1970 and be completed by the end of 1971. The cobalt will be extracted from pyrite concentrates that are being produced at a rate of 7,000 tons per month. In addition, stocks have accumulated since copper recovery began in 1956. The cobalt compound will be shipped to Norway for further treatment at the Norwegian refinery of Falconbridge.

Zambia.—Roan Selection Trust Ltd. and Rhokana Corporation Ltd. approved the main terms of agreement with the Zambian Government whereby the latter, through the Industrial Development Corporation of Zambia (INDECO), would acquire a 51-percent interest in the mining, smelting, and refining operations of the companies on January 1, 1970. Production and shipment of cobalt cathodes by Rhokana Corporation in the fiscal year ended June 30, 1969, constituted a record production of 1,817 short tons at an overall recovery of 69.1 percent, compared with 1,499 tons at 66.2 percent in 1968. At the Chibuluma mine of Roan Selection Trust

[2] Metal Bullentin (London). No. 5408, June 20, 1969, pp. 24–25.

[3] Mining Journal (London). V. 272, No. 6971, Mar. 28, 1969, p. 253.

in the same fiscal year, a total of 34,620 short tons of cobalt-copper concentrate was produced, of which 8,765 tons was sold and 14,103 tons was treated for extraction of copper and the precipitation of cobalt hydroxide. A plant to make cobalt hydroxide from Chibuluma concentrate was built at Chambishi and integrated with the existing roast-leach-electrowinning plant. Precipitation of the hydroxide began towards the end of the fiscal year, and samples were sent to prospective customers. Ore reserves remaining at the Chibuluma and Chibuluma West mines as of June 30, 1969, were estimated at 6,354,000 tons averaging 5.12 percent copper and 0.21 percent cobalt, without allowance for dilution in mining. Ore production during the fiscal year totaled 768,480 tons containing 4.10 percent copper and 0.16 percent cobalt. Ore-reserve estimates for the Baluba project were reduced to 65,800,000 short tons at 2.71 percent total copper and 0.17 percent cobalt. Metallurgical tests of the Baluba ore gave satisfactory results for copper, but cobalt recovery at a satisfactory grade of concentrate was disappointing. The tests were continuing.

TECHNOLOGY

The Bureau of Mines developed a chemical process in the laboratory for separate recovery of cobalt, nickel, chromium, and molybdenum from complex cobalt-base and nickel-base superalloy scrap. The procedure consisted essentially of the following steps: Scrap preparation by screening, magnetic separation, and burning; leaching with hot chlorinated dilute hydrochloric acid; removal of tungsten and silica from the leach liquor by carbon adsorption; successive solvent extraction of molybdenum, iron, and cobalt with manganese; selective precipitation of manganese dioxide from the cobalt strip liquor using soda ash and chlorine; precipitation of cobalt carbonate with soda ash followed by calcination to metallurgical-grade cobalt oxide. Chromium basic sulfate and metallurgical-grade nickel oxide products were obtained in subsequent steps. Cobalt recovery of 95 percent was obtained in the laboratory from the waste derived from dry-grinding nickel-base superalloy billets. The cobalt oxide product analyzed 73 percent cobalt, 1.2 percent sodium, 0.2 percent nickel, 0.04 percent sulfur, and 0.01 percent chlorine.[4]

In other Bureau work, a new method was developed for reclaiming refractory carbides and cobalt from cemented-carbide scrap. Molten zinc is used to form an alloy with the cobalt binder and thereby break up the cemented carbide. The zinc is recovered from the alloy by distillation, and more than 98 percent of the cobalt can be recovered to use again as a carbide binder.[5]

Rare-earth-rich cobalt alloys were produced in a Bureau laboratory from relatively inexpensive rare-earth oxides by electrodeposition of the rare-earth metals on a consumable cobalt cathode. The electrolytes were lithium fluoride and the respective rare-earth fluorides, except that the electrolyte for preparing cobalt-didymium alloy also contained barium fluoride. By the addition of more cobalt upon melting, compounds suitable for the production of high-strength, fine-particle, permanent magnets can be obtained.[6]

During the year, there was considerable activity in the study and development of cobalt heat-resisting alloys, permanent magnet materials, and high-strength steels and alloys.[7]

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[4] Brooks, P. T., G. M. Potter, and D. A. Martin. Chemical Reclaiming of Superalloy Scrap. BuMines Rept. of Inv. 7316, 1969, 28 pp.

[5] Barnard, P. G., A. G. Starliper, and H. Kenworthy. Reclaiming Refractory Carbides and Cobalt From Cemented-Carbide Scrap. Secondary Raw Materials, v. 7, No. 9, September 1969, pp. 19–21.

[6] Morrice, E., E. S. Shedd, M. M. Wong, and T. A. Henrie. Preparation of Cobalt Rare-Earth Alloys by Electrolysis. J. Metals, v. 21, No. 1, January 1969, pp. 34–37.

[7] Cobalt—A Quarterly Publication on Cobalt and Its Uses. Cobalt Information Center, Battelle Memorial Institute, Columbus, Ohio, No. 46, March 1970, 56 pp.

Coke and Coal Chemicals

By Carl W. Kelley[1]

Coke production in the United States totaled 64.8 million tons in 1969, up slightly from the 63.7 million tons produced in 1968. The increase was due to an increase in oven coke production in 1969. Oven plant production was 64.0 million tons or 1.9 percent above the 1968 output of 62.9 million tons. Production of beehive coke in 1969 totaled 710,000 tons, 8.4 percent less than the 775,000 tons produced in 1968.

Although coke production increased 1.1 million tons in 1969, pig iron production increased 1.7 million tons. Less coke was required at blast furnaces as the coke rate, the amount of coke required to produce 1 ton of pig iron, fell from 1,263.4 pounds in 1968 to 1,260.4 pounds in 1969.

Coke demand exceeded production throughout the year. At the beginning of 1969 stocks were 6.0 million tons and declined to 3.1 million tons by yearend 1969. This supply was equivalent to 17.1 days' production at the December rate of output.

Blast furnaces continued to use the bulk of the Nation's coke production, receiving 91.1 percent of total shipments from producers. The remaining coke was consumed principally in foundries and miscellaneous industrial plants. A very small quantity was sold for residential heating. This latter market is rapidly declining and is expected to be nonexistent within the next few years.

Breeze production in 1969 was 4.4 million tons compared with 4.1 million tons in 1968. Breeze is primarily used by integrated coke producers for sintering iron ore and for raising steam; it is suitable for most metallurgical applications because of its size and high ash content. However, about one-third of the 1969 output was sold for use mainly as a reductant in electric furnaces that smelt phosphate rock to produce elemental phosphorus. Sales of breeze were 12.8 percent higher than in 1968.

Coal costs at coking plants in 1969 were on the average 41 cents more per ton than in 1968. Coal cost at plants increased in most States, but averaged lower in California, Colorado, and Utah. Delivered prices of coal to oven coke plants ranged from $8.28 to $13.66 per ton. The average value of bituminous coking coal at slot ovens was $10.41 and at beehive ovens was $6.24. West Virginia, Pennsylvania, and Kentucky continued to be the main suppliers of coal to coke plants. Shipments from these States were 72.4 million tons or 79 percent of total coking coal shipments in 1969.

Production of coal chemicals normally parallels oven-coke output, and this was true of all primary coal chemicals in 1969. Production of tar, light oil, and coke-oven gas registered increases ranging between 1 and 8 percent over the quantities produced in 1968. Yields of coke-oven gas and light oil increased in 1969, whereas those of ammonias and tar decreased. Processing of crude tar and crude light oil for the production of various tar and light oil derivatives is an integral part of coke oven operations at many plants. There was no change in the number of producers processing crude tar, and about the same percentage of tar was processed in 1969 as in 1968. With crude light oil, however, the greatest proportion of the output was sold for processing outside the producing plants. This marked change in the processing or refining of crude light oil started in the early 1960's, when a few of the producing plants started to sell their output because their processing equipment was not able to produce the high-purity derivatives required by some of the large markets.

Price quotations on oven foundry coke as published in various trade journals in-

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[1] Chemist, Division of Fossil Fuels.

Table 1.—Salient coke statistics

	1965	1966	1967	1968	1969
United States:					
Production:					
Oven coke_____thousand short tons__	65,198	65,959	63,775	62,878	64,047
Beehive coke________________do____	1,657	1,442	806	775	710
Total [1]___________________do____	66,854	67,402	64,580	63,653	64,757
Exports_________________________do____	834	1,066	710	792	1,629
Imports_________________________do____	90	96	92	94	173
Producers' stocks, Dec. 31_________do____	2,703	3,079	5,468	5,985	3,120
Consumption, apparent___________do____	65,379	66,019	61,572	62,438	60,436
Value of coal-chemical materials used or sold_____________________thousands__	$311,407	$309,143	$292,579	$282,922	$288,963
Value of coke and breeze used or sold thousands__	1,118,070	1,166,663	1,107,144	1,175,503	1,402,716
Total value of all products used or sold thousands__	1,429,477	1,475,806	1,399,723	1,458,425	1,691,679
World production:					
Hard coke_________thousand short tons__	342,039	342,194	334,970	346,826	333,747
Gashouse and low-temperature coke thousand short tons__	38,413	37,043	34,273	31,438	29,873

[1] Data may not add to totals shown because of independent rounding.

creased $3.00 per ton during 1969. Beehive coke prices at some locations increased $5.40 per ton. Prices on coal-chemical materials changed only slightly during the year. There was a $2.25 per ton drop in ammonium sulfate, but naphtha prices increased approximately 3 cents per pound. Prices on the principal light oil derivative benzene remained about the same. Toluene prices increased approximately 8 cents per gallon.

Foreign trade in coke was relatively small, but exports were more than 100 percent greater than in 1968. This was due entirely to the almost doubling of exports to Mexico. Imports were insignificant and only about one-tenth as large as exports.

The total value of all coals carbonized was $968 million, and the total value of carbonization products was $1,648 million or 70.2 percent more than the value of the coal. The value of coke and breeze represented 84.4 percent of the value of all coke oven products.

COKE AND BREEZE

DOMESTIC PRODUCTION

Production of coke, which had been decreasing in the second half of 1968, increased in the first half of 1969. From January through June, daily average output ranged between 168,000 and 180,000 tons. The daily average output of coke dropped during the next 3 months but turned upward in October and reached 182,000 tons in December.

The terms "merchant" and "furnace" in this report apply only to oven-coke plants. Furnace plants are owned by, or affiliated with, iron and steel companies that produce coke mainly for use in their own blast furnaces. Merchant plants include those that manufacture metallurgical, industrial, and residential-heating grades of coke for sale on the open market; those associated with chemical companies or gas utilities; and those affiliated with local ironworks that consume only a small part of their output in affiliated blast furnaces. Both merchant and furnace plants shared in the increased output primarily because of demands from all markets. Oven-coke output supplied by merchant plants increased in 1969, their share of the output amounting to less than 10 percent. Tables 6 and 7 show production of oven coke by merchant and furnace plants in 1969.

Coke was produced in 19 States in 1969, with 93 percent manufactured in 14 States east of the Mississippi River. Since the nationwide pattern of supply has not changed to any marked degree in the past decade, the relative proportions supplied by the individual States have remained relatively static. The bulk of coke output in 1969, as always, was centered in the highly industrialized States which use coke as blast-furnace fuel for ironmaking. Pennsylvania continued to be the largest producer;

its oven- and beehive-coke output was nearly 30 percent of the U.S. total.

Breeze is the small sizes of coke that result from screening and, although there is no designated size, usually includes the coke that passes through a ½-inch screen, or in a few instances, a ⅝-inch screen. In past years, this material, which generally has a higher ash and moisture content than the large sizes, has been used principally as boiler fuel at producing plants. Although about 12 percent of that produced is still used for this purpose by producers, usage has changed considerably in the past decade, and 40 percent of the production in 1969 was used by integrated producers for sintering iron ores.

The yield of breeze at oven-coke plants ranged between 7 percent for plants in Minnesota and Wisconsin to 3.2 percent for plants in Pennsylvania but averaged 4.8 percent for the industry. Most beehive plants do not recover breeze, but the average yield for the plants that did report production was 8.4 percent.

Table 9 shows the production and disposal of breeze in 1969 by State; table 10 shows the quantities of breeze used by producers according to major end use and the quantities and values of the breeze sold in 1969 and in prior years and base periods.

CONSUMPTION AND SALES

The United States consumed 60.4 million short tones of coke in 1969. This apparent consumption, (total production plus imports, minus exports and changes in producers' stocks) was 3.2 percent less than in 1968 and 1.8 percent less than in 1967 and 23 percent less than the record high of 1951.

Although total apparent coke consumption decreased 2,002,000 tons in 1969, blast furnace consumption of coke increased 3,938,000 tons compared with that in 1968. Pig iron production, however, was 6.2 million tons higher in 1969 than in 1968. Blast furnaces required 27 pounds less coke in 1969 than in 1968 to produce 1 ton of pig iron. This improvement in the coke rate, which has occurred each year since 1951 with the exception of 1965, is the largest single factor in the general decline in coke consumption in recent years. The continuing downward trend in coke rates is attributed mainly to improved burdens (coke and iron ore) and advanced operating techniques, such as higher blast temperatures, fuel injection, and oxygen enrichment of the blast. The effect of these technologic improvements on the coke industry can be illustrated as follows: If blast furnaces operated in 1969 at 1951 rates, the 95 million tons of pig iron and ferroalloys produced in 1969 would have required 85.7 million tons of coke rather than the 57.3 million tons actually consumed.

All other consuming groups used more coke in 1969. Sales to all other industrial plants increased more than sales to other categories, nearly 27 percent. Sales to the residential heating market decreased again in 1969; fuel oil and natural gas have virtually replaced coke for this purpose, and the quantity of coke so used will soon be negligible.

Data on coke consumption are shown in table 11; data on coke rates are shown in table 12.

Tables 13 and 14 summarize, by major end use, the disposal of oven and beehive coke in 1969. Furnace oven-coke plants supplied 90 percent of the 67.8 million tons of oven and beehive coke distributed. Ninety-eight percent of the coke distributed by furnace plants was consumed in integrated and affiliated blast furnaces. An additional 0.5 percent was used for other purposes, and the remaining 1½ percent was marketed, chiefly to blast furnaces and other industrial plants, but small quantities also went to foundries and for residential heating.

Merchant coke plants distributed nearly 6 million tons of coke in 1969, 95 percent of which was placed on the commercial market. Principal markets were blast-furnace operations without coke facilities, independent gray-iron foundries, nonferrous smelters, and chemical plants. Of the 5.9 million tons of oven coke sold by merchant plants in 1969, 39 percent was shipped to blast furnaces, 46 percent to foundries, and 14 percent to other industrial plants; the remaining 1 percent was sold for residential heating. Only 3 percent of the total coke distributed by merchant plants was retained for use by the producers.

Less than 1 percent of the coke distributed in 1969 came from beehive plants. Seventy-eight percent of the beehive shipments went for use in blast furnaces. Most of the remainder went to other industrial plants. These were mainly chemical plants that used the coke to produce calcium carbide and elemental phosphorus. Minor quantities were used also in foundries and for residential heating. Coke was produced in or received by all States except Alaska, Hawaii, and the District of Columbia in 1969. A total of 66.8 million tons of coke was distributed domestically. This was approximately 4.9 million tons higher than shipments in 1968. Shipments to blast furnaces rose by 4.5 million tons, and shipments to foundries and to all other industrial plants increased by more than 743,000 tons.

Nineteen States consumed 60.9 million tons of blast-furnace coke. Pennsylvania, Ohio, Indiana, Illinois, Michigan, New York, Maryland, Alabama, and West Virginia together received 90 percent of the total. Most blast-furnace installations are integrated with coke ovens, and blast-furnace coke generally moves only short distances, usually by conveyor belt or company railroad within the producing establishment. Coke so restricted in its movement accounted for 90 percent of the blast-furnace distribution. The remaining 10 percent was shipped out of the producing State, mainly to affiliated blast furnaces in nearby States.

The chief recipients of foundry-coke shipments were the automotive, farm-machinery, machine-tool, heavy-machinery, railroad, and electrical-equipment industries. Most of these industries are concentrated in the East and Midwest. To reach these markets, foundry coke generally must be shipped long distances by rail. In 1969, the combined consumption of Michigan, Ohio, Alabama, Pennsylvania, Illinois, Indiana, Wisconsin, and New York accounted for 76 percent of the foundry-coke shipments. Lesser quantities were sent to 37 other States.

Less than 5 percent of the total coke distributed was utilized for miscellaneous industrial applications by among others, nonferrous smelters, alkali plants, and chemical plants that manufacture calcium carbide and elemental phosphorus. Leading consumers of this classification of coke were, in the order named, Pennsylvania, Ohio, Minnesota, Michigan, and Idaho. Together, these 5 States consumed nearly two-thirds of the total other-industrial markets.

The quantity of coke used for residential heating in 1969 declined 23 percent from the 1968 level. Although 22 States used coke for this purpose, the quantity sent to each was so small that the total distributed was only 48,000 tons. Eleven States consumed less than 500 tons each, and only three States used more than 5,000 tons. Distribution of oven and beehive coke and breeze, by major end use and final destination, are shown in table 15.

STOCKS

Coke stockpiled at producers' plants decreased in quantity in 1969. Stocks on hand at the close of the year fell below those of December 31, 1968, by nearly 48 percent and the 3.1 million tons of coke on hand at the end of the year represented an alltime low. Data on stocks are shown in tables 16 and 17.

Furnace plants ended the year with 3.0 million tons of coke on hand. Merchant plants had coke stocks of 99,000 tons. In terms of days supply, furnace plants had a supply equivalent to 19 days production at the December rate, while merchant plants had 6 days' production. Stocks at merchant plants were composed of 2 percent blast-furnace coke; 69 percent foundry coke; and 29 percent other grades.

Stocks of coke at beehive plants were insignificant and varied only slightly from those in the preceding year.

Coke breeze stocks were almost identical to those of 1968. Producers had a 274,000 ton supply at merchant plants and 806,000 tons at furnace plants.

VALUE AND PRICE

Average receipts for commercial sales f.o.b. plant of the different grades of coke as reported by producers are shown in table 18. Receipts for sales of oven coke in 1969 averaged $24.50 per ton, an increase of $2.50. The average value of blast-furnace plant receipts increased $2.74 per ton. Foundry prices were on the average $2.86 higher, and residential heating prices increased $.71 per ton. Receipts for total beehive-coke sales were $1.23 above those of 1968.

The large variance in price for blast-furnace and foundry oven coke was attributed principally to the lower yields obtained in producing foundry coke, and to larger minimum sizes required to meet foundry coke specifications. The differences in f.o.b. prices of oven and beehive foundry coke were due largely to transportation costs for coal and/or coke.

FOREIGN TRADE

U.S. exports of coke increased over 100 percent from those of the preceding year. This increase was the result of the amount of coke shipped to Mexico, Rumania, Netherlands, and Venezuela. Mexico remained the leading export market, absorbing nearly 38 percent of the foreign consumption of U.S. coke. The combined total of shipments to Mexico, Canada, Rumania, Netherlands, and Venezuela accounted for 88 percent of total coke exports.

More than three-fourths of the coke exports were through the Detroit, Mich., Mobile, Ala., Baltimore, Md., and Laredo, Tex. customs districts. Each of these ports handled well in excess of 100,000 tons. Table 19 shows exports of coke by country and customs district for 1967, 1968, and 1969. The quantity shown is substantially larger than that reported by producers and shown in table 15, because there were additional shipments to foreign countries by export firms.

The United States imported 173,000 tons of coke. Almost twice this amount was produced domestically in a single day. This imported coke had a negligible bearing on the general nationwide market and was significant only in certain local areas, such as the Northwest, which are far removed from sources of coke production.

Ninety-eight percent of the coke imported for consumption in 1969 originated in Canada and was produced in the Province of British Columbia. This coke was used mainly in nonferrous smelters and enters the United States through the Great Falls, Mont., customs district. One and one-half percent of the imported coke came from West Germany, and the remaining ½ percent from France, the Netherlands, and Japan.

Table 20 shows imports of coke for 1969 and the two immediately preceding years, by country and customs district.

WORLD PRODUCTION

World production of metallurgical coke in 1969 was estimated at 334 million tons, an apparent decrease of 3.8 percent from the 1968 output. This decrease, however, is attributable entirely to the exclusion of the coke production of 10 countries for which data were not available.

Europe maintained the lead in world production with 78 percent of the output. This share would be higher if data for Belgium and France were available. These countries combined produced 21 million tons of coke in 1968.

Output of coke and breeze in the Soviet Union, the world's largest producer, was estimated at 81 million tons, about one-third of the European total and nearly one-fourth of the world output. This was an increase of 3 percent over the 1968 production and a record output for the U.S.S.R. Although Soviet production exceeds that of the United States, the actual difference in outputs of the two countries was 11.8 million tons rather than 16.2 million tons as reflected in table 21, because the U.S. production figure does not include 4.4 million tons of breeze produced in 1969.

The United States with 18 percent of the world output ranked second and West Germany, with 10 percent, ranked third. The United States had a 1.7 percent production increase, while West Germany's output was nearly 9 percent below that of 1968.

Other leading coke-producing countries in order of output were Japan, mainland China, United Kingdom and Poland. The greatest production increases of 19, 13, and 12 percent, repectively, were recorded in Japan, mainland China, and North Korea. Production in other countries did not change appreciably.

COAL CHEMICALS

The term "coal chemicals" refers to the chemical materials recovered from the volatile matter released during carbonization. Normally, three basic materials—ammonia, tar, and light oil—are recovered at oven-coke plants through a series of complex condensation and absorption processes. The remaining material, which is rich in hydrogen and methane, is called coke-oven gas. Except for ammonia, which is recovered as an aqueous solution or converted to a salt and sold as produced, the basic materials are in most instances further processed to yield a number of primary organic chemicals or chemical mixtures of which the most important are benzene, toluene, xylene, solvent naphtha, crude chemical oil, creosote oil, pitch, and pyridine. Although most oven-coke plants in the United States are equipped to process tar and light oil the extent to which individual plants produce the various products depends upon economic conditions and a number of other factors.

Yields of the basic, as well as the primary, chemicals vary somewhat with the kind of coals carbonized, carbonizing temperatures, and operating techniques and equipment, but approximately 315 pounds of coke-oven gas, 90 pounds of tar, 20 pounds of light oil, and 5 pounds of ammonia are recovered for each ton of coal carbonized. In standard units of measure these quantities amount to about 10,500 cubic feet of coke-oven gas, 10 gallons of tar and 3 gallons of light oil. Ammonia is recovered as ammonium sulfate at most operations, and the yield per ton of coal is approximately 20 pounds. Data on production and sales of basic chemical materials and derivatives at oven-coke plants in 1969 are shown in table 33.

Table 34 shows the heating value and coal equivalent of products other than coke produced at oven-coke plants. Although the quantities vary from year to year, most of the changes were due to differences in the amount of coal carbonized, rather than the fluctuations in yields. In terms of heating value, the products, not including coke, recovered in 1969, were roughly equivalent to the heating value of about one-fourth of the coal carbonized in slot ovens. Table 35 shows average values for the chemicals and surplus gas used and sold, compared with the unit values of the coke and breeze produced, from each ton of coal carbonized.

COKE-OVEN GAS

Coke-oven gas is one of the primary coproducts recovered in the carbonization of coal in slot ovens. After tar, ammonia, and light oil have been removed from the gaseous streams, coke-oven gas remains as the final product. Because it has a high calorific value producers use most of it as fuel for heating coke ovens and other steel-and allied-plant furnaces. Small quantities are also sold for distribution through city mains and other industrial uses.

Generally, between 9,300 and 11,000 cubic feet of gas is produced for each ton of coal carbonized at high temperatures in slot ovens. This equals from 14 to 16 percent of the weight of the coals. In 1969, the yield of gas was 10,480 cubic feet per ton of coal, an increase of 2.2 percent from the 1968 yield.

About 36 percent of the output was used at the plants to heat coke ovens. Gas used otherwise is called surplus gas and was used by producers to fire boilers, transferred to steel or allied plants to heat open-hearth and other metallurgical furnaces, sold for industrial use or distributed through city mains. A small part of the production was wasted, because storage facilities at most plants are limited and the gas was burned in the atmosphere when production exceeded demand.

Furnace plants consumed almost all of their own surplus gas, mostly in steel and allied plants. Only 2.1 percent of the surplus gas at merchant plants was used by the producers. The rest, except for the small amount wasted, was sold commercially for distribution through city mains and for industrial use. The bulk of the furnace-plant gas sales were to industrial plants. Table 39 shows the quantities of various gases used to heat ovens in each State and the total gas consumption in terms of coke-oven gas equivalent. Coke-oven gas was the principal fuel used for heating slot ovens, but blast-furnace gas, a mixture of coke-oven and blast-furnace gases, and natural gas were also used. Over 450 billion cubic feet of coke-oven gas equivalent was so consumed, of which 77 percent was coke-oven gas; 22 percent was blast-furnace gas; and the remainder was natural gas and producer gas.

Surplus coke-oven gas used and sold in 1969 was valued at $138 million. This is a 3.3 percent increase from the 1968 value. No value is reported by producers for coke-oven gas used to heat coke ovens, but applying the average value of $0.232 per thousand cubic feet reported for surplus gas to the gas used for underfiring, the total value of all coke-oven gas used and sold in 1969 would be $219 million. This value is equivalent to nearly one-fourth the total value of the coal carbonized.

COKE-OVEN AMMONIA

Coal carbonized at high temperatures releases nitrogen, which oven-coke operators recover as either ammonia liquor, a weak solution of ammonia (about 7 grams per liter of solution), or as a crystallized solid (ammonium sulfate and diammonium and monoammonium phosphate). This ammonia must be removed prior to further processing of the gas, because it would otherwise form corrosive salts which would damage equipment or, if released as a waste material, would create stream pollution problems.

Most of the coke-oven ammonia is reacted with sulfuric acid to form ammonium sulfate. In 1969, 55 plants used 92 percent of the total ammonia recovered to produce 638,000 tons of ammonium sulfate, and another 5 percent was treated with phosphoric acid to produce 38,000 tons of diammonium phosphate at three plants. Eight plants recovered ammonia liquor, and six recovered no ammonia products at all.

Table 40 shows production and sales of ammonia products and yields in 1969 in terms of sulfate equivalent. Compared with 1968 the yield of ammonia declined 5 percent, and total output also fell 4 percent.

Sales of ammonium sulfate decreased 8 percent and ammonia liquor sales were about the same as in 1968. The average value per ton, f.o.b. plant, of ammonium sulfate decreased $2.22 per ton to $18.72 and the average plant values of diammonium phosphate and ammonia liquor decreased $9.72 per ton and increased $2.99 per ton, respectively. The total value of all ammonia products sold was $15 million, equivalent to 5.3 percent of the total value of all coal-chemical materials sold.

COAL TAR AND DERIVATIVES

Crude coal tar is a black, viscous mixture of complex organic compounds that condense from the volatile matter when it is cooled. Most of the tar is recovered in collecting mains at the ovens when the gas is cooled by spraying with ammonia liquor; the remainder is recovered principally from the primary coolers when the gas undergoes further cooling.

All oven-coke plants produce tar. However, yields of tar vary widely among plants; in 1969 they ranged from 6.28 to 9.82 gallons per ton of coal carbonized, and averaged 8.33 gallons. Generally, from 4 to 5 percent of the weight of the coals carbonized is recovered as tar. High-volatile coals evolve a larger percentage of tar; hence, California, Colorado, Utah, West Virginia, and Pennsylvania, which used the most high-volatile coal in their blends, had the highest tar yields. Conversely plants using higher percentages of low- and medium-volatile coals and anthracite, such as those mainly producing foundry coke, had the lowest yields.

Production of coal tar at oven-coke plants in 1969 increased 1 percent from 1968 principally because more coal was carbonized. The average yield of tar decreased slightly, 8.33 gallons per ton of coal as compared with the yield of 8.45 gallons in 1968. Table 41 shows the quantities of tar produced, used by producers, sold, and in stock in the various States at the end of 1969.

Coke-plant operators used 49.6 percent of the tar produced in 1969. Of this quantity, 74.1 percent was processed (refined or "topped"), 25.7 percent underwent no processing and was burned for fuel, and less than 1 percent was used for miscellaneous purposes, such as tarring ingots, road materials, and tar paints. The remaining 50.4 percent of the production was sold, principally to tar-distilling plants which refined it to produce many tar derivatives.

Of the 13 coke plants that processed tar in 1969, seven topped their tar. In so doing, the low-boiling distillate fraction, consisting mainly of tar acids, bases, and naphthalenes is separated from the crude tar. The residue, or soft pitch, is usually burned as fuel. Furnace plants in particular benefit from this procedure, because they can sell the distillate and retain the pitch for use as fuel in open-hearth furnaces. This reduces the amount of other fuels that normally have to be purchased. However, the relative quantities of tar topped and burned, as well as the quantities sold, depend upon a number of economic factors, such as the availability and current market prices of tar, tar distillates, and other substitute fuels. All of the merchant-plant tar production was sold, because these plants have no use for the pitch which makes up the bulk of the products recovered through topping.

The majority of the plants that processed tar in 1969 recovered only crude chemical oil and a residual tar or soft pitch. However, some of the larger plants recovered a number of tar derivatives, including creosote oil, cresylic acid, cresols, naphthalene, phenol, pyridine, and medium and hard pitch. Statistics on some of these products could not be shown in this report, but the data were transmitted to the U.S. Tariff Commission, which published them, along with similar data from tar distillers and petroleum refiners, in monthly and annual reports on synthetic organic chemicals.

CRUDE LIGHT OIL AND DERIVATIVES

Light oil is a light-colored liquid composed of a number of aromatic hydrocarbons, that is extracted from the gas after tar, ammonia, and, in some instances, naphthalene, have been removed. Crude tar also contains a small amount of light oil, but this usually is not recovered by coke plants. Virtually all light oil produced at coke plants is recovered by an absorption process in which the gas is sprayed with a higher boiling petroleum oil as the gas stream is channeled through absorption towers. After recovery, light oil is separated from the absorption oil by direct steam distillation. Approximately 3 gallons of light oil, equal to 1 percent of the weight of the coal, is recovered for each ton of coal carbonized. Yields vary, of course, with the kind of coals carbonized and with operating conditions, but an average of 2.87 gallons of light oil was recovered at the plants that extracted light oil in 1969. Most plants recover light oil, but a few plants which find it uneconomical to remove the light oil, leave it in the gas to be burned as fuel. Yields per ton of coal decreased 0.87 gallon at merchant plants, but increased by three-tenths of a gallon at furnace plants.

Producers sold 51 percent of their output in 1969. The large increase in light-oil sales in recent years is attributed principally to the inability of some plants to produce derivatives, particularly benzene, that meet the more rigid specifications established for these products. Such plants sell light oil to petroleum-refining companies which process it along with petroleum fractions into benzene and a number of other chemical intermediates. Data on light oil and total derived products produced and sold in the various States are shown in table 42.

In the older light-oil-refining facilities at coke plants, light oil is refined by fractional distillation at atmospheric pressures, but in plants built in recent years, catalytic-pressure refining is employed to produce benzene, toluene, xylene, and solvent naphtha. As with other coal-chemical materials, yields vary somewhat, but approximately 85 percent of the light oil processed is recovered as salable products. Average yields of light-oil derivatives decreased in 1969. Average yields for 1969 and prior years are shown in table 43.

Table 44 shows the quantities of the various grades of benzene and toluene produced at coke plants, while table 45 shows the principal light-oil derivatives produced and sold and yields of the various products by State.

COKING COALS

QUANTITY AND VALUE OF COAL CARBONIZED

The carbonization of bituminous coal for coke production is currently the second largest end use of this fuel. Only electric utilities, whose annual consumption of bituminous coal generally absorbs about half of the production, ranks higher in usage. In 1969, coke producers charged 93 million tons of bitumious coal, one-sixth of the total bituminous coal produced, into coke ovens. An additional 542,000 tons of anthracite was blended with bituminous coal at oven-coke plants and carbonized, chiefly to produce foundry coke.

The average value per ton for all coals carbonized at oven-coke plants was $10.42 compared with an average value of $6.24 per ton for the coal carbonized at beehive ovens. The difference in value was attributed mainly to transportation charges for coal shipped to oven plants, as virtually all beehive plants are located at the mines where they obtain their coal. In some instances transportation charges exceed the value of the coal at the mine, and this partially accounts for the high values of coals used at plants in the Western States, most of which receive shipments of low-volatile coals from the East.

The overall average value per ton of the coals carbonized at both oven- and beehive-coke plants was 41 cents more than in 1968.

An overall average of 1.44 tons of coal, valued at $15.01, was required for each ton of oven coke produced in 1969. Beehive ovens required an average of 1.63 tons of coal per ton of coke production, but coal costs averaged only $10.18 per ton of coke because of the lower value of the coal delivered to beehive ovens.

Tables 22–25 present data on the coals carbonized at oven and beehive plants.

BLENDING

The production of high-quality coke requires the use of coal with certain special characteristics. Since all of the desired properties are not inherent in an individual coal, it becomes necessary to blend coals, exploiting the most favorable traits of each in a carefully balanced mixture. Thus, coals are selected and combined in order to improve the chemical and physical properties of the coke, control the pressure developed in slot ovens during carbonization, regulate the yield of products, and broaden the use of inferior coals. The usual procedure followed is to blend relatively small proportions of low-volatile coal with high-volatile coal. The exclusive use of high-volatile coals would result in a weaker coke and lower yields. The addition of low-volatile coals improves the yield and the physical structure of the coke. However, the proportions of low-volatile coals used must be restricted, because they are highly expanding and, if used alone or in large proportions in the coal mix, would damage the oven walls when coke was discharged from the ovens. Some plants add medium-volatile coals or other materials, such as anthracite or coal-tar pitch, to their high- and low-volatile coals. The addition of medium-volatile coals can regulate the volatile matter in a mix to the desired content, while anthracite and coal-tar pitch are used to impart special properties to the resulting coke.

Some coals are unsuitable for the production of coke, because they contain excessive amounts of sulfur. These coals still may be utilized to some extent if they are blended with low-sulfur coals. This is permissible if the low-sulfur coals compensate for the excess in the high-sulfur coals, maintaining the total sulfur at a level no higher than nomally used for the production of coke of high quality.

The relative quantities of high-, medium- and low-volatile coals blended by coke producers are fairly constant, with little variation from year to year at individual plants. The largest proportions of low-volatile coals were used at merchant plants to improve the strength of the foundry coke which makes up the bulk of their output. Table 26 shows the average volatile-matter content of the coals carbonized at oven-coke plants, and table 27 shows the volatile-matter content of the coals received by oven-coke plants in the various States.

SOURCES

Although 23 States produced bituminous coal (excluding lignite) in 1969, only 10 shipped coal to coke plants. Of this number, five States (Alabama, Kentucky, Pennsylvania, Virginia, and West Virginia) supplied 90.2 percent of the total. The remainder was supplied by Colorado, Illinois, New Mexico, Oklahoma, and Utah.

Of the coals received by oven-coke plants, 36 percent was produced in West Virginia and 28 percent in Pennsylvania. West Virginia shipments were principally low-volatile coals from McDowell County, and high-volatile coals from Logan, Marion, and Fayette Counties. Pennsylvania shipments were principally high-volatile coals from Washington, Greene, and Allegheny Counties, and low-volatile coals from Cambria County.

Illinois supplied more than 3 million tons of high-volatile coal to coke plants in Illinois and Indiana. This coal was blended with larger proportions of high-rank Eastern coals that were shipped principally from Kentucky, Virginia, and West Virginia.

Most of the coals carbonized in California, Colorado, and Utah were produced in the latter two Western States. In most instances, plants in the Western States also received shipments of West Virginia low-volatile coals that were used for blending. Tables 28 and 29 show the origin of the coals received by oven-coke plants in 1968.

The coke industry received 58 percent of its coal from company owned or affiliated mines in 1969. Most of the captive mines are owned by iron- and steel-producing companies. In 1969, 62.8 percent of the total coal received by furnace plants was captive. Merchant plants received 35.3 percent of their coal from company owned or affiliated sources. Table 30 shows the quantities and percentages of captive coal received by oven-coke plants each year from 1965 through 1969.

STOCKS

Producers' month-end stocks of bituminous coal at oven-coke plants, which averaged 8 million tons during the first 6 months of the year increased slightly but at the end of December were still 6 percent lower than at the end of 1968. Bituminous coal stocks at merchant plants were sufficient for 67.4 days supply at the December rate of production; furnace plants had coal sufficient for 31.6 days supply.

Stocks of anthracite amounted to 130,000 tons at the end of 1969, a decrease of 24,000 tons from the end of 1968. Tables 31 and 32 show month-end stocks of bituminous coal and anthracite at oven-coke plants.

TECHNOLOGY

The major emphasis of research and development work on coal carbonization in 1969 was directed toward reducing carbonizing costs, improving coke quality and increasing oven productivity. More intensive efforts were made to develop equipment and establish techniques to reduce atmospheric and stream pollution. Work continued on developing methods or processes of producing metallurgical coke from noncoking coals.

One of the more important innovations for reducing coke production costs in recent years has been the installation of high-capacity or large ovens. These ovens range in height from about 16.5 to 20 feet and average about 60 percent greater in capacity than the usual 13-foot-high ovens. Reduction in costs per ton of coke produced is achieved through increased productivity.

Various studies of the coking process to identify the important influencing factors and to determine the effect of these factors on the character of the coke produced increased the ability to control the production of uniform and high-quality coke. The quality and uniformity of metallurgical coke are becoming increasingly important as blast furnace burdens and operating practices are improved. Under such conditions, and with the continuing decrease in the amount of coke required to produce a ton of iron, small changes in the character of the coke can have a relatively large influence on blast furnace performance. To minimize the possible disruptive effects of such changes, operators must develop adequate means to control the quality and uniformity of the coke. To this end, the research conducted in 1969 has identified with three independent coke plant operating variables that influence the quality and uniformity of coke and a determination was made of the effect of these factors on the character of the coke produced. Although substantial progress has been made in determining the factors that influence the quality and uniformity of coke, much remains to be done. Investigations are under way to test the validity of the relationships for various types of coal mixes, and related studies are in progress to determine the effect of coking variables on other properties of coke such as coke microstructure and reactivity.

A reduction in coking requirement was accomplished through injection of reducing gases which lowered the coke ratio to 720 pounds per net ton of steel and thereby created a 35 percent savings in coking coal requirements in pilot blast furnace operations. Normal operation of the pilot plant without the use of supplemental reducing gases resulted in a coke ratio of 1,100 pounds per net ton of steel. The new process involves injection of reducing gases manufactured by partial combustion of fuel oil, into the lower portion of the blast furnace shaft.

Considerable research in the control of water pollution at coke plants was conducted during the year. C F and I Steel Corporation experimented with two new water quality control devices to improve the treatment of wastes either during the manufacturing process or once the water has left the coke plant. One device successfully uses "imported" bacteria, taken from the city sewage plants and supplemented with phosphate, which feed on the effluents. The other device now in operation is a pilot plant that uses the cigarette filter principle. The water goes through tall glass columns containing granules of activated carbon which absorbs the effluents. The carbon is later heated to burn off all the absorbed organic matter.

Bureau of Mines research during 1969 was directed toward predictions of coke strength and carbonization product yields from coal exploration data. Capability to forecast coal quality is useful in mine planning and provides basic information for optimization of blending and crushing techniques that should lead to the production of uniform coke.

The Bureau also continued its effort to obtain a more uniform quality of coke by using different types of blending operations.

Table 2.—Statistical summary of the coke industry in the United States in 1969

	Slot ovens	Beehive ovens	Total
Coke produced:			
At merchant plants ---- thousand short tons	5,919	(1)	(1)
At furnace plants [2] ---- do	58,129	(1)	(1)
Total [3] ---- do	64,047	710	64,757
Breeze produced ---- do	4,401	20	4,421
Coal carbonized:			
Bituminous:			
Thousand short tons	91,743	1,158	92,901
Value (thousands)	$955,022	$7,226	$962,248
Average per ton	$10.41	$6.24	$10.36
Anthracite:			
Thousand short tons	543	----------	543
Value (thousands)	$6,243	----------	$6,243
Average per ton	$11.52	----------	$11.52
Total: [3]			
Thousand short tons	92,285	1,158	93,443
Value (thousands)	$961,265	$7,226	$968,491
Average per ton	$10.42	$6.24	$10.36
Average yield in percent of total coal carbonized:			
Coke	69.40	61.31	69.30
Breeze (at plants actually recovering)	4.77	8.36	4.73
Coke used by producing companies:			
In blast furnaces:			
Thousand short tons	57,289	----------	57,289
Value (thousands)	$1,112,745	----------	$1,112,745
In foundries:			
Thousand short tons	362	----------	362
Value (thousands)	$11,910	----------	$11,910
For other industrial uses:			
Thousand short tons	482	----------	482
Value (thousands)	$11,276	----------	$11,276
Breeze used by producing companies:			
In steam plants:			
Thousand short tons	439	----------	439
Value (thousands)	$3,365	----------	$3,365
In agglomerating plants:			
Thousand short tons	1,650	----------	1,650
Value (thousands)	$14,863	----------	$14,863
For other industrial uses:			
Thousand short tons	775	----------	775
Value (thousands)	$5,224	----------	$5,224
Coke sold (commercial sales):			
To blast furnaces:			
Thousand short tons	3,409	557	3,966
Value (thousands)	$65,247	$9,084	$74,331
Average per ton	$19.14	$16.31	$18.74
To foundries:			
Thousand short tons	3,103	20	3,123
Value (thousands)	$109,509	$244	$109,753
Average per ton	$35.29	$12.20	$35.14
To other industrial plants:			
Thousand short tons	2,393	131	2,524
Value (thousands)	$43,680	$2,164	$45,844
Average per ton	$18.25	$16.52	$18.16
For residential heating:			
Thousand short tons	48	(4)	48
Value (thousands)	$896	(4)	$896
Average per ton	$18.67	(4)	$18.67
Breeze sold (commercial sales):			
Thousand short tons	1,518	20	1,538
Value (thousands)	$12,369	$140	$12,509
Average per ton	$8.15	$7.00	$8.13

See footnotes at end of table.

Table 2.—Statistical summary of the coke industry in the United States in 1969—Continued

	Slot ovens	Beehive ovens	Total
Coal-chemical materials produced:			
Crude tar:			
Thousand gallons	768,766	----------	768,766
Gallons per ton of coal	8.33	----------	8.33
Ammonia:[5]			
Thousand short tons	732	----------	732
Pounds per ton of coal	16.68	----------	16.68
Crude light oil:			
Thousand gallons	258,910	----------	258,910
Gallons per ton of coal	2.87	----------	2.87
Gas:			
Million cubic feet	962,048	----------	962,048
Thousand cubic feet per ton of coal	10.48	----------	10.48
Percent burned in coking process	36.12	----------	36.12
Percent surplus used or sold	61.87	----------	61.87
Percent wasted	2.01	----------	2.01
Value of coal-chemical materials used or sold:			
Crude tar and derivatives:			
Used ..... thousands	$29,765	----------	$29,765
Sold ..... do	$63,430	----------	$63,430
Ammonia products[6] ..... do	$15,208	----------	$15,208
Crude light oil and derivatives[7] ..... do	$42,577	----------	$42,577
Surplus gas ..... do	$137,983	----------	$137,983

[1] Not separately recorded.
[2] Plants associated with iron-blast furnaces.
[3] Data may not add to totals shown because of independent rounding.
[4] Combined with coke sold "To foundries" to avoid disclosing individual company data.
[5] In terms of sulfate equivalent.
[6] Includes ammonium sulfate, ammonia liquor (NH_3 content), and diammonium phosphate.
[7] Includes intermediate light oil.

Table 3.—Summary of oven-coke operations in the United States in 1969, by States

State	Plants in existence Dec. 31 [1]	Coal carbonized (thousand short tons)	Yield of coke from coal (percent)	Coke produced (thousand short tons)
Alabama	7	8,018	70.54	5,656
California, Colorado, Utah	3	5,033	63.42	3,192
Maryland, New Jersey, New York	5	11,057	69.32	7,664
Illinois	5	3,672	63.76	2,341
Indiana	6	11,724	69.36	8,132
Kentucky, Missouri, Tennessee, Texas	5	3,087	69.86	2,157
Michigan	3	4,846	73.92	3,582
Minnesota and Wisconsin	3	1,435	75.73	1,086
Ohio	12	12,262	70.44	8,638
Pennsylvania	12	25,951	69.32	17,989
West Virginia	3	5,201	69.41	3,609
Total 1969 [2]	64	92,285	69.40	64,047
At merchant plants	16	8,315	71.19	5,919
At furnace plants	48	83,971	69.22	58,127
Total 1968	64	90,029	69.84	62,878

[1] Excludes plants retired permanently during year.
[2] Data may not add to totals shown because of independent rounding.

Table 4.—Summary of beehive-coke operations in the United States in 1969, by States

State	Plants in existence Dec. 31	Coal carbonized (thousand short tons)	Yield of coke from coal (percent)	Coke produced (thousand short tons)
Pennsylvania	4	530	60.94	323
Virginia	3	628	61.62	387
Total:				
1969	7	1,158	61.31	710
1968	7	1,268	61.12	775

Table 5.—Production of oven and beehive coke in the United States, by months

(Thousand short tons)

Month	1968 Total [1]	1968 Daily average [2]	1969 Total [1]	1969 Daily average [2]
OVEN COKE				
January	5,602	181	5,177	167
February	5,352	185	4,873	174
March	5,686	183	5,297	171
April	5,529	184	5,312	177
May	5,692	184	5,514	178
June	5,468	182	5,347	178
July	5,453	176	5,386	174
August	5,046	163	5,412	175
September	4,633	154	5,274	176
October	4,613	149	5,552	179
November	4,669	156	5,333	178
December	5,137	163	5,570	180
Total	62,878	172	64,047	175
BEEHIVE COKE				
January	74	2	43	1
February	69	2	42	2
March	79	3	52	2
April	81	3	60	2
May	82	3	53	2
June	72	2	53	2
July	64	2	47	2
August	60	2	70	2
September	51	2	76	3
October	46	1	69	2
November	46	2	63	2
December	49	2	81	3
Total	775	2	710	2
TOTAL				
January	5,676	183	5,220	168
February	5,421	185	4,915	176
March	5,765	186	5,349	173
April	5,610	187	5,372	179
May	5,774	186	5,567	180
June	5,540	185	5,400	180
July	5,517	178	5,433	175
August	5,106	165	5,482	177
September	4,685	156	5,350	178
October	4,660	153	5,621	181
November	4,715	157	5,396	180
December	5,186	167	5,651	182
Total	63,653	174	64,757	177

[1] Data may not add to totals shown because of independent rounding.
[2] Daily average calculated by dividing monthly production by number of days in month.

Table 6.—Production of oven coke in the United States, by type of plant

(Thousand short tons)

Month	1968 Merchant plants	1968 Furnace plants	1969 Merchant plants	1969 Furnace plants
PRODUCTION				
January	524	5,077	496	4,681
February	510	4,842	461	4,412
March	527	5,159	504	4,793
April	508	5,021	507	4,806
May	515	5,177	514	5,000
June	516	4,952	495	4,852
July	504	4,948	482	4,906
August	454	4,591	493	4,918
September	417	4,216	470	4,803
October	443	4,171	506	5,046
November	462	4,206	485	4,848
December	499	4,638	507	5,065
Total [1]	5,879	56,999	5,919	58,129
DAILY AVERAGE				
January	17	164	16	151
February	18	167	16	158
March	17	166	16	155
April	17	167	17	160
May	17	167	17	161
June	17	165	16	161
July	16	160	16	158
August	15	148	16	159
September	14	141	16	160
October	14	136	16	163
November	15	140	16	156
December	16	150	16	163
Average for year	16	156	16	159

[1] Data may not add to totals shown because of independent rounding.

Table 7.—Production of oven coke and number of plants in the United States, by type of plant

Year	Number of active plants [1]		Coke produced (thousand short tons)		Percent of production	
	Merchant plants	Furnace plants	Merchant plants	Furnace plants	Merchant plants	Furnace plants
1965	17	48	6,673	58,524	10.2	89.8
1966	16	50	6,377	59,583	9.7	90.3
1967	16	50	6,220	57,555	9.8	90.2
1968	16	48	5,879	56,999	9.4	90.6
1969	16	49	5,919	58,129	9.2	90.8

[1] Includes plants operating any part of year.

Table 8.—Production of coke in the United States, by States

(Thousand short tons)

State	1968	1969
Oven coke:		
Alabama	5,462	5,656
California, Colorado, Utah	3,174	3,192
Maryland, New Jersey, New York	7,599	7,664
Illinois	2,074	2,341
Indiana	8,144	8,132
Kentucky, Missouri, Tennessee, Texas	2,000	2,157
Michigan	3,684	3,582
Minnesota and Wisconsin	844	1,086
Ohio	8,428	8,638
Pennsylvania	18,110	17,989
West Virginia	3,360	3,609
Total [1]	62,878	64,047
Beehive coke:		
Pennsylvania	355	323
Virginia	419	387
Total [1]	775	710
Grand total [1]	63,653	64,757

[1] Data may not add to totals shown because of independent rounding.

Table 9.—Breeze recovered at coke plants in the United States in 1969, by States

(Thousand short tons and thousand dollars)

State	Yield per ton of coal [1] (percent)	Produced	Used by producers			
			In steam plants		In agglomerating plants	
		Quantity	Quantity	Value	Quantity	Value
OVEN COKE						
Alabama	6.19	496	(2)	(2)	174	$2,625
California, Colorado, Utah	5.65	284	------	------	198	1,597
Connecticut, Maryland, New Jersey, New York	5.30	586	237	$1,969	(2)	(2)
Illinois	5.41	199	(2)	(2)	(2)	(2)
Indiana	5.65	[3] 663	------	------	397	2,601
Kentucky, Missouri, Tennessee, Texas	6.68	206	(2)	(2)	(2)	(2)
Michigan	5.06	245	------	------	(2)	(2)
Minnesota and Wisconsin	7.07	102	(2)	(2)	(2)	(2)
Ohio	4.39	539	(2)	(2)	35	227
Pennsylvania	3.16	820	(2)	(2)	528	5,611
West Virginia	5.02	261	(2)	(2)	(2)	(2)
Undistributed	------	------	202	1,396	318	2,204
Total 1969 [4]	4.77	4,401	439	3,365	1,650	14,863
At merchant plants	7.50	623	116	1,391	------	------
At furnace plants	4.50	3,778	323	1,974	1,650	14,863
Total 1968 [4]	4.53	4,074	508	3,021	1,634	11,545
BEEHIVE COKE						
Pennsylvania and Virginia, 1969	8.36	20	------	------	------	------
Total 1968	6.87	25	------	------	------	------

State	Used by producers		Sold		On hand Dec. 31
	For other industrial use				
	Quantity	Value	Quantity	Value	
OVEN COKE					
Alabama	30	$373	270	$3,153	32
California, Colorado, Utah	18	120	71	583	21
Connecticut, Maryland, New Jersey, New York	(2)	(2)	93	594	410
Illinois	16	87	(2)	(2)	46
Indiana	120	877	142	870	82
Kentucky, Missouri, Tennessee, Texas	(2)	(2)	135	1,250	20
Michigan	30	197	101	686	149
Minnesota and Wisconsin	59	293	14	136	85
Ohio	92	535	400	2,688	57
Pennsylvania	71	689	176	1,575	152
West Virginia	33	225	(2)	(2)	25
Undistributed	307	1,828	116	833	--------
Total 1969 [4]	775	5,224	1,518	12,369	1,080
At merchant plants	93	541	346	3,152	274
At furnace plants	683	4,683	1,171	9,217	806
Total 1968 [4]	589	4,430	1,338	10,844	1,012
BEEHIVE COKE					
Pennsylvania and Virginia, 1969	--------	--------	20	140	(5)
Total 1968	--------	--------	26	--------	(5)

[1] Calculated by dividing production by coal carbonized at plants actually recovering breeze.
[2] Included with "Undistributed" to avoid disclosing individual company data.
[3] Includes some breeze resulting from the screening of coke at blast furnaces.
[4] Data may not add to totals shown because of independent rounding.
[5] Less than ½ unit.

Table 10.—Oven- and beehive-coke breeze used and sold in the United States, by uses

(Thousand short tons)

Year	Used by producers: In steam plants	In agglomerating plants	For other industrial use	Sold	Average value per ton
1965	642	1,744	427	1,312	7.56
1966	644	1,873	505	1,172	7.27
1967	594	1,695	517	1,250	8.46
1968	508	1,634	589	1,364	7.34
1969	439	1,650	775	1,538	8.13

Table 11.—Apparent consumption of coke in the United States

(Thousand short tons)

Year	Total production	Imports	Exports	Net change in stocks	Apparent consumption [1]	Consumption: In iron furances [2]: Quantity	In iron furances: Percent	All other purposes: Quantity	All other purposes: Percent
1965	66,854	90	834	+731	65,379	59,072	90.4	6,307	9.6
1966	67,402	96	1,102	+376	66,019	59,637	90.3	6,383	9.7
1967	64,580	92	710	+2,390	61,572	56,205	91.3	5,367	8.7
1968	63,653	94	792	+517	62,438	56,238	90.1	6,200	9.9
1969	64,757	173	1,629	−2,865	60,436	60,176	90.9	5,990	9.1

[1] Production plus imports minus exports, plus or minus net change in stocks.
[2] American Iron and Steel Institute; figures include coke consumed in manufacturing ferroalloys.

Table 12.—Coke and coking coal consumed per short ton of pig iron and ferroalloys produced in the United States

Year	Coke per short tons of pig iron and ferroalloys [1] (pounds)	Yield of coke from coal (percent)	Coking coal per short tons of pig iron and ferroalloys (pounds calculated)
1965	1,329.5	70.1	1,896.6
1966	1,300.6	69.9	1,860.7
1967	1,287.8	69.6	1,850.2
1968	1,263.4	69.8	1,810.0
1969	1,260.4	69.4	1,816.1

[1] American Iron and Steel Institute; consumption of pig iron only, excluding furnaces making ferroalloys, was 1,312 pounds in 1965, 1,282 in 1966, 1,262 in 1967, 1,248 in 1968, and 1,252 in 1969.

Table 13.—Oven coke produced in the United States, used by producers, and sold in 1969, by States

(Thousand short tons and thousand dollars)

State	Produced	Used by producing companies: In blast furnaces		Used by producing companies: For other purposes [1]		Commercial sales: To blast-furnace plants	
	Quantity	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	5,656	4,382	$93,444	151	$4,874	610	$11,660
California, Colorado, Utah	3,192	3,023	70,005	14	305	-------	-------
Maryland, New Jersey, New York	7,664	7,047	135,705	21	410	588	12,084
Illinois	2,341	2,255	50,558	(2)	(2)	(2)	(2)
Indiana	8,132	7,870	122,200	(2)	(2)	70	1,280
Kentucky, Missouri, Tennessee, Texas	2,157	(2)	(2)	(2)	(2)	(2)	(2)
Michigan	3,582	(2)	(2)	142	3,104	(2)	(2)
Minnesota and Wisconsin	1,086	(2)	(2)	(2)	(2)	(2)	(2)
Ohio	8,638	7,852	136,270	69	1,439	471	11,086
Pennsylvania	17,989	17,420	355,022	66	1,371	469	9,069
West Virginia	3,609	3,357	63,849	(2)	(2)	-------	-------
Undistributed	-------	4,083	85,694	382	11,681	1,201	20,068
Total 1969 [3]	64,047	57,289	1,112,745	845	23,183	3,409	65,247
At merchant plants	5,919	-------	6	169	5,141	2,302	41,054
At furnace plants	58,127	57,289	1,112,739	676	18,042	1,108	24,193
Total 1968	62,878	53,312	944,527	974	19,060	3,345	54,837

State	Commercial sales—Continued: To foundries		To other industrial plants		For residential heating		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	602	$19,920	548	$10,437	10	$131	1,769	$42,148
California, Colorado, Utah	(2)	(2)	210	4,073	(2)	(2)	211	4,085
Maryland, New Jersey, New York	(2)	(2)	92	2,005	(2)	(2)	1,020	25,836
Illinois	------	------	(2)	(2)	(2)	(2)	48	953
Indiana	(2)	(2)	(2)	(2)	(2)	(2)	606	18,559
Kentucky, Missouri, Tennessee, Texas	(2)	(2)	(2)	(2)	(2)	(2)	1,489	30,193
Michigan	(2)	(2)	413	7,353	(2)	(2)	824	22,461
Minnesota and Wisconsin	(2)	(2)	(2)	(2)	(2)	(2)	579	18,206
Ohio	(2)	(2)	251	2,459	(2)	(2)	1,044	24,675
Pennsylvania	(2)	(2)	547	10,778	(2)	(2)	1,363	32,217
West Virginia	------	------	(4)	(4)	(2)	(2)	(4)	(4)
Undistributed	2,501	89,589	332	6,574	38	765	------	------
Total 1969 [3]	3,103	109,509	2,393	43,680	48	896	8,953	219,332
At merchant plants	2,718	95,673	817	16,342	47	885	5,883	153,954
At furnace plants	385	13,836	1,576	27,338	1	11	3,070	65,378
Total 1968	2,934	95,127	1,883	30,071	113	2,041	8,275	182,076

[1] Comprises 362,000 tons valued at $11,908,000 used in foundries; 482,000 tons valued at $11,276,000 for other purposes.
[2] Included with "Undistributed" to avoid disclosing individual company data.
[3] Data may not add to totals shown because of independent rounding.
[4] Included with Michigan to avoid disclosing company data.

Table 14.—Production and sales of beehive coke in the United States, in 1969, by States
(Thousand short tons and thousand dollars)

State	Produced	Commercial sales			
		To blast-furnace plants		To foundries	
	Quantity	Quantity	Value	Quantity	Value
Pennsylvania	323	282	$4,824	20	$244
Virginia	387	274	4,260	------	------
Total:					
1969 [1]	710	557	9,084	20	244
1968	775	570	8,636	31	$212

State	Commercial sales—Continued					
	To other industrial plants		For residential heating		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
Pennsylvania	19	$269	------	------	322	$5,337
Virginia	112	1,895	------	------	387	6,155
Total:						
1969 [1]	131	2,164	------	------	709	11,492
1968	174	r 2,848	(2)	(2)	775	r 11,697

r Revised.
[1] Data may not add to totals shown because of independent rounding.
[2] Combined with coke sold "To blast-furnace plants" to avoid disclosing individual company data.

Table 15.—Distribution of oven and beehive coke and breeze in 1969 [1]

(Thousand short tons)

Consuming State	Coke					Breeze
	To blast-furnace plants	To foundries	To other industrial plants	For residential heating	Total	
Alabama	3,843	328	35	7	4,213	319
Arizona	--------	2	2	--------	4	--------
Arkansas	--------	3	2	--------	5	(2)
California	1,299	58	59	--------	1,416	67
Colorado	660	8	20	--------	689	78
Connecticut	--------	23	1	--------	24	(2)
Delaware	(2)	(2)	(2)	--------	(2)	(2)
Florida	1	2	52	(2)	56	17
Georgia	--------	12	3	(2)	15	1
Idaho	--------	(2)	158	--------	158	--------
Illinois	2,621	219	27	4	2,872	252
Indiana	8,286	184	77	4	8,551	596
Iowa	--------	89	5	(2)	94	--------
Kansas	--------	13	1	--------	14	(2)
Kentucky	1,076	22	46	2	1,146	139
Louisiana	25	2	40	--------	67	1
Maine	--------	1	(2)	(2)	2	--------
Maryland	3,696	32	4	--------	3,732	290
Massachusetts	--------	30	2	4	36	(2)
Michigan	4,352	923	182	(2)	5,457	157
Minnesota	302	24	277	--------	603	23
Mississippi	--------	1	(2)	--------	1	(2)
Missouri	9	44	73	1	127	4
Montana	--------	2	54	--------	56	14
Nebraska	--------	4	10	--------	14	--------
New Hampshire	--------	1	(2)	--------	1	--------
New Jersey	(2)	87	42	11	140	68
New Mexico	--------	--------	1	--------	1	(2)
New York	3,767	52	50	9	3,878	290
North Carolina	--------	15	19	1	35	12
North Dakota	--------	(2)	1	--------	1	--------
Ohio	8,466	486	341	(2)	9,293	492
Oklahoma	--------	6	1	--------	6	3
Oregon	--------	2	23	--------	26	(2)
Pennsylvania	17,357	185	664	(2)	18,206	780
Rhode Island	--------	5	5	1	10	--------
South Carolina	--------	9	49	(2)	58	1
South Dakota	--------	(2)	3	--------	4	(2)
Tennessee	20	79	104	(2)	204	116
Texas	903	85	28	(2)	1,016	122
Utah	1,065	17	27	--------	1,109	79
Vermont	--------	2	1	--------	3	--------
Virginia	2	87	5	(2)	94	4
Washington	(2)	7	4	--------	11	--------
West Virginia	3,119	9	36	--------	3,165	262
Wisconsin	--------	164	1	3	168	56
Wyoming	--------	--------	5	--------	5	(2)
Total [3]	60,869	3,326	2,542	48	66,785	4,246
Exported	386	160	464	(2)	1,010	156
Grand total [3]	61,256	3,486	3,006	49	67,796	4,402

[1] Based upon reports from producers showing destination and principal end use of coke used and sold. Does not include imported coke which totaled 173,000 tons in 1969.

[2] Less than ½ unit.

[3] Data may not add to totals shown because of independent rounding.

Table 16.—Producers' stocks of coke and breeze in the United States on Dec. 31, 1969, by States

(Thousand short tons)

State	Coke				Breeze
	Blast furnace	Foundry	Residential heating and other	Total	
OVEN COKE					
Alabama	605	2	2	609	32
California, Colorado, Utah	174	-------	-------	174	21
Maryland, New Jersey, New York	148	22	1	170	410
Illinois	28	-------	3	30	46
Indiana	231	8	1	240	82
Kentucky, Missouri, Tennessee, Texas	7	6	4	20	20
Michigan	12	6	6	25	149
Minnesota and Wisconsin	78	8	4	89	85
Ohio	205	10	4	219	57
Pennsylvania	1,460	20	13	1,492	152
West Virginia	53	-------	-------	53	25
Total 1969 [1]	3,000	83	37	3,120	1,080
At merchant plants	2	69	29	99	274
At furnace plants	2,998	14	8	3,020	806
Total 1968 [1]	5,617	190	178	5,985	1,012
BEEHIVE COKE					
Pennsylvania	1	-------	1	1	-------
Virginia	(2)	-------	-------	1	(2)
Total:[1]					
1969	1	-------	1	2	-------
1968	1	-------	1	1	-------

[1] Data may not add to totals shown because of independent rounding.
[2] Less than ½ unit.

Table 17.—Producers' month-end stocks of oven coke in the United States

(Thousand short tons)

Month	At merchant plants		At furnace plants		Total	
	1968	1969	1968	1969	1968	1969
January	495	323	4,879	5,542	5,375	5,865
February	460	283	4,766	5,278	5,226	5,562
March	437	223	4,579	4,792	5,016	5,015
April	501	197	4,240	4,310	4,740	4,507
May	373	193	4,152	3,969	4,525	4,162
June	344	167	3,992	3,729	4,336	3,896
July	359	193	3,953	3,594	4,312	3,787
August	410	186	4,329	3,629	4,739	3,816
September	424	146	4,969	3,553	5,393	3,699
October	395	121	5,364	3,309	5,759	3,430
November	338	119	5,590	3,202	5,929	3,320
December	348	99	5,637	3,020	5,985	3,120

Table 18.—Average receipts per short ton of coke sold (commercial sales) in the United States, by uses

Year	To blast-furnace plants	To foundries	To other industrial plants	For residential heating	Total
	OVEN COKE				
1965	$16.46	$30.94	$16.41	$17.12	$21.68
1966	16.33	31.75	16.90	17.39	12.22
1967	16.29	32.40	17.16	17.35	22.67
1968	16.40	32.43	15.97	17.96	22.00
1969	19.14	35.29	18.25	18.67	24.50
	BEEHIVE COKE				
1965	$14.45	$15.40	$16.12	$16.12	$14.96
1966	13.58	15.30	16.77	16.77	14.60
1967	14.97	12.34	15.41	15.41	15.03
1968	15.14	6.84	14.80	18.60	15.00
1969	16.31	6.84	15.93	16.52	16.23

Table 19.—Coke exported from the United States, by country and by customs district

	1967		1968		1969	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
COUNTRY						
Argentina	---	---	---	---	12,233	$535
Australia	152	$3	175	$4	---	---
Belgium-Luxembourg	17	(2)	---	---	6,212	132
Bolivia	34	2	22	1	---	---
Brazil	7,144	248	8,205	267	29,285	1,027
Canada	439,853	10,562	247,515	6,840	292,223	8,189
Chile	147	7	(1)	(1)	3,517	37
Colombia	266	4	466	17	---	---
Dominican Republic	41	2	349	9	195	5
Germany, West	12	1	468	10	14,882	631
India	---	---	1,697	47	655	19
Japan	21,312	392	39,010	451	55,640	648
Mexico	162,022	4,142	346,547	8,776	629,816	15,253
Netherlands	627	9	---	---	234,460	4,929
Peru	49	2	---	---	64,394	1,595
Philippines	148	2	1,038	31	---	---
Rumania	---	---	---	---	129,035	3,192
Spain	119	2	---	---	13,552	164
United Kingdom	40	1	188	4	447	10
Venezuela	77,807	1,103	145,919	2,128	141,920	2,098
Other	590	10	310	28	1,022	46
Total	710,380	16,492	791,909	18,613	1,629,488	38,510
CUSTOMS DISTRICT						
Baltimore	554	13	1,185	35	278,311	6,334
Buffalo	238,578	5,751	125,296	3,316	106,831	2,873
Detroit	144,771	3,282	85,231	2,372	152,431	4,316
Duluth	3,190	108	4,000	132	4,690	166
El Paso	223	4	9,060	233	29,361	762
Great Falls	360	12	---	---	---	---
Houston	3,746	136	2,565	71	1,276	37
Laredo	161,102	4,120	336,964	8,523	598,579	14,438
Los Angeles	21,151	390	39,164	450	55,565	646
Mobile	47,048	672	145,036	2,102	230,044	4,455
New Orleans	784	16	150	29	13,869	179
New York City	2,931	81	5,233	174	667	21
Nogales	117	5	239	11	845	25
Norfolk	148	2	---	---	9,729	169
Ogdensburg	16,413	316	5,358	124	11,915	337
Pembina	26,191	737	15,730	492	15,815	550
Philadelphia	30,483	427	4,550	137	90,117	2,374
Port Arthur	1,653	53	---	---	---	---
Portland, Maine	---	---	---	---	16,359	376
St. Albans	2,220	93	---	---	---	---
San Diego	458	10	248	8	1,072	29
Seattle	8,130	262	11,520	390	11,741	408
Other	129	2	380	14	271	15
Total	710,380	16,492	791,909	18,613	1,629,488	38,510

[1] 39 short tons ($11,063) reported by the Bureau of the Census, has been deleted.

Table 20.—Coke imported for consumption in the United States, by country and customs district

	1967		1968		1969	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
COUNTRY						
Canada	87,549	$1,295	90,580	$1,630	169,341	$2,989
France	80	9	52	6	858	102
Germany, West	3,650	326	2,668	186	2,758	248
Japan	--------	--------	--------	--------	13	(1)
Mexico	84	2	--------	--------	--------	--------
Netherlands	638	72	785	82	82	15
Total	92,001	1,704	94,085	1,904	173,052	3,354
CUSTOMS DISTRICT						
Buffalo	8,115	38	2,362	23	2,703	38
Chicago	--------	--------	--------	--------	19,085	124
Detroit	30	1	4,083	44	43,475	882
Galveston	152	15	--------	--------	--------	--------
Great Falls	64,795	1,138	78,285	1,462	92,795	1,776
Honolulu	330	10	218	7	345	15
Houston	16	3	--------	--------	--------	--------
Miami	--------	--------	--------	--------	74	9
Mobile	--------	--------	--------	--------	777	93
New Orleans	3,388	361	3,078	249	2,428	246
Nogales	--------	--------	492	9	--------	--------
Ogdensburg	10,000	40	--------	--------	5,440	43
Portland, Maine	35	1	17	(1)	55	1
St. Albans	44	1	35	1	34	1
San Juan	482	18	529	21	105	4
Seattle	4,614	78	4,986	88	5,736	122
Total	92,001	1,704	94,085	1,904	173,052	3,354

[1] Less than ½ unit.

Table 21.—World production of coke, by country and type (excluding breeze) [1]

(Thousand short tons)

Kind of coke and country [2]	1967	1968	1969 p
METALLURGICAL COKE [3]			
North America:			
Canada [4]	4,430	5,311	5,002
Mexico	1,135	1,271	1,258
United States	64,580	63,653	64,757
South America:			
Argentina [5]	r 498	402	NA
Brazil	r 1,453	1,550	1,661
Chile	316	332	353
Colombia	e 122	e 480	513
Peru	45	40	NA
Europe:			
Austria	1,551	1,887	1,784
Belgium	7,559	7,716	NA
Bulgaria	r 885	901	904
Czechoslovakia	10,114	10,410	e 10,692
Finland	44	e 55	e 77
France [5]	13,923	13,541	NA
Germany, East	3,220	2,812	e 2,756
Germany, West [6]	38,770	39,867	e 36,376
Hungary	715	551	551
Italy	6,885	7,139	7,352
Netherlands [5]	3,653	[7] 3,231	[7] 2,240
Norway	333	342	353
Poland	15,351	e 15,598	e 16,094
Rumania	1,247	1,249	1,035
Spain [6]	r 3,266	3,882	4,070
Sweden	560	577	573
U.S.S.R. [5]	77,048	78,821	81,020
United Kingdom	17,157	18,228	18,577
Yugoslavia	1,344	1,360	e 1,349
Africa:			
Rhodesia, Southern	226	244	268
South Africa, Republic of e	3,307	3,527	3,638
United Arab Republic	e 303	NA	NA
Asia:			
China, mainland e	14,330	16,535	18,739
India	8,367	8,122	e 8,157
Iran [8]	23	23	55
Japan	24,439	28,810	34,186
Korea, North e	1,984	2,205	2,480
Taiwan	r e 207	e 212	208
Turkey [4] [6]	r 1,501	1,576	1,757
Oceania:			
Australia e	r 4,073	4,360	4,906
New Zealand	6	6	6
Subtotal—Metallurgical coke	r 334,970	346,826	333,747
GASHOUSE COKE [9]			
South America:			
Brazil	226	218	192
Chile	r 80	63	NA
Uruguay	23	22	18
Europe:			
Austria	r 213	165	138
Czechoslovakia	r 146	98	e 110
Denmark	r 295	244	e 243
Finland	106	83	e 63
France	10	9	NA
Germany, West	3,163	2,563	e 2,756
Hungary	605	775	e 772
Ireland [5]	r 103	90	83
Italy	349	297	214
Netherlands [5]	20	------	------
Poland	r 1,407	e 1,433	e 1,461
Portugal	11	11	11
Spain [5]	61	7	7
Sweden	550	e 496	e 496
Switzerland	303	250	261
United Kingdom	6,930	5,125	3,319
Yugoslavia	8	2	2

See footnotes at end of table.

Table 21.—World production of coke, by country and type (excluding breeze)—Continued [1]

(Thousand short tons)

Kind of coke and country [2]	1967	1968	1969 p
GASHOUSE COKE—Continued			
Africa:			
South Africa, Republic of	193	193	193
Asia:			
Hong Kong [5]	10	------	------
India	r 74	e 55	e 61
Japan	4,591	4,927	5,521
Taiwan	r 62	55	62
Oceania:			
Australia	827	728	772
New Zealand [10]	62	66	NA
Subtotal—Gashouse coke	20,428	17,975	16,755
ALL OTHER TYPES [11]			
North America:			
United States	163	174	NA
Europe:			
Czechoslovakia	1,997	1,993	2,039
France	219	241	NA
Germany, East [12]	7,670	7,489	e 7,496
Germany, West	434	------	------
Poland	276	276	276
Asia:			
India	r 3,086	3,290	e 3,307
Subtotal—All other types	r 13,845	13,463	13,118
Grand total—All types [13]	r 369,243	378,264	363,620

e Estimate. p Preliminary. r Revised. NA Not available.

1 Beehive coke, where produced, is included with oven coke.

2 Production data for gashouse coke for Algeria, Ceylon, Malaysia, mainland China, Mexico, Rumania, United Arab Republic, U.S.S.R., and possibly other countries are not available. Low-temperature coke is produced in Japan but data are not available.

3 Includes coke produced at high temperature in conventional carbonizing equipment (slot and beehive coke ovens).

4 Includes breeze and small amount of gas coke.

5 Includes breeze.

6 Includes a small amount of low-temperature coke.

7 Includes all types.

8 Year ended March 20 following that stated.

9 Includes coke produced at high temperatures in carbonizing equipment designed primarily for gas manufacture. (Horizontal and vertical coal-gas retorts).

10 Year ended March 31 of the year following that stated.

11 Includes coke produced at low and medium temperatures; also coke produced in unconventional equipment (chain-grate cokers).

12 Includes high-temperature coke.

13 Totals are of listed figures only; oven coke includes small quantities of other coke.

Table 22.—Quantity and value at ovens of coal carbonized in the United States in 1969, by States

State	Coal carbonized: Thousand short tons	Coal carbonized: Value: Total (thousands)	Coal carbonized: Value: Average	Coal per ton of coke: Short tons	Coal per ton of coke: Value
OVEN COKE					
Alabama	8,018	$81,910	$10.22	1.42	$15.48
California, Colorado, Utah	5,033	55,283	10.98	1.58	17.32
Maryland, New Jersey, New York	11,057	138,469	12.52	1.44	18.11
Illinois	3,672	35,775	9.74	1.57	15.28
Indiana	11,724	130,315	11.11	1.44	16.02
Kentucky, Missouri, Tennessee, and Texas	3,087	25,557	8.28	1.43	11.85
Michigan	4,846	55,166	11.38	1.35	15.40
Minnesota and Wisconsin	1,435	19,603	13.66	1.32	18.05
Ohio	12,262	123,421	10.07	1.42	14.29
Pennsylvania	25,951	251,204	9.68	1.44	13.96
West Virginia	5,201	44,562	8.57	1.44	12.35
Total 1969 [1]	92,285	961,265	10.42	1.44	15.01
At merchant plants	8,315	80,838	9.72	1.40	13.66
At furnace plants	83,971	880,427	10.48	1.44	15.15
Total 1968 [1]	90,029	901,295	10.01	1.43	14.33
BEEHIVE COKE					
Pennsylvania	530	3,673	6.93	1.64	11.37
Virginia	628	3,552	5.66	1.62	9.18
Total:					
1969 [1]	1,158	7,226	6.24	1.63	10.18
1968	1,268	7,238	5.71	1.64	9.34

[1] Data may not add to totals shown because of independent rounding.

Table 23.—Bituminous coal carbonized in coke ovens in the United States, by months

(Thousand short tons)

Month	1968: Slot	1968: Beehive	1968: Total	1969: Slot	1969: Beehive	1969: Total
January	7,975	120	8,095	7,379	73	7,452
February	7,634	113	7,747	6,937	70	7,007
March	8,082	131	8,213	7,579	86	7,665
April	7,870	134	8,004	7,581	97	[1] 7,679
May	8,122	135	8,257	7,866	88	7,954
June	7,840	117	7,957	7,656	87	7,743
July	7,835	103	7,938	7,755	78	7,833
August	7,198	97	7,295	7,729	111	7,840
September	6,561	85	6,646	7,594	120	7,714
October	6,524	76	6,600	7,981	111	8,092
November	6,632	78	6,710	7,664	105	7,769
December	7,224	79	7,303	8,022	132	8,154
Total	89,497	1,268	90,765	91,743	1,158	[1] 92,901

[1] Data may not add to totals shown because of independent rounding.

Table 24.—Anthracite carbonized at oven-coke plants in the United States, by months

(Thousand short tons)

Month	1968	1969
January	45	49
February	45	46
March	45	46
April	43	43
May	46	44
June	42	41
July	40	40
August	44	40
September	41	49
October	45	48
November	45	44
December	51	53
Total	532	[1] 542

[1] Data may not add to total shown because of independent rounding.

Table 25.—Average value per short ton of coal carbonized at oven-coke plants in the United States, by States

State	1968	1969
Alabama	$10.04	$10.22
California, Colorado, Utah	12.47	10.98
Maryland, New Jersey, New York	12.05	12.52
Illinois	9.73	9.74
Indiana	10.68	11.11
Kentucky, Missouri, Tennessee, Texas	8.13	8.28
Michigan	10.65	11.38
Minnesota and Wisconsin	11.15	13.66
Ohio	9.37	10.07
Pennsylvania	9.12	9.68
West Virginia	8.00	8.57
Average	10.01	10.42
Value of coal per ton of coke	14.33	15.01

Table 26.—Average volatile content of bituminous coal carbonized by oven-coke plants in the United States

(Thousand short tons)

Year	High		Medium		Low		Total	
	Quantity	Volatile content (percent)	Quantity	Volatile content (percent)	Quantity	Volatile content (percent)	Quantity	Volatile content (percent)
1965	61,725	35.2	11,791	25.9	18,570	17.8	92,086	30.5
1966	63,061	34.6	10,395	26.2	20,067	17.8	93,523	30.1
1967	59,787	35.1	12,470	26.4	18,644	18.2	90,900	30.4
1968	55,853	35.0	12,906	27.3	20,074	18.7	88,833	30.2
1969	59,284	35.1	12,785	26.8	19,674	18.6	91,743	30.4

Table 27.—Coal received by oven-coke plants in the United States in 1969, by consuming States and volatile content [1]

(Thousand short tons)

Consuming State	High-volatile		Medium-volatile		Low-volatile		Total coal receipts
	Quantity	Percent of total	Quantity	Percent of total	Quantity	Percent of total	
Alabama	1,585	19.3	5,907	71.7	739	9.0	8,231
California, Colorado, Utah	4,414	85.4	682	13.2	70	1.4	5,166
Maryalnd, New Jersey, New York	7,706	70.5	538	4.9	2,690	24.6	10,934
Illinois	2,865	77.8	141	3.8	679	18.4	3,685
Indiana	7,295	62.3	1,788	15.3	2,632	22.4	11,715
Kentucky, Missouri, Tennessee, Texas	1,784	57.8	459	14.8	846	27.4	3,089
Michigan	3,375	67.9	326	6.6	1,271	25.5	4,972
Minnesota and Wisconsin	720	49.8	115	8.0	611	42.2	1,446
Ohio	9,262	74.8	610	5.0	2,502	20.2	12,374
Pennsylvania	16,704	67.2	1,621	6.5	6,527	26.3	24,852
West Virginia	4,364	84.2	------	----	820	15.8	5,184
Total 1969	60,074	65.5	12,187	13.3	19,387	21.2	91,648
At merchant plants	3,764	45.7	1,405	17.1	3,063	37.2	8,232
At furnace plants	56,310	67.5	10,782	12.9	16,324	19.6	83,416
Total 1968	57,483	64.6	11,272	12.7	20,194	22.7	88,949

[1] Volatile matter on moisture-free basis: High-volatile—over 31 percent; medium-volatile—22 to 31 percent; and low-volatile—14 to 22 percent.

Table 28.—Origin of coal received by oven-coke plants in the United States in 1969, by producing county and volatile content

(Thousand short tons)

State and county	Volatile content [1]			Total
	High	Medium	Low	
Alabama:				
Bibb	277	------	------	277
Jefferson	305	5,405	------	5,710
Walker	30	35	------	65
Colorado:				
Gunnison	699	------	------	699
Las Animas	1,062	------	------	1,062
Moffat	1	------	------	1
Pitkin	------	651	------	651
Illinois:				
Franklin	2,003	------	------	2,003
Jefferson	1,123	------	------	1,123
Saline	242	------	------	242
Williamson	30	------	------	30
Kentucky:				
Boyd	1,450	------	------	1,450
Floyd	1,205	------	------	1,205
Harlan	3,199	------	------	3,199
Knott	120	------	------	120
Letcher	1,871	------	------	1,871
Perry	86	------	------	86
Pike	4,564	------	------	4,564
New Mexico: Colfax	742	------	------	742
Oklahoma:				
Haskell	------	202	1	203
Le Flore	------	------	154	154
Rogers	147	------	------	147
Pennsylvania:				
Anthracite	------	------	322	322
Bituminous:				
Allegheny	2,563	------	------	2,563
Cambria	------	290	2,687	2,977
Fayette	25	------	------	25
Greene	6,281	------	------	6,281
Somerset	------	------	721	721
Washington	11,760	28	------	11,788
Westmoreland	1,754	------	------	1,754
Utah: Carbon	1,911	------	------	1,911
Virginia:				
Buchanan	407	242	795	1,444
Dickenson	662	------	------	662
Russell	246	876	------	1,122
Tazewell	------	26	------	26
Wise	1,173	------	------	1,173
West Virginia:				
Barbour	478	------	------	478
Boone	1,839	40	------	1,879
Fayette	2,439	142	913	3,494
Greenbrier	------	128	------	128
Kanawha	1,211	------	------	1,211
Logan	4,067	384	------	4,451
McDowell	------	1,495	9,391	10,886
Marion	2,114	------	------	2,114
Mercer	------	2	1,137	1,139
Mingo	1,680	------	------	1,680
Nicholas	277	1,008	------	1,285
Raleigh	------	------	1,677	1,677
Wayne	------	250	------	250
Webster	26	3	------	29
Wyoming	479	427	1,668	2,574
Total	60,548	11,634	19,466	91,648

[1] Volatile matter on moisture-free basis: High-volatile—over 31 percent; medium-volatile—22 to 31 percent; and low-volatile—14 to 22 percent.

Table 29.—Origin of coal received by oven-coke plants in the United States in 1969, by producing States

(Thousand short tons)

Consuming State	Producing State: Alabama	Colorado	Illinois	Kentucky	New Mexico	Oklahoma
Alabama	6,053	--------	--------	--------	--------	--------
California, Colorado, Utah	--------	2,412	--------	--------	742	--------
Maryland, New Jersey, New York	--------	--------	--------	2,388	--------	--------
Illinois	--------	--------	1,702	1,036	--------	--------
Indiana	--------	--------	1,690	3,957	--------	--------
Kentucky, Missouri, Tennessee, Texas	--------	--------	--------	96	--------	503
Michigan	--------	--------	--------	1,859	--------	--------
Minnesota and Wisconsin	--------	--------	--------	89	--------	--------
Ohio	--------	--------	--------	924	--------	--------
Pennsylvania	--------	--------	--------	1,974	--------	--------
West Virginia	--------	--------	--------	259	--------	--------
Total 1969 [1]	6,053	2,412	3,392	12,582	742	503
At merchant plants	664	--------	--------	301	--------	--------
At furnace plants	5,389	2,412	3,392	12,281	742	503
Total 1968	5,579	2,404	2,454	10,544	705	469

Consuming State	Producing State—Continued: Pennsylvania	Utah	Virginia	West Virginia	Total
Alabama	49	----------	1,399	730	8,230
California, Colorado, Utah	----------	1,911	----------	101	5,166
Maryland, New Jersey, New York	4,137	----------	402	4,007	10,934
Illinois	10	----------	19	918	3,685
Indiana	45	----------	377	5,647	11,716
Kentucky, Missouri, Tennessee, Texas	61	----------	166	2,263	3,089
Michigan	50	----------	234	2,829	4,972
Minnesota and Wisconsin	35	----------	285	1,038	1,447
Ohio	5,139	----------	619	5,693	12,375
Pennsylvania	13,767	----------	692	8,417	24,850
West Virginia	3,142	----------	21	1,762	5,184
Total 1969 [1]	26,435	1,911	4,214	33,405	91,648
At merchant plants	264	----------	682	6,321	8,232
At furnace plants	26,171	1,911	3,532	27,084	83,416
Total 1968	25,718	1,761	4,800	34,514	88,948

[1] Data may not add to totals shown because of independent rounding.

Table 30.—Quantity and percentage of captive coal received by oven-coke plants in the United States

(Thousand short tons)

Year	At merchant plants			At furnace plants			Total [1]		
	Total coal received	Captive coal		Total coal received	Captive coal		Total coal received	Captive coal	
		Quantity	Percent		Quantity	Percent		Quantity	Percent
1965	9,167	3,229	35.2	84,654	55,228	65.2	93,820	58,457	62.3
1966	8,670	3,006	34.7	85,694	54,155	63.2	94,364	57,161	60.6
1967	8,545	3,109	36.4	85,495	52,928	61.9	94,040	56,038	59.6
1968	7,735	2,659	34.4	81,213	48,999	60.3	88,948	51,658	58.1
1969	8,232	2,895	35.2	83,416	52,447	62.9	91,648	55,342	60.4

[1] Data may not add to totals shown because of independent rounding.

Table 31.—Month-end stocks of bituminous coal at oven-coke plants in the United States

(Thousand short tons)

Month	1968	1969
January	10,422	8,654
February	9,815	8,222
March	10,492	7,422
April	11,882	8,001
May	11,994	8,743
June	11,633	8,822
July	10,321	6,553
August	10,575	6,618
September	11,203	7,338
October	9,533	8,376
November	9,541	8,807
December	9,537	8,962

Table 32.—Month-end stocks of anthracite at oven-coke plants in the United States

(Thousand short tons)

Month	1968	1969
January	153	125
February	106	95
March	85	74
April	79	73
May	83	85
June	82	100
July	85	99
August	98	110
September	124	119
October	151	122
November	167	137
December	154	130

Table 33.—Coal-chemical materials, exclusive of breeze, produced at oven-coke plants in the United States in 1969 [1]

Product	Produced	Sold: Quantity	Sold: Value: Total (thousands)	Sold: Value: Average per unit	On hand Dec. 31
Tar, crude ... thousand gallons	768,766	377,229	$36,551	$0.097	50,270
Tar derivatives:					
Sodium phenolate or carbolate ... do	3,249	3,261	285	.087	205
Crude chemical oil (tar acid oil) ... do	23,466	20,255	4,684	.231	516
Pitch-of-tar: [2]					
Soft ... thousand short tons	522	209	4,196	20.077	23
Hard ... do	330	154	3,040	19.740	5
Other tar derivatives: [3]	-------	-------	14,525	-------	-------
Ammonia products:					
Sulfate ... thousand short tons	676	598	11,195	18.721	175
Liquor (NH_3 content) ... do	15	15	902	60.133	2
Diammonium phosphate ... do	38	38	3,111	81.868	3
Total ... do	-------	-------	15,208	-------	-------
Sulfate equivalent of all forms ... do	732	696	-------	-------	177
NH_3 equivalent of all forms ... do	230	212	-------	-------	41
Gas:					
Used under boilers, etc. million cubic feet	[4] 962,048	104,861	22,272	.212	-------
Used in steel or allied plants ... do		391,591	95,902	.245	-------
Distributed through city mains ... do		13,818	4,589	.332	-------
Sold for industrial use ... do		84,476	15,220	.180	-------
Total [5] ... do	[4] 962,048	594,746	137,983	.232	-------
Crude light oil ... thousand gallons	[6] 258,910	98,193	12,226	.125	8,588
Light-oil derivatives:					
Benzene:					
Specification grades (1°, 2°, 90%) thousand gallons	97,503	96,503	21,356	.221	4,338
Other industrial grades ... do	4,192	4,339	605	.139	53
Toluene (all grades) ... do	19,603	18,713	5,084	.272	1,490
Xylene (all grades) ... do	5,246	5,381	1,109	.206	595
Solvent naphtha (all grades) ... do	3,567	3,539	577	.163	262
Other light-oil derivatives ... do	6,172	3,583	406	.113	381
Total [5] ... do	136,283	132,058	29,137	.229	7,119
Intermediate light oil ... do	5,019	1,562	126	.081	213
Grand total [5]	-------	-------	257,961	-------	-------

[1] Includes products of tar distillation conducted by oven-coke operators under the same corporate name.
[2] Soft-water-softening point less than 110° F; medium-110° to 160° F; hard-over 160° F. Figures on hard pitch include small amount of medium pitch.
[3] Creosote oil, cresols, cresylic acid, naphthaline, phenol, pyridine, refined tar, tar paint.
[4] Includes gas used for heating ovens and gas wasted.
[5] Data may not add to totals shown because of independent rounding.
[6] 151,787,000 gallons refined by coke-oven operators to make derived products shown.

Table 34.—Coal equivalent of the thermal materials, except coke, produced at oven-coke plants in the United States

Year	Materials produced: Coke breeze (thousand short tons)	Materials produced: Surplus gas (billion cubic feet)	Materials produced: Tar (thousand gallons)	Materials produced: Light oil (thousand gallons)	Estimated equivalent in heating value [1] (billion Btu): Coke breeze	Surplus gas	Tar	Light oil	Total	Coke equivalent (thousand short tons)
1965	4,037	630	802,738	262,701	80,740	346,500	120,411	34,151	581,802	22,206
1966	4,102	630	801,867	262,640	80,240	346,300	120,280	34,143	580,963	22,174
1967	4,025	606	780,334	252,138	80,500	333,300	117,050	32,778	563,628	21,513
1968	4,074	575	760,812	238,887	81,480	316,250	114,114	31,055	542,899	20,721
1969	4,401	595	768,766	258,910	88,020	327,250	115,315	33,658	564,243	21,536

[1] Breeze 10,000 Btu per pound; gas, 550 Btu per cubic foot; tar, 150,000 Btu per gallon; and light oil, 130,000 Btu per gallon.

Table 35.—Average value of coal-chemical materials used or sold and of coke and breeze per short ton of coal carbonized in the United States

	1965	1966	1967	1968	1969
Ammonia products	$0.268	$0.280	$0.254	$0.194	$0.173
Light oil and its derivatives	.505	.481	.441	.427	.435
Surplus gas used or sold	1.556	1.522	1.512	1.483	1.502
Tar and its derivatives (including naphthalene):					
Tar burned by producers [1]	.362	.328	.318	.311	.317
Sold	.672	.677	.675	.727	.685
Total	3.363	3.288	3.200	3.142	3.112
Coke produced	11.890	12.167	12.152	12.246	[2] 12.560
Breeze produced	.301	.292	.318	.314	.388
Grand total	15.554	15.747	15.670	15.702	16.060

[1] Includes pitch-of-tar.
[2] Average value of coke used or sold in 1969.

Table 36.—Percentage of coal costs recovered from the recovery of coal-chemical materials in the United States

	1965	1966	1967	1968	1969
Product:					
Ammonia products	2.8	2.9	2.5	1.9	1.8
Light oil and its derivatives	5.3	4.9	4.4	4.3	4.4
Surplus gas used or sold	16.4	15.6	15.1	15.1	14.4
Tar and its derivatives used or sold (including naphthalene)	11.0	10.3	11.4	10.4	10.5
Total	35.5	33.7	33.4	31.7	31.1
Value of coal per short ton	$9.51	$9.78	$10.02	$10.01	$10.42

Table 37.—Production and disposal of coke-oven gas in the United States in 1969, by States

(Million cubic feet)

State	Produced		Used in heating ovens	Surplus used or sold			Wasted
					Value		
	Total	Thousand cubic feet per ton of coal coked		Quantity	Thousands	Average per thousand cubic feet	
Alabama	78,191	9.75	35,755	40,329	$5,858	$0.145	2,107
California, Colorado, Utah	60,258	11.97	17,514	42,217	6,760	.160	527
Maryland, New Jersey, New York	120,528	10.90	36,299	82,443	24,688	.299	1,786
Illinois	37,562	10.23	12,764	22,591	8,938	.396	2,206
Indiana	118,353	10.09	40,231	77,294	15,951	.206	828
Kentucky, Missouri, Tennessee, Texas	30,282	9.81	14,583	13,203	1,725	.131	2,496
Michigan and Minnesota	54,219	9.32	13,990	38,663	9,185	.238	1,566
Ohio	125,422	10.23	48,002	75,233	20,708	.275	2,187
Pennsylvania	279,834	10.73	111,685	163,669	34,864	.213	4,479
West Virginia	57,397	11.04	17,115	39,103	9,308	.238	1,179
Total 1969 [1]	962,048	10.48	347,940	594,746	137,983	.232	19,362
At merchant plants	69,737	8.88	34,939	32,327	6,341	.196	2,471
At furnace plants	892,311	10.63	313,000	562,419	131,642	.234	16,891
Total 1968	922,910	10.25	331,841	577,278	133,486	.232	13,792

[1] Data may not add to totals shown because of independent rounding.

Table 38.—Surplus coke-oven gas used by producers in the United States and sold in 1969, by States

(Million cubic feet)

State	Used by producers					
	Under boilers, etc.			In steel or allied plants		
		Value			Value	
	Quantity	Thousands	Average per thousand cubic feet	Quantity	Thousands	Average per thousand cubic feet
Alabama	15,853	$2,285	$0.144	20,831	$3,205	$0.154
California, Colorado, Utah	(1)	(1)	(1)	(1)	(1)	(1)
Maryland, New Jersey, New York	2,627	458	.174	71,265	20,987	.294
Illinois	5,518	790	.143	12,637	7,519	.595
Indiana	5,272	1,327	.252	68,729	13,348	.194
Kentucky, Missouri, Tennessee, Texas	6,594	870	.132	(1)	(1)	(1)
Michigan	(1)	(1)	(1)	(1)	(1)	(1)
Minnesota and Wisconsin	(1)	(1)	(1)	(1)	(1)	(1)
Ohio	11,028	5,005	.454	57,898	14,716	.254
Pennsylvania	23,456	4,856	.207	77,224	18,077	.234
West Virginia	(1)	(1)	(1)	(1)	(1)	(1)
Undistributed	34,513	6,681	.194	83,007	18,051	.217
Total 1969 [2]	104,861	22,272	.212	391,591	95,902	.245
At merchant plants	9,816	1,576	.161	850	190	.224
At furnace plants	95,045	20,696	.218	390,741	95,711	.245
Total 1968	91,875	19,937	.217	448,412	104,402	.234

State	Sold					
	Distributed through city mains			For industrial use		
		Value			Value	
	Quantity	Thousands	Average per thousand cubic feet	Quantity	Thousands	Average per thousand cubic feet
Alabama	(1)	(1)	(1)	(1)	(1)	(1)
California, Colorado, Utah	------	------	------	------	------	------
Maryland, New Jersey, New York	------	------	------	(1)	(1)	(1)
Illinois	------	------	------	(1)	(1)	(1)
Indiana	(1)	(1)	(1)	(1)	(1)	(1)
Kentucky, Missouri, Tennessee, Texas	------	------	------	(1)	(1)	(1)
Michigan	(1)	(1)	(1)	(1)	(1)	(1)
Minnesota	(1)	(1)	(1)	(1)	(1)	(1)
Ohio	------	------	------	6,308	986	$0.156
Pennsylvania	(1)	(1)	(1)	(1)	(1)	(1)
West Virginia	(1)	(1)	(1)	(1)	(1)	(1)
Undistributed	13,818	$4,589	$0.332	78,168	$14,233	.182
Total 1969 [2]	13,818	4,589	.332	84,476	15,220	.180
At merchant plants	8,023	2,479	.309	13,638	2,095	.154
At furnace plants	5,795	2,110	.364	70,838	13,124	.185
Total 1968	14,840	5,613	.378	22,152	3,534	.160

[1] Included with undistributed to avoid disclosing individual company confidential data.
[2] Data may not add to totals shown because of independent rounding.

Table 39.—Coke-oven gas and other gases used in heating coke ovens in the United States in 1969, by States [1]

(Million cubic feet)

State	Coke-oven gas	Blast-furnace gas	Natural gas	Total coke-oven gas equivalent
Alabama	35,755	-------	-------	35,755
California, Colorado, Utah	17,514	-------	43	17,557
Maryland, New Jersey, New York	36,299	12,243	412	48,954
Illinois	12,764	5,160	-------	17,925
Indiana	40,231	48,625	1,542	90,398
Kentucky, Missouri, Tennessee, Texas	14,583	-------	-------	14,583
Michigan	13,990	12,717	-------	26,708
Minnesota and Wisconsin	(2)	-------	-------	(2)
Ohio	48,002	3,773	-------	51,775
Pennsylvania	111,685	11,909	-------	123,594
West Virginia	17,115	6,144	-------	23,260
Total 1969 [3]	347,940	100,571	1,997	450,509
At merchant plants	34,939	-------	-------	34,939
At furnace plants	313,000	100,571	1,997	415,569
Total 1968	331,838	95,168	1,785	428,791

[1] Adjusted to an equivalent of 550 Btu per cubic foot.
[2] Included with Michigan to avoid disclosing individual company confidential data.
[3] Data may not add to totals shown because of independent rounding.

Table 40.—Coke-oven ammonia produced in the United States and sold in 1969, by States

(Thousand short tons and thousand dollars)

State	Active plants [1]	Yield of ammonia sulfate		Production	
		Tons	Pounds per ton of coal coked	As sulfate [2]	As liquor (NH_3 content)
Alabama	7	76	19.02	75	(3)
California, Colorado, Utah	3	79	31.66	56	(4)
Maryland, New Jersey, and New York	4	109	20.45	103	(4)
Illinois	4	30	16.61	30	--------
Indiana	6	84	14.35	79	(4)
Kentucky, Tennessee, Texas	3	17	14.88	6	(4)
Michigan	3	29	11.96	29	--------
Minnesota and Wisconsin	(5)	(5)	(5)	(5)	--------
Ohio	11	101	17.16	92	(4)
Pennsylvania	11	162	13.10	162	--------
West Virginia	3	45	17.33	45	--------
Undistributed	--------	--------	--------	--------	15
Total 1969 [6]	55	732	16.68	[7] 676	15
At merchant plants	9	39	14.14	12	8
At furnace plants	46	693	16.85	664	7
Total 1968	57	768	17.06	701	17

State	Sold				On hand Dec. 31	
	As sulfate [2]		As liquor (NH_3 content)		As sulfate [2]	Liquor (NH_3 content)
	Quantity	Value	Quantity	Value		
Alabama	77	$1,297	(3)	(3)	13	-------
California, Colorado, Utah	53	2,451	(4)	(4)	11	(3)
Maryland, New Jersey, New York	94	2,071	(4)	(4)	23	(3)
Illinois	24	656	-------	------	11	-------
Indiana	73	1,240	(4)	(4)	22	(3)
Kentucky, Tennessee, Texas	6	92	(4)	(4)	1	(3)
Michigan	29	1,680	-------	------	9	-------
Minnesota and Wisconsin	(5)	(5)	-------	------	(5)	-------
Ohio	90	1,546	(4)	(4)	18	(4)
Pennsylvania	150	2,734	-------	------	62	-------
West Virginia	40	539	-------	------	9	-------
Undistributed	------	------	15	$902	------	-------
Total 1969 [6]	[8] 636	14,306	15	902	177	2
At merchant plants	12	231	8	425	4	1
At furnace plants	624	14,075	7	477	173	(3)
Total 1968	688	16,535	17	969	137	1

[1] Number of plants that recovered ammonia.
[2] Includes diammonium phosphate.
[3] Less than ½ unit.
[4] Included with "Undistributed" to avoid disclosing individual company confidential data.
[5] Included with Michigan to avoid disclosing individual company confidential data.
[6] Data may not add to totals shown because of independent rounding.
[7] Comprises 638,000 tons of ammonium sulfate and 38,000 tons of diammonium produced in California, Colorado, and Michigan.
[8] Comprises 598,000 tons of ammonium sulfate valued at $11,195,000 and 38,000 tons of diammonium phosphate valued at $3,110,000.

Table 41.—Coke-oven tar produced in the United States, used by producers, and sold in 1969, by States

(Thousand gallons)

State	Produced		Used by producers		
	Total	Gallons per ton of coal coked	For refining or topping	As fuel	Otherwise
Alabama	57,918	7.22	(1)	(1)	(1)
California, Colorado, Utah	49,437	9.82	(1)	(1)	(1)
Maryland, New Jersey, New York	96,368	8.72	(1)	(1)	(1)
Illinois	25,280	6.89	(1)	(1)	(1)
Indiana	85,387	7.28	(1)	(1)	(1)
Kentucky, Missouri, Tennessee, Texas	19,687	6.38	(1)	(1)	(1)
Michigan	31,736	6.55	(1)	(1)	(1)
Minnesota and Wisconsin	9,003	6.38	(1)	(1)	(1)
Ohio	110,124	8.98	3,218	42,816	(1)
Pennsylvania	235,492	9.07	127,987	35,181	587
West Virginia	48,333	9.29	(1)	(1)	(1)
Undistributed	-------	--------	151,579	20,068	84
Total 1969 [2]	768,766	8.33	282,785	98,065	671
At merchant plants	46,112	5.55	681	--------	-------
At furnace plants	722,653	8.61	282,104	98,065	671
Total 1968	760,812	8.45	301,254	104,905	1,650

State	Sold for refining into tar products			On hand Dec. 31
	Quantity	Value: Thousands	Value: Average per gallon	
Alabama	33,220	$3,362	$0.101	5,269
California, Colorado, Utah	28,722	3,027	.105	3,037
Maryland, New Jersey, New York	19,308	1,819	.094	3,840
Illinois	24,009	2,321	.097	1,509
Indiana	35,105	3,093	.088	4,178
Kentucky, Missouri, Tennessee, Texas	19,564	2,123	.109	492
Michigan	26,012	2,445	.094	2,725
Minnesota and Wisconsin	8,862	844	.095	935
Ohio	60,188	6,168	.102	8,618
Pennsylvania	83,443	8,053	.097	16,695
West Virginia	38,795	3,297	.085	2,971
Undistributed	---------	---------	---------	---------
Total 1969 [2]	377,229	36,551	.097	50,270
At merchant plants	45,792	4,542	.099	1,376
At furnace plants	331,437	32,009	.097	48,894
Total 1968	358,039	34,612	.097	40,104

[1] Included with "Undistributed" to avoid disclosing individual company data.
[2] Data may not add to totals shown because of independent rounding.

Table 42.—Coke-oven crude light-oil produced in the United States and derived products produced and sold in 1969, by States

(Thousand gallons)

State	Active plants [1]	Crude light oil: Produced	Crude light oil: Gallons per ton of coal coked	Crude light oil: Refined on premises [2]	Crude light oil: On hand Dec. 31	Derived products: Produced	Derived products: Sold [3] Quantity	Derived products: Sold [3] Value
Alabama	7	17,997	2.44	18,667	832	13,773	13,157	$2,830
California, Colorado, Utah	3	17,598	3.50	11,591	365	10,252	8,340	1,567
Maryland, New Jersey, New York	6	36,054	3.26	22,339	1,070	19,568	19,009	5,441
Illinois, Indiana, and Michigan	10	46,100	2.50	2,379	2,054	1,921	1,993	1,540
Kentucky, Missouri, Tennessee, Texas, West Virginia	8	31,129	3.76	2,337	722	2,343	2,369	358
Ohio	11	31,855	2.63	19,925	1,149	17,066	17,102	3,221
Pennsylvania	11	78,177	3.01	74,548	2,397	71,360	70,088	15,269
Total 1969 [4]	56	258,910	2.87	151,788	8,588	136,282	132,058	30,225
At merchant plants	10	13,468	2.01	9,531	826	7,781	8,007	1,558
At furnace plants	46	245,442	2.94	142,257	7,763	128,501	124,051	28,666
Total 1968	58	238,887	2.65	144,842	10,289	128,248	128,775	26,914

[1] Number of plants that recovered crude light oil.
[2] Includes small quantity of material also reported in sales of crude light oil in table 33.
[3] Excludes 98,193,000 gallons of crude light oil valued at $12,226,000 sold as such.
[4] Data may not add to totals shown because of independent rounding.

Table 43.—Yield of light-oil derivatives from refining crude light oil at oven-coke plants in the United States

(Percent)

Year	Benzene (all grades)	Toluene (all grades)	Xylene (all grades)	Solvent naphtha (crude and refined)	Other light-oil products
1965	63.0	12.8	3.5	2.8	4.1
1966	63.4	12.7	3.4	1.8	3.5
1967	58.9	12.6	3.6	2.4	5.4
1968	63.9	13.6	3.8	2.6	4.6
1969	67.0	13.1	3.5	2.9	4.4

Table 44.—Benzene and toluene produced at oven-coke plants in the United States, by grades

(Thousand gallons)

Year	Benzene: Specification grades (1°, 2°, 90 percent)	Benzene: Other industrial grades	Toluene (all grades)
1965	117,991	3,927	24,816
1966	110,223	3,709	22,791
1967	86,683	3,959	19,358
1968	88,449	4,136	19,645
1969	97,503	4,192	19,603

Table 45.—Light-oil derivatives produced at oven-coke plants in the United States and sold in 1969, by States

(Thousand gallons and thousand dollars)

State	Benzene (all grades) Produced	Benzene Yield from crude light-oil refined (percent)	Benzene Sold Quantity	Benzene Sold Value	Toluene (all grades) Produced	Toluene Yield from crude light-oil refined (percent)	Toluene Sold Quantity	Toluene Sold Value
Alabama	10,173	54.5	9,501	$2,157	2,461	13.9	2,486	$476
Colorado, Illinois, and Utah	7,856	57.8	8,250	1,616	1,725	12.7	888	182
Indiana, Maryland, and New York	17,296	72.1	16,462	3,441	1,429	6.3	1,534	1,852
Ohio	12,642	63.4	12,686	2,406	3,071	15.4	3,068	594
Pennsylvania	52,177	69.4	52,351	12,076	10,677	14.6	10,505	1,941
Tennessee and Texas	1,551	53.11	1,592	267	240	10.3	232	39
Total 1969 [1]	101,695	67.0	100,842	21,961	19,603	13.1	18,713	5,084
At merchant plants	5,537	58.1	5,681	1,226	1,197	12.6	1,296	192
At furnace plants	96,158	67.6	95,161	20,736	18,406	13.2	17,417	4,891
Total 1968	92,585	63.9	97,434	21,311	19,645	13.6	19,867	3,704

State	Xylene (all grades) Produced	Xylene Yield from crude light-oil refined (percent)	Xylene Sold Quantity	Xylene Sold Value	Solvent naphtha (crude and refined) Produced	Solvent naphtha Yield from crude light-oil refined (percent)	Solvent naphtha Sold Quantity	Solvent naphtha Sold Value
Alabama	524	3.0	575	$135	245	2.8	238	$27
Colorado, Illinois, and Utah	353	2.6	351	78	364	2.7	245	56
Indiana, Maryland, and New York	214	0.9	366	77	(2)	(2)	(2)	(2)
Ohio	740	3.7	711	143	612	3.4	637	78
Pennsylvania	3,370	4.6	3,334	663	2,191	3.3	2,209	388
Tennessee and Texas	44	1.9	43	13	153	0.8	209	1,116
Total 1969 [1]	5,245	3.5	5,381	1,109	3,567	2.9	3,539	1,665
At merchant plants	247	2.6	243	58	41	1.3	37	8
At furnace plants	4,999	3.6	5,138	1,051	3,526	2.9	3,502	1,657
Total 1968	5,576	3.8	5,473	1,088	3,714	2.6	2,921	460

[1] Data may not add to totals shown because of independent rounding.
[2] Included with Tennessee and Texas to avoid disclosing individual company confidential data.

Table 46.—Estimated consumption of commerical benzene (excluding motor grade) in the United States, by use [1]

(Million gallons)

	1965	1966	1967	1968	1969
Styrene	312	360	378	398	506
Phenol (synthetic)	161	178	178	165	220
Dodecylbenzene	34	42	45	38	35
Cyclohexane	160	184	172	197	242
Aniline	24	29	30	28	40
DDT	14	14	11	11	13
Dichlorobenzene and monochlorobenzene	20	20	20	20	20
Maleic anhydride	22	28	29	33	37
Diphenyls	5	5	5	5	5
Nitrobenzene	2	2	2	2	2
Miscellaneous	20	20	27	25	25
Reported	45	97	100	80	92
Total	819	979	997	1,002	1,237

[1] Coal Chemicals Committee, American Coke and Coal Chemicals Institute, Washington, D.C.

Columbium and Tantalum

By Meherwan C. Irani [1]

Consumption of columbium as indicated by imports rose 14 percent in 1969. The primary use of columbium in the form of ferrocolumbium in steelmaking increased 22 percent to a new record high. The consumption of tantalum, which continued to be used primarily in the manufacture of capacitors, fell 21 percent. About 2,456,488 pounds of combined pentoxides (Cb_2O_5 + Ta_2O_5) was sold to industry from Government stocks on sealed bids.

[1] Metallurgist, Eastern Field Operation Center, Pittsburgh, Pa.

Table 1.—Salient columbium statistics
(Thousand pounds)

	1965	1966	1967	1968	1969
United States:					
Mine production of columbite-tantalite concentrates	------	W	W	W	W
Releases from Government stocks (Cb content)[1] [2]	------	1,659	779	1,191	1,573
Consumption of concentrate: Columbium metal contained in all raw materials consumed (Cb content) [1]	2,749	3,873	r 4,519	r 3,997	2,918
Production of primary products:					
Columbium metal (Cb content)	W	W	W	W	W
Ferrocolumbium and ferrotantalum-columbium (Cb + Ta content)	1,961	3,664	1,960	2,380	2,554
Consumption of primary products:					
Columbium metal (Cb content)	33	100	111	92	179
Ferrocolumbium and ferrotantalum-columbium (Cb + Ta content)	2,199	2,697	3,192	r 3,094	3,328
Exports:					
Columbium ore and concentrate (gross weight)	NA	NA	NA	NA	NA
Columbium metal, compounds, and alloys (gross weight)	4	7	6	7	41
Imports for consumption:					
Columbium mineral concentrate (gross weight)	4,892	9,278	7,431	3,657	4,161
Columbium metal and columbium-bearing alloys (Cb content)	10	4	(3)	1	5
Ferrocolumbium (gross weight) e	691	1,280	629	1,171	NA
World: Production of columbium-tantalum concentrates (gross weight)	14,617	23,031	20,551	19,844	29,192

e Estimate. r Revised. W Withheld to avoid disclosing individual company confidential data.
NA Not available.
[1] Includes columbium content in raw materials from which columbium is not recovered.
[2] Includes material released as pigment-in-kind for upgrading.
[3] Less than ½ unit.

Table 2.—Salient tantalum statistics

(Thousand pounds)

	1965	1966	1967	1968	1969
United States:					
Mine production of columbium-tantalum concentrates	------	W	W	W	W
Releases from Government stocks (Ta content) [1] [2]	------	634	307	163	171
Consumption of concentrate: Tantalum metal contained in all raw materials consumed (Ta content) [1]	775	1,392	1,730	1,060	928
Production of primary products:					
Tantalum metal (Ta content)	712	1,064	1,021	692	1,046
Ferrocolumbium and ferrotantalum-columbium (Cb + Ta content)	1,961	3,664	1,960	2,380	2,554
Consumption of primary products:					
Tantalum metal (Ta content)	435	493	443	423	751
Ferrocolumbium and ferrotantalum-columbium (Cb + Ta content)	2,199	2,697	3,192	r 3,094	3,328
Exports:					
Tantalum ore and concentrate (gross weight)	284	163	75	65	85
Tantalum metal, compounds, and alloys (gross weight)	21	35	59	106	124
Tantalum and tantalum alloy powder (Ta content)	25	51	51	84	100
Imports for consumption:					
Tantalum mineral concentrates (gross weight)	1,196	2,143	1,675	1,230	975
Tantalum metal and tantalum-bearing alloys (Ta content)	26	48	55	18	11
World: Production of columbium-tantalum concentrates (gross weight)	14,617	23,031	20,551	19,844	29,192

r Revised. W Withheld to avoid disclosing individual company confidential data.
[1] Includes tantanlum content in raw materials from which tantalum is not recovered.
[2] Includes material released as payment-in-kind for upgrading.

Legislation and Government Programs.—During 1969 the Office of Mineral Exploration (OME), U.S. Geological Survey continued to offer financial assistance of 50 percent (columbium) and 75 percent (tantalum) for the exploration and development of approved columbium and tantalum resources. The General Services Administration (GSA) continued its columbite disposal program during 1969. It sold to industry 2,456,488 pounds of combined pentoxides containing 1,572,823 pounds of columbium and 170,749 pounds of tantalum from the Defense Production Act (DPA) inventory in February, April, June, August, October, and December at prices ranging from $0.81 to $1.19 per

Table 3.—Columbium and tantalum materials in Government inventories as of Dec. 31, 1969

(Thousand pounds, columbium and tantalum content)

Material	Objective	National (strategic) stockpile	Defense Production Act (DPA) inventory	Supplemental stockpile	Total
COLUMBIUM					
Concentrates	-----	5,999	2,735	358	9,092
Carbide powder: Stockpile grade	20	21	-----	---	21
Ferrocolumbium:					
Stockpile grade	930	554	-----	---	554
Nonstockpile grade	-----	553	-----	---	553
Metal: Stockpile grade	45	44	-----	---	44
Oxide powder: Stockpile	-----	86	-----	---	86
TANTALUM					
Tantalum minerals: Stockpile grade	2,947	3,149	925	6	4,080
Carbide powder: Stockpile grade	27	29	-----	---	29
Metal: Stockpile grade	360	201	-----	---	201

pound of the mixed oxides. The total value of these sales amounted to $2,456,493.

The companies which purchased columbium and tantalum concentrate from GSA during 1969 are listed below.

Company	Pounds of combined pentoxides ($Cb_2O_5 + Ta_2O_5$)	Approximate columbium content (pounds of Cb)	Approximate tantalum content (pounds of Ta)
Associated Metals & Minerals Corp	98,913	63,223	6,938
Intsel Corp	16,394	11,346	113
International Selling Corp	36,992	25,356	590
Kawecki Berylco Industries, Inc	248,974	151,209	26,742
Nissho-Iwai American Corp	66,931	44,490	2,691
Norton Company	90,050	54,247	10,231
Metada Enterprises, Inc	13,839	8,596	1,261
Metallurg Inc	164,924	110,248	7,063
Philipp Brothers Division of Engelhard Minerals and Chemicals Corp	1,376,629	888,196	87,262
South American Minerals and Merchandising Corp. (SAMINCORP)	74,975	48,682	4,352
Socomet Inc	27,794	16,744	3,157
Teledyne Wah Chang Albany	97,034	58,540	10,924
Union Carbide Corp	143,039	91,946	9,425

DOMESTIC PRODUCTION

Domestic mining activity was insignificant during the year. Only two companies reported shipments of small quantities of columbium-tantalum concentrates from two mines in South Dakota. The shipments were from materials stockpiled during 1968.

Production of columbium metal powder increased 259 percent in 1969, but data continued to be withheld to avoid disclosing individual company confidential data. There was an approximate 250-percent increase in production of columbium metal ingots during the year, but the production figures also cannot be revealed. Production of tantalum metal powder (including capacitor-grade powder) increased 51 percent to 523 tons in 1969.

Ferrocolumbium, ferrotantalum-columbium-base, and/or columbium base master alloys were produced by the thermite process by the Kawecki Division of Kawecki Berylco Industries, Inc. (formerly Kawecki Chemical Co.), Reading Alloys Co., Inc., and Shieldalloy Corp. Molybdenum Corporation of America (Molycorp.) Union Carbide Corp. and the Metallurgical Products Division of Foote Mineral Co. produced these alloys in electric furnaces.

Table 4.—Major domestic columbium and tantalum processing and producing companies in 1969

Company	Location	Columbium	Tantalum	Tantalum carbide	Ferrocolumbium	Ferrotantalum-columbium
Fansteel Inc	Muskogee, Okla	X	X	X	----	----
General Electric Co	Euclid, Ohio	X	X	----	----	----
Kawecki Division, Kawecki Berylco Industries, Inc	Boyertown, Pa	X	X	X	X	----
Kennametal, Inc	Latrobe, Pa	X	X	X	----	----
Linde Division, Union Carbide Corp	Indianapolis, Ind	X	X	X	----	----
Mallinckrodt Chemical Works	St. Louis, Mo	X	X	X	----	----
Mining and Metals Division, Union Carbide Corp	Niagara Falls, N.Y.; Marietta, Ohio	X	X	----	X	X
Molybdenum Corporation of America	Washington, Pa	----	----	----	X	X
Metals Division, Norton Co	Newton, Mass	X	X	----	----	----
Reading Alloys, Co., Inc	Robesonia, Pa	----	----	----	X	X
Shieldalloy Corp	Newfield, N.J	----	----	----	X	X
Stellite Works, Materials Systems Division, Union Carbide Corp	Kokomo, Ind	X	X	X	----	----
Metallurgical Products Division, Foote Mineral Co	Vancoram, Ohio; Graham, W. Va	----	----	----	X	X
Wah Chang Albany (A Teledyne Company)	Albany, Oreg	X	X	X	----	----

CONSUMPTION AND USES

Columbium consumption in the form of high-purity metal totaled 179,446 pounds, an increase of 94 percent over that of 1968. Tantalum metal (including capacitor-grade powder) consumed during the year increased 78 percent and totaled 751,259 pounds.

Use of columbium in ferroalloy additions to steels continued to account for approximately 90 percent of the metal consumed. Total consumption of columbium plus tantalum in ferroalloys increased to 3.3 millon pounds compared with revised 1968 consumption figures of 3.1 million pounds. Domestic consumption of ferrocolumbium (FeCb) during the year, by major use catagories, was as follows: Alloy steel other than stainless and heat-resisting alloys (36 percent), superalloys (24 percent), carbon steels (21 percent), and stainless and heat-resisting steels (16 percent).

Consumption of ferrotantalum-columbium (FeTa-Cb) continued to be small and amounted to less than 1 percent of the total reported FeCb plus FeTa-Cb consumption, compared with slightly more than 1 percent in 1968. The major uses of ferrotantalum-columbium in 1968 were in the production of stainless and heat-resisting steel (53 percent), miscellaneous and unspecified uses (38 percent), and other alloy steels (9 percent). Additional data on ferrocolumbium and ferrotantalum-columbium are contained in the "Ferralloy" chapter.

Table 5.—Reported shipments of columbium and tantalum materials
(Pounds of metal content)

Material	1968	1969	Percent change
Columbium products:			
Compounds, including alloys	r 2,121,600	1,651,750	−22.1
Metal, including worked products	47,363	109,898	+132.0
All other	---------	4,700	-------
Total Cb	r 2,168,963	1,766,348	−18.6
Tantalum products:			
Oxides and salts	63,000	57,400	−8.9
Alloy additive	16,300	13,700	−16.0
Carbide	62,350	174,300	+179.6
Powder and anodes	458,303	474,742	+3.6
Ingot (unworked consolidated metal)	14,360	21,600	+50.4
Mill products	171,117	206,035	+20.4
Scrap	12,163	37,000	+204.2
Other	1,100	---------	-------
Total Ta	798,693	984,777	+23.3

r Revised.

Atomergic Chemicals Co. announced the availability of electron-beam-melted columbium ingots over 99.99-percent pure.

Linde Division of Union Carbide Corp. disclosed the development of an AC columbium-coated superconductive cable. It consists of three pipes within a pipe. The outer surface of the smaller pipe and the inner surface of the larger pipe will be coated with ultrapure columbium—the conductor. The fourth pipe will carry liquid helium, which will also be distributed throughout the entire cable. The pure columbium will be deposited on a backing of tubular metal by a proprietary molten-salt electroplating process.

Table 6.—Consumption of ferrocolumbium and ferrotantalum-columbium in the United States by end use, 1969

End use	Pounds of contained columbium plus tantalum
Steel:	
Carbon	707,729
Stainless and heat-resisting	537,151
Alloy (excludes stainless and heat-resisting)	1,190,582
Superalloys	803,211
Alloys (excludes alloy steels and superalloys)	74,143
Miscellaneous and unspecified [1]	15,411
Total	3,328,227

[1] Includes tool steel.

STOCKS

The following yearend columbium and tantalum materials (given in pounds) were reported in inventories:

Material	Dec. 31, 1968	Dec. 31, 1969
COLUMBIUM		
Primary metal	42,268	46,451
Ingot	r 47,924	40,845
Scrap	r 77,192	122,132
Oxide	679,604	712,959
Other compounds	16,366	20,753
TANTALUM		
Primary metal	154,752	92,233
Capacitor-grade powder	146,295	123,595
Ingot	r 172,199	89,067
Scrap	r 188,855	260,935
Oxide	293,111	117,963
Potassium tantalum fluoride (K_2TaF_7)	455,881	138,779
Other compounds	44,040	48,346

r Revised.

Stocks of columbium and tantalum raw materials, as reported by consumers and dealers at yearend 1969, were as follows (in short tons—1968 figures in parentheses): Columbite, 432 (1,020); tantalite, 2,147 (1,972); pyrochlore, 392 (464); tin slag, 30,397 (31,981); and other, 226 (233).

Consumer inventories of ferrocolumbium and ferrotantalum-columbium, as of December 31, 1969, were as follows (with 1968 yearend stocks in parentheses): Ferrocolumbium, 849,189 pounds contained columbium plus tantalum (Cb + Ta) (561,013); and ferrotantalum-columbium, 15,736 pounds contained (Cb + Ta) (16,800). Producer stocks of ferrocolumbium at yearend 1969 were 1,168,000 pounds contained Cb (1,194,300); producer stocks of ferrotantalum-columbium were withheld to avoid disclosing individual company confidential data.

PRICES

Prices for columbite ores, as reported by Metals Week, increased during the year. Columbite ore, c.i.f. U.S. ports increased from $0.80–$0.89 per pound of contained pentoxides for material having a Cb_2O_5 to Ta_2O_5 ratio of 10 to 1 at the beginning of 1969 to $1.12–$1.17 per pound at yearend. Columbite was reportedly sold at a discount under long-term contracts. The prices were subject to negotiation and no quotations were published. The quoted price of Brazilian pyrochlore concentrate, f.o.b. shipping point, remained constant during the year at $0.995 per pound of Cb_2O_5. The price of Canadian pyrochlore concentrate, f.o.b. mine or mill, increased from $0.92–$0.98 per pound to $1–$1.05. The price for tantalite ore and concentrate, 60-percent basis, at the yearend was $6.75–$7.50 per pound Ta_2O_5, c.i.f. U.S. ports, as compared to $5.50–$7.50 at the beginning of the year. The contract price for Canadian tantalite concentrate, 50-percent basis, at the yearend was $7 per pound of contained Ta_2O_5.

The quoted price for various grades of ferrocolumbium per pound of columbium content, ton lots, f.o.b. shipping points, at the beginning of the year were as follows: Low alloy, standard grades, $2.45 to $2.60; and high-purity grades, $3.82 to $4.50. Quotation at yearend increased to $2.05–$3.52 for the low-alloy grades and $4.28–$5.53 for high-purity grades.

Through November, tantalum metal was quoted at $32 to $46 per pound for powder, $36 to $60 per pound for sheet, and $40 to $52 per pound for rod. In December these prices were quoted at $26 to $36, $36 to $60, and $35 to $50, respectively.

Throughout the year the price of columbium metal remained unchanged. Columbium-powder roundels, 99.5-to 99.8-percent purity, were quoted at $11 to $22 per pound for metallurgical-grade material and at $12 to $23 per pound for reactor-grade material. Columbium ingots were quoted at $16 to $27 per pound for metallurgical-grade material and at $17.50 to $28 per pound for reactor-grade material.

Table 7.—Average grade of imported concentrate received by U.S. consumers and dealers in 1969 by country of origin

(Percent of contained pentoxides)

Country of origin	Columbite			Tantalite	
	Cb_2O_5	Ta_2O_5	Ratio	Ta_2O_5	Cb_2O_5
Argentina	----	----	----	36	30
Australia	----	----	----	44	29
Belgium	----	----	----	30	28
Brazil [1] [2]	55	0.054	1,019:1	43	19
Burundi	----	----	----	40	30
Canada [3]	52	.004	1,300:1	56	.021
Congo (Kinshasa) [1]	----	----	----	43	38
Germany, West [4]	55	15	3.7:1	----	----
Malaysia	64	16	4:1	40	71
Mozambique	----	----	----	10	64
Nigeria [1]	65	7	9.3:1	31	49
Norway	45	.007	643:1	----	----
Rwanda	55	16	3.4:1	----	----
South Africa, Republic of	----	----		40	47
Spain	----	----		34	37
Thailand [1]	----	----		32	26

[1] Excludes tin slag.
[2] Material reported from Brazil as columbite represents primarily pyrochlore.
[3] Contains pyrochlore and columbite.
[4] Material reported as tantalite is primarily columbite.

FOREIGN TRADE

Most of the exports of columbium and tantalum were to Western Europe, Japan, and Canada. Tantalum powder, which was the largest export item by value, was destined for West Germany (31 percent), the United Kingdom (18 percent), Japan (16 percent), Austria (12 percent), Canada (7 percent), France (5 percent), the Netherlands (5 percent), and Italy (4 percent). The remainder of the tantalum powder exported (2 percent of the total) was destined for Switzerland, Sweden, Uruguay, Belgium-Luxembourg, India, Yugoslavia, and Iran. Wrought tantalum and tantalum and tantalum alloys, which accounted for the next largest value item, were exported as follows: Belgium-Luxembourg (48 percent), France (12 percent), the United Kingdom (10 percent), Japan (10 percent), West Germany (8 percent), and Canada (6 percent). The remainder (totaling 6 percent) was exported to the Netherlands, Italy, India, Sweden, Mexico, Argentina, Australia, Poland, Chile, Taiwan, Venezuela, and the Republic of South Africa. Unwrought tantalum metal and alloys in crude form and scrap were exported to the United Kingdom (25 percent), Japan (25 percent), West Germany (42 percent), Sweden (2 percent), Canada (5 percent), and Belgium-Luxembourg, and Italy (1 percent). Tantalum ore and concentrate, believed not to be of domestic origin, was shipped to Austria (26 percent), Japan (21 percent), United Kingdom (34 percent), West Germany (13 percent), France (5 percent), and Canada (1 percent).

Table 8.—U.S. exports of columbium and tantalum, by classes

(Thousand pounds, gross weight, and thousand dollars)

Class	1968		1969	
	Quantity	Value	Quantity	Value
Columbium and columbium alloys, unwrought, and waste and scrap	2	$28	5	$94
Columbium and columbium alloys, wrought	6	263	36	507
Tantalum ores and concentrates	65	142	85	357
Tantalum and tantalum alloys, wrought	13	727	29	1,391
Tantalum metals and alloys in crude form and scrap	93	1,030	95	904
Tantalum and tantalum alloy powder	84	2,668	100	2,952

Imports of unwrought columbium alloy, all from West Germany, totaled 5,119 pounds valued at $7,823. Imports of unwrought columbium metal, waste, and scrap, totaling 66 pounds valued at $1,336, were received from West Germany (62 percent) and Switzerland (38 percent). A small quantity of wrought columbium totaling 28 pounds valued at $2,252 was imported from the United Kingdom (61 percent) and France (39 percent). Imports for consumption of unwrought tantalum metal, including waste and scrap, decreased 34 percent during the year to 10,889 pounds, tantalum content, valued at $58,653. This material was imported from the United Kingdom (40 percent), France (40 percent), Belgium-Luxembourg (14 percent), Canada (5 percent), and West Germany and Switzerland (1 percent). Imports of unwrought tantalum alloys, all from West Germany, decreased to 56 pounds valued at $1,982 during the year. A very small quantity of wrought columbium totaling 4 pounds valued at $270 was imported from the United Kingdom.

Table 9.—Receipts of tin slags reported by consumers

(Thousand pounds)

Year	Gross weight	Cb_2O_5 content	Ta_2O_5 content
1967	28,913	2,902	1,572
1968	8,709	541	510
1969	8,327	649	453

Table 10.—U.S. imports for consumption of columbium-mineral concentrates by countries

(Thousand pounds and thousand dollars)

Country	1967		1968		1969	
	Quantity	Value	Quantity	Value	Quantity	Value
Angola	-----	-----	33	$94	22	$42
Argentina	11	$17	2	6	-----	-----
Australia	1	4	-----	-----	-----	-----
Belgium-Luxembourg [1]	33	111	-----	-----	41	72
Brazil	3,536	1,963	2,163	1,348	2,462	1,440
Burundi-Rwanda	15	47	8	12	48	62
Canada	891	482	295	157	920	473
Congo (Kinshasa)	66	189	207	542	90	182
Gabon	-----	-----	7	4	-----	-----
Germany, West	80	224	-----	-----	-----	-----
Kenya	-----	-----	6	6	-----	-----
Malagasy Republic	7	9	-----	-----	-----	-----
Malaysia	202	272	133	122	59	49
Mozambique	11	19	18	34	4	7
Netherlands [1]	-----	-----	13	19	69	48
Nigeria	2,519	1,848	737	431	423	267
Portugal	18	29	16	30	-----	-----
Rhodesia, Southern	8	13	3	11	-----	-----
Spain	-----	-----	9	26	20	37
Uganda	4	5	7	6	3	2
United Kingdom	18	15	-----	-----	-----	-----
Western Africa, n.e.c	11	19	-----	-----	-----	-----
Total	7,431	5,266	3,657	2,848	4,161	2,681

[1] Presumably country of transshipment rather than original source.

Table 11.—U.S. imports for consumption of tantalum-mineral concentrates by countries

(Thousand pounds and thousand dollars)

Country	1967		1968		1969	
	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	3	$17	7	$25	-----	-----
Australia	58	211	71	247	75	$170
Belgium-Luxembourg[1]	60	244	15	42	30	97
Brazil	356	1,668	342	1,472	253	767
Burundi-Rwanda	45	136	62	144	31	47
Canada	-----	-----	-----	-----	220	1,195
Central African Republic	5	32	-----	-----	-----	-----
Congo (Kinshasa)	313	798	242	845	179	394
Cyprus	-----	-----	1	1	-----	-----
Germany, West	-----	-----	22	108	-----	-----
Kenya	21	53	5	9	-----	-----
Malagasy Republic	15	23	-----	-----	-----	-----
Malaysia	33	106	15	10	25	15
Mozambique	241	988	306	869	77	350
Netherlands[1]	42	86	41	65	-----	-----
Nigeria	135	233	20	77	8	23
Portugal	99	262	24	76	-----	-----
Rhodesia, Southern	41	183	17	72	-----	-----
South Africa, Republic of	18	98	14	25	19	36
Spain	11	37	14	30	27	40
Tanzania	-----	-----	-----	-----	9	22
Thailand	138	212	-----	-----	22	40
Uganda	24	67	12	47	-----	-----
Western Africa, n.e.c.	17	56	-----	-----	-----	-----
Total	1,675	5,510	1,230	4,164	975	3,196

[1] Presumably country of transshipment rather than country of origin.

Table 12.—U.S. import duties

Tariff classification number	Article	Rate of duty per pound[1]	
		Effective Jan. 1, 1969	Effective Jan. 1, 1970
601.21	Columbium concentrate	Free	Free.
601.42	Tantalum concentrate	do	Do.
607.80	Ferrocolumbium and ferrotantalum-columbium	8 percent ad valorem	7 percent ad valorem.
	Columbium:		
628.15	Unwrought, waste and scrap	do	Do.
628.20	Wrought	14 percent ad valorem	12.5 percent ad valorem.
628.17	Unwrought Cb alloys	12 percent ad valorem	10 percent ad valorem.
	Tantalum:		
629.05	Unwrought, waste and scrap	8 percent ad valorem	7 percent ad valorem.
629.10	Wrought	14 percent ad valorem	12.5 percent ad valorem.
629.07	Unwrought Ta alloys	12 percent ad valorem	10 percent ad valorem.
423.00	Columbium and tantalum chemicals	8 percent ad valorem	7 percent ad valorem.

[1] Not applicable to Communist countries.

WORLD REVIEW

Australia.—Greenbushes Tin N.L. revealed plans to spend $120,000 for mining operations at the Greenbushes tin-and tantalum-bearing pegmatite deposit. Geological investigation of the property revealed a 3-mile-long pegmatite carrying low-grade values in serpentine rocks.

Vulcan Minerals Ltd. completed a successful test-drilling on one of its leases at Bridgetown, Greenbushes, Western Australia. The drilling indicated a proved tin-tantalum deposit of 140,000 cubic yards with an additional inferred reserves of 816,000 cubic yards. The company reported completion of its new plant designed to attain a five-fold increase in production capability of 1,700 pounds per week of tin-tantalite concentrate.

Brazil.—There was continued strong demand for Brazilian columbium concentrate in 1969. Companhia Brasileira de Metalúrgia e Mineração (CBMM), which is 33-percent owned by Molybdenum Corporation of America continued to be the world's largest producer of columbium concentrates. It produced 11.3 million pounds of columbium oxide contained in concentrate, more than double the 1968 production. The mine, located near Araxá, is a large deposit of high-grade pyrochlore containing over 4 percent Cb_2O_5.

Table 13.—Production of columbium and tantalum mineral concentrates by countries [1] [2]

(Pounds, gross weight)

Country [3]	1967		1968		1969 p	
	Columbium	Tantalum	Columbium	Tantalum	Columbium	Tantalum
Argentina	6,614		----------		NA	
Australia	r 79,587		231,134		e 95,000	
Brazil:						
Columbite-tantalite [4]	r 223,769	r 451,781	138,428	598,828	NA	NA
Pyrochlore	10,198,572	--------	11,020,895	------	19,098,623	------
Canada: Pyrochlore e	r 4,318,850	--------	4,362,943	------	6,020,817	------
Congo (Kinshasa) [5]	100,489		249,122		e 220,462	
French Guiana	2,200		----------		----------	
Ivory Coast	----------		1,393		465	
Malagasy Republic	148		2,985		NA	
Malaysia	r 194,884		114,199		e 132,000	
Mozambique:						
Columbite-tantalite	r 195,204		135,906		e 132,000	
Microlite	----------	r 154,844	----------	199,375	----------	NA
Nigeria	4,309,752	42,558	2,527,817	25,133	3,340,065	13,351
Portugal [6]	30,865		26,455		e 20,900	
Rwanda	69,225		61,729		48,502	
South Africa, Republic of	----------	11,023	----------	39,683	----------	e 13,000
Thailand	101,412		88,185		57,320	
Uganda	59,763		19,842		NA	
Total [7]	r 20,551,540		19,844,052		29,192,505	

e Estimate. p Preliminary. r Revised. NA Not available.

[1] Excludes columbium and tantalum-bearing tin slag.

[2] When the content of neither Cb_2O_5 nor Ta_2O_5 predominates, or when insufficient identification is available, the production figure is given in the center column under each year.

[3] Columbium and tantalum mineral concentrates are also produced in Spain, South-West Africa, Southern Rhodesia and the U.S.S.R., but quantitative data are not available.

[4] Exports.

[5] In addition, Congo (Kinshasa) produces tin-tantalum-columbium concentrate; 1968 output was 176,370 pounds containing about 10 percent combined $Ta_2O_5 + Cb_2O_5$.

[6] As reported. Trade data suggest actual output may be greater than reported.

[7] Total is of listed figures in all three columns under each year.

Canada.—St. Lawrence Columbium and Metals Corp. continued to be Canada's sole columbium producer in 1969. It produced pyrochlore concentrates containing 3.5 million pounds of columbium pentoxide from its underground mining operations near Oka, Quebec. The milling rate increased from an average of 39,600 tons per month in the beginning of 1969 to an average of 54,100 tons during the last quarter. By yearend the mill capacity was reportedly increased to 60,000 tons per month. St. Lawrence indicated that it anticipated production of 4,500,000 pounds of columbium pentoxide during the fiscal year beginning September 1969.

Tantalum Mining Corporation of Canada Ltd. (TMCC), the only commercial tantalum mine in North America, started operation of its 500-ton-per-day mill in September 1969. The flat-lying pegmatite sill containing tantalite is located at Bernic Lake, about 120 miles northeast of Winnipeg, Manitoba. The deposit is worked by underground methods. It is reported that the size of the pegmatite is at least 3,500 feet long and 1,500 feet wide with a maximum thickness of 280 feet. The tantalite-bearing zone of the pegmatite is in the medial portion of the sill. The ore reserves are reportedly estimated at 1,900,000 tons grading 0.23 percent tantalum oxide. By yearend the mill was reportedly operating at close to its 500-ton-per-day rated capacity. The processing scheme involves gravity concentration and low-intensity magnetic separation. It is reported that tests have indicated that the mill would recover about 70 percent of the tantalum oxide contained in the ore. The concentrate was reportedly sold at a price of $7 per pound of tantalum pentoxide in 50-percent-plus concentrate, f.o.b. mine. TMCC is owned by Goldfield Corp. (60 percent) and Chemalloy Minerals Ltd. (40 percent).

Congo (Kinshasa).—Sociéte Miniére-Union Carbide-Somikubi (SOMUCAR), a joint venture of Union Carbide, Belgian interests, and the Government of the Democratic Republic of the Congo announced plans for the development of a columbium ore body (pyrochlore). The deposit, located at Bingo in Kivu Province, reportedly has proven ore reserves of 2.3 million tons containing 3.6 percent columbium pentoxide to depths of 25 meters. Probable ore reserves are estimated at 4.8 million tons grading 2.4 percent columbium pentoxide. The mine is expected to be in production early in 1970.

Mozambique.—Columbo-tantalite ore was mined principally in the District of Zambezia near Ile, Alto Nolocue, Maganja da Costa, and Nocuba. The best ore is reportedly found in the mineralized pegmatites of Alto Ligonha. Over the years columbo-tantalite has generally ranked fourth in value among the minerals mined in Mozambique. The columbium-tantalite was exported mostly to the United States and the United Kingdom.

Nigeria.—In response to increased demand and rising prices Nigeria's production of columbite rose from 94.66 tons in January to 162.32 tons in December. Nigeria continued to rank third (behind Brazil and Canada) in columbium production. The local price reportedly rose from approximately 150–160 shillings (sterling) to more than 200 shillings (sterling) per long ton for high-grade material during the year.

TECHNOLOGY

Studies of columbium-bearing materials were continued by the Bureau of Mines. The effects of the microstructure on superconductivity in the columbium-hafnium system were studied.[2] It was found that in the absence of an external magnetic field, the current-carrying capacity of columbium was greatly reduced with addition of up to 85 weight-percent hafnium.

Alloys in wire and rod form were evaluated by critical temperature, critical current, magnetization, resistivity measurements, and optical and electron microscopy. Elevated-temperature, electrical-resistivity measurements were made on arc-melted, spin-cast, and hot-pressed columbium carbide-carbon (CbC-C) up to 2,000° C.[3]

Tetragonal silicides of columbium and tantalum were investigated for the presence of a superconducting transition temperature.[4] These compounds containing up to 37.5 atomic percent silicon were found to become superconducting at temperatures near 7.5° K.

A report on the sampling and evaluation of tantalum-bearing pegmatite dikes, conducted by the Federal Bureau of Mines during the summer of 1963 in the Rociada area of Mora and San Miguel Counties, N. Mex. was published.[5] Eleven dikes, in an area of about 4 square miles, were stripped of overburden and sampled at regular intervals. Samples were also collected from an existing adit, shaft workings, and an open cut.

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[2] Siemens, R. E., L. L. Oden, and D. K. Deardorff. Effect of Microstructure on Superconductivity in the Columbium-Hafnium System. BuMines Rept. of Inv. 7258, 1969, 29 pp.

[3] Paulson, Denton L., and Gene Asai. Electrical Resistivity of Hyperstoichiometric Columbium and Zirconium Carbide Materials at Elevated Temperatures. BuMines Rept. of Inv. 7289, 1969, 30 pp.

[4] Deardorff, D. K., R. E. Siemens, P. A. Romans, and R. A. McCune. New Tetragonal Compounds Nb_3Si and Ta_3Si. J. Less Common Metals, v. 18, No. 1, May 1969, pp. 11–26.

[5] Sheffer, Herman W., and Louis A. Goldsmith. Tantalum Project. Rociada, New Mexico. State Bureau of Mines and Mineral Resources, New Mexico Institute of Mining and Technology, Socorro, N. Mex., Miner. Res. Rept. 2, 1969, 15 pp.

Copper

By Harold J. Schroeder [1] and John W. Cole [1]

Increases in production were posted by most of the major copper-producing countries of the world with the exceptions of Canada, where a long labor strike in the nickel mining industry reduced the copper output, and Peru, where a 42-day labor strike at Southern Peru Copper Corp. reduced copper output. Domestic mine, smelter and refinery production was essentially uninterrupted and production of copper from primary and secondary sources was the highest in history.

Legislation and Government Programs.—The quantity of copper in the national stockpile, on December 31, 1969, was 60,112 tons of oxygen-free, high-conductivity (OFHC) copper, 7,085 tons of copper in beryllium-copper master alloy, and 193,286 tons of copper in the "other" classification for a total of 260,483 tons, 33 percent of the objective of 775,000 tons. During 1969, about 8,000 tons of the "other" classification copper was released to Government agencies.

The U.S. Office of Minerals Exploration (OME) continued to offer up to 75-percent Government participation in the authorized cost of exploration for copper deposits. Three participating contracts were executed during 1969 as follows:

Operator	Property	Commodity	Estimated total cost	Government participation
J. Howard Simms, Salmon, Idaho	Pope-Shenon mine, Lemhi County, Idaho.	Copper	$85,700	$42,850
Western States Minerals, Inc., Riverton, Wyo.	Crown Point & East Crown Point Claims, Utah and Juab, Utah.	Silver, copper, gold	238,230	75,025
Colorado Geneva Industries, Carbondale, Colo.	Copper King, Gunnison, Colo.	Copper and silver.	34,360	21,475

Export controls on copper products continued through 1969. The quota on refined copper from domestic primary sources was 50,000 tons and on scrap was 60,000 tons of contained copper. Set-asides of refined copper for defense purposes were 16 percent of the base period at the start of the year and 14 percent at yearend. The percentage depletion rate on foreign produced copper was lowered from 15 to 14 percent, effective October 9. The 15 percent rate was retained on domestic copper mines.

[1] Physical scientist, Division of Nonferrous Metals.

Table 1.—Salient copper statistics

	1965	1966	1967	1968	1969
United States:					
Ore produced___thousand short tons__	173,286	186,966	127,066	170,054	223,752
Average yield of copper, percent__	0.70	0.67	0.63	0.60	0.60
Primary (new) copper produced—					
From domestic ores, as reported by—					
Mines__________short tons__	1,351,734	1,429,152	954,064	1,204,621	1,544,579
Value________thousands__	$957,028	$1,033,850	$729,401	$1,008,195	$1,468,400
Smelters________short tons__	1,402,806	1,429,863	841,343	1,234,724	1,547,496
Percent of world total_____	23	24	14	19	21
Refineries_______short tons__	1,335,660	1,353,087	846,551	1,160,925	1,468,889
From foreign ores, matte, etc., as reported by refineries short tons__	376,133	357,897	286,431	276,461	273,926
Total new refined, domestic and foreign_________short tons__	1,711,793	1,710,984	1,132,982	1,437,386	1,742,815
Secondary copper recovered from old scrap only____________short tons__	513,436	534,860	482,659	520,772	574,890
Exports:					
Metallic copper__________do____	379,498	319,314	221,066	313,741	241,254
Refined_________________do____	324,965	273,071	159,353	240,745	200,269
Imports, general:					
Unmanufactured_________do____	523,141	594,704	649,227	709,975	414,057
Refined_________________do____	137,443	164,328	330,571	400,278	131,171
Stocks Dec. 31: Producers:					
Refined_________________do____	35,000	43,000	27,000	48,000	39,000
Blister and materials in solution short tons__	246,000	270,000	220,000	272,000	291,000
Total_________________do____	281,000	313,000	247,000	320,000	330,000
Withdrawals (apparent) from total supply on domestic account:					
Primary copper______short tons__	1,526,000	1,593,000	1,320,000	1,576,000	1,683,000
Primary and old copper (old scrap only)_______short tons__	2,039,000	2,128,000	1,803,000	2,097,000	2,258,000
Price: Weighted average, cents per pound_________________________	35.4	36.6	38.6	42.2	47.9
World:					
Production:					
Mine_______________short tons__	5,549,074	5,800,341	5,551,797	6,012,100	6,612,276
Smelter_________________do____	6,104,622	6,123,899	5,922,806	6,805,050	7,292,717
Price: London, average cents per pound_________________________	58.52	69.04	51.19	56.13	66.24

DOMESTIC PRODUCTION

PRIMARY COPPER

Mine Production.—The copper mining industry in the United States operated the full year with only minor interruptions. Record production was reached by most operating mines, and expansions of producing facilities led to an alltime record output. Production at the Tyrone, N. Mex., mine of Phelps Dodge Corp. started early in the year and achieved capacity output by yearend. The Twin Buttes mine in Arizona, operated by The Anaconda Co., started production in October and was producing at about two-thirds capacity at yearend. The Duval Sierrita mine in Arizona, owned and operated by Penzoil United Corp., was nearing production at yearend. Operations at the Calumet & Hecla copper-producing complex in northern Michigan were closed permanently after having been interrupted by a labor strike starting in August 1968. The Lakeshore mine in Arizona, owned equally by El Paso Natural Gas Corp. and Hecla Mining Co. and operated by Hecla, was under development. Two inclines were started to reach a deep ore body that will be mined by underground methods while an open pit mine is being developed. Newmont Mining Corp. increased production at the San Manuel mine in Arizona on the basis of doubled ore reserves achieved by acquisition of the Kalamazoo ore body in 1968. The company announced plans to build a 200,000-ton-per-year electrolytic copper refinery at San Manuel to produce continous-cast wire rod. The refinery is to start production in 1973, when it is anticipated that the company's production from properties at Superior and San Manuel will be sufficient to provide the anodes needed for the refinery. The Anaconda Co. increased production from the Berkeley pit in Butte by reactivating the mill at Anaconda to treat 22,000 tons of ore per day, which with the 34,000 tons per day treated at the Butte mill, raised its total milling rate to 56,000 tons of ore per day.

Arizona, Utah, New Mexico, Nevada, and Michigan produced at record levels. Montana was the only major producing State that produced less than in 1966. Arizona was first with 52 percent of mine production followed by Utah, New Mexico, Nevada, and Montana with 19, 7, 6, and 6 percent, respectively. These five States accounted for 90 percent of the total production.

In order to provide better coverage of the increasingly important copper leaching recovery process, copper precipitates shipped are tabulated separately in table 11 instead of being footnoted in table 8 as in prior years. Data on ore leached and the recoverable copper content, heretofore included in table 8 under "ore shipped or concentrated" and "recoverable copper content," also are tabulated in table 11.

In order for 1969 quantities to be compared with previous years, table 7 has been added to show mine production of recoverable copper by method of treatment.

The copper content of shipments of precipitated copper from dump and in place leaching was 165,000 tons, 12 percent higher than that of 1968 and equal to 11 percent of recoverable mine production. The total copper recovered by precipitation with iron was about 207,000 tons.

Smelter Production.—Total output of copper at primary smelters in the United States was 1.7 million tons, up 23 percent from 1968 production.

Refinery Production.—Production of refined copper from all materials processed at primary refineries was a record 2,156,000 tons, an increase of 20 percent from 1968, but only 7,000 tons more than the previous record established in 1966. Refined copper produced at secondary plants was 78,000 tons compared with 73,000 tons in 1968. The total production of refined copper produced from scrap in the United States was 491,000 tons, equal to 22 percent of total refined copper production.

Copper Sulfate.—Copper sulfate was produced from primary and/or secondary metal by companies with plants located as follows:

Company	Plant location
The Anaconda Company	Great Falls, Mont.
Chevron Chemical Co	Richmond, Calif.
Cities Service Co	Copperhill, Tenn.
Phelps Dodge Refining Corp	Laurel Hill, N. Y., El Paso, Tex.
The Sherwin-Williams Co	Cleveland, Ohio
Van Waters & Rogers, Inc., English & Bagby Co. Division.	Wallace, Idaho Midvale, Utah Metalline Falls, Wash.

Copper sulfate production and shipments increased 15 and 13 percent, respectively, on those of 1968, but were below the high levels established in 1966. Stocks at yearend were equal to 1 month's shipments. Of total shipments of 49,500 tons, producers' reports indicated that 21,000 tons was for agricultural uses, 26,200 tons was for industrial uses, and 2,300 tons was for other uses (chiefly exports).

Byproduct Sulfuric Acid.—Sulfuric acid produced from the sulfur contained in off-gases from copper smelters increased 21 percent from that of 1968 as a result of added acid-producing capacity at several copper smelters.

SECONDARY COPPER AND BRASS

Recovery of copper in the United States in alloyed and unalloyed products from all classes of purchased scrap was a record 1.38 million tons, 13 percent more than that of 1968. Copper recovered in all forms from copper-based scrap also increased 13 percent to a record 1.36 million tons. The largest increase (20 percent) was attributed to primary copper producers; recovery by secondary smelters and brass mills increased 6 and 15 percent, respectively.

Consumption of purchased copper-base scrap was 1.9 million tons, an increase of 14 percent from that of 1968. Use at secondary smelters increased 7 percent to 482,000 tons, of which 75 percent was old scrap. Primary producers used 621,000 tons, a 21-percent increase from that of 1968, and brass-mill consumption rose to 695,000 tons, an increase of 17 percent. Foundries and other plants used 94,000 tons compared with 103,000 tons in 1968.

CONSUMPTION

Apparent withdrawals of primary refined copper totaled 1.7 million tons, 7 percent more than in 1968. Actual consumption of refined copper was 2.1 million tons, an increase of 14 percent from that of 1968. Consumption of refined copper is based on consumers' reports of quantities entering processing with no adjustments for changes in stocks.

As far as it is possible to ascertain, only new or primary copper is included in table 27, but table 28 includes all refined copper, from secondary as well as primary sources.

STOCKS

Fabricators' stocks of refined copper, including in-process metal and primary fabricated shapes, were 502,000 tons at yearend, a decrease of 2 percent from the beginning of the year.

PRICES

The domestic producer price for refined copper was raised from 42 to 44 cents per pound early in January 1969; it was raised to 46 cents per pound in May, to 48 cents in August, and to 52 cents per pound in September, where it remained until yearend. The quantity of copper available at domestic producer prices was inadequate for total demand; consumers were forced to purchase copper on the open markets for the remainder of their requirements.

The open market price and the New York Commodity and Mercantile Exchange's prices paralleled prices on the London Metal Market and were substantially above the domestic producers price throughout the year. The average monthly spot price on the London Metal Exchange increased fairly constantly from $0.566 per pound in January to $0.769 per pound in December.

FOREIGN TRADE

U.S. exports of copper in ore, concentrates, and matte totaled 1,200 tons compared to 65,000 tons in 1968, when the domestic copper industry strike forced some producers to ship their concentrates abroad for smelting. Exports of blister copper declined from 16,000 tons in 1968 to 4,000 tons. Exports of refined copper and semimanufactures were 237,000 tons, down 20 percent from those of 1968.

Exports of copper-base alloy were down 4 percent to 95,000 tons; exports of unalloyed copper scrap were 7,600 tons compared with 34,100 tons in 1968; exports of copper alloy scrap were 78,300 tons, down 9 percent from those of 1968.

U.S. imports of copper (unmanufactured) were 408,000 tons, down 43 percent from those of 1968. Chile and Peru each supplied 30 percent and Canada supplied 23 percent; these three countries accounted for 83 percent of total imports compared to 63 percent of the total in 1968. Imports for consumption of refined copper were 131,000 tons compared with 404,000 tons in 1968. Imports for consumption of blister copper were 242,000 tons, down 12 percent from those of 1968. Imports for consumption of unalloyed copper scrap were 5,900 tons, down 49 percent from those of 1968.

WORLD REVIEW

Encouraged by continuing high demand and consequent high prices, world mine production of copper reached a record high. The United States increased copper mine production 340,000 tons, 28 percent over that of 1968, when the copper industry labor strike of 1967–68 cut back output. Most countries posted substantial increases in mine production; major producing countries with increases include

Poland, and Yugoslavia with, respectively 80, and 27-percent increases. The Philippines and Australia each reported 19-percent increases in production. The Congo and Zambia each reported 12-percent increases. Nicaragua reported a 64-percent decrease. Canada's production was 13 percent less than in 1968 because of the labor strike in the nickel mining industry, and Peru's output was below that of 1968 because of a 42-day labor strike at Southern Peru Copper Corp.

The first Conference of Ministers of the Intergovernmental Council of Copper Exporting Countries (CIPEC) was held during the latter half of November at Lima, Peru. The member countries are Chile, Peru, Zambia, and Congo (Kinshasa). Among agreements reached at the Conference was one aimed at increasing production in all member countries in order to meet growing world demand.

Exploration and development activity continued at a high rate. The willingness of the Japanese copper smelting industry, backed by the Japanese Government, to enter into long-term purchase contracts for copper concentrates was an important facor in obtaining financing for many new mines in various countries. Japanese companies also were contenders for copper mining rights in many countries, notably in Sabah and Ecuador, where they were successful in obtaining exclusive concessions.

Argentina and Panama were among small copper-producing countries who offered copper mining concessions for bid.

Australia.—Australia's mine production of copper was 143,300 tons, up 19 percent from that of 1968. Mount Isa Mines Ltd., 53-percent owned by American Smelting and Refining Company, produced 81,400 tons of copper in the year ended June 30, 1969, up from 53,900 tons produced the year before.

High exploration activity throughout Australia included establishment of a new regional headquarters by The Anaconda Co. in the Mount Isa district of Queensland where several areas are under investigation. Anaconda geologists also are exploring large concessions in Western Australia under a joint working agreement with Conzinc Rio Tinto of Australia Ltd. (CRA).

Kennecott Copper Corporation examined a copper prospect in the Territory of Papua and New Guinea. The results were sufficiently encouraging to warrant a closely spaced drilling program in 1970. Called the Ok Tedi, the deposit is in an extremely remote location where the terrain, climate, and transporation involve difficult working conditions.

Negotiations for financing the development of the Panguna copper ore deposit on Bougainville Island in the Territory of Papua and New Guinea were conducted successfully by Rio Tinto-Zinc Corp. Ltd. A loan of up to $246.4 million was agreed to by two banking syndicates headed by the Bank of America. A loan of $60 million will be advanced by seven Japanese smelting companies as advance payment for future copper concentrate deliveries. The remainder will be equity financing by Bougainville Copper shareholders. Bougainville Copper is two-thirds owned by Con Zinc Rio Tinto of Australia Ltd. (CRA) and one-third owned by New Broken Hill Conolidated Ltd. CRA owns 31.6 percent of New Broken Hill, and the Rio Tinto-Zinc Corp. Ltd., owns 85.1 percent of CRA. The Panguna ore body contains 760 million tons containing 0.47 percent copper and about 0.02 ounces of gold per ton. Mining is planned to start in 1972 at the rate of 80,000 tons of ore per day. The Japanese smelter group has a contract to purchase 80,000 tons of copper in concentrates annually. The West German firm Norddeutsche Affinerie intends to buy 52,500 tons of copper in concentrates per year, and the Rio Patino Company will buy 15,000 tons of contained copper per year for smelting at the new copper smelter it is building at Huelva, Spain.

Canada.—Canadian mine production of copper decreased 13 percent to 551,427 tons. The reduced output was largely the result of strikes at Gaspé Copper Mines, Ltd., The International Nickel Company of Canada, Ltd. (Inco.), and Falconbridge Nickel Mines, Ltd. Ontario produced approximately 41.0 percent of the total, followed by Quebec with 28.3 percent, British Columbia with 14.6 percent, Manitoba with 6.6 percent, Newfoundland with 3.5 percent, Saskatchewan with 3.2 percent, and the Yukon, New Brunswick, Northwest Territories, and Nova Scotia with a combined 2.8 percent.[2]

[2] Killan, A. F. The Canadian Mineral Industry in 1969, Preliminary. Canadian Dept. Mines and Tech. Surveys, Miner. Res. Div., Miner. Inf. Bull. MR 102, 1970, pp. 34–42.

A 3 month strike at Gaspé Copper Mines in Quebec resulted in reduction of smelter copper output from 61,100 tons in 1968 to 49,400 tons in 1969. Yearend reserves were 28 million tons of 1.34 percent copper at the Needle Mountain mine and 28.7 million tons of 0.71 percent copper at the Copper Mountain mine.

Deliveries of copper from the Ontario and Manitoba operations of Inco., were reduced 34 percent to 14,000 tons as a result of a 128-day strike at the Ontario facilities. The company reported proven ore reserves at yearend to be 380 million tons containing 6.2 million tons of nickel and 3.9 million tons of copper.

Ecstall Mining, Ltd., a subsidiary of Texas Gulf Sulphur Co., produced 184,000 tons of copper concentrate from 3.6 million tons of lead-zinc-copper-silver ore mined from its open pit mine near Timmins, Ontario. Work began on a head frame for a 3,000-foot shaft to be completed by late 1971 for underground mining to supplement surface-mining operations.

Hudson Bay Mining and Smelting Co. Ltd., milled 1.7 million tons of ore yielding 42,302 tons of refined copper plus quantities of zinc, cadmium, selenium, gold, and silver. Proven ore reserves at yearend were 18 million tons averaging 3.0 percent copper and 3.5 percent zinc. It is interesting to note that reserves were the highest since 1958 and approximately the same as listed in the company's first Annual Report, 41 years ago.

Sherritt Gordon Mines Ltd., continued operation of its Lynn Lake mine and development work at the Fox mine in Manitoba. Initial production from the latter is scheduled for the second quarter of 1970. Reserves at yearend were 12.6 million tons of 0.77 percent nickel and 0.40 percent copper at Lynn Lake and 11.3 million tons of 1.96 percent copper and 2.74 percent zinc at the Fox mine to a depth of 2,000 feet. A new discovery at Ruttan Lake had calculated reserves of 12.9 million tons grading 1.44 percent copper and 2.61 percent zinc to a depth of 400 feet which would be amenable to open pit mining.

The Britannia mine in British Columbia yielded concentrates containing 6,583 tons of copper compared with 4,853 tons in 1968. Development continued on a new ore body scheduled for production in October 1970 with total output anticipated to be at an annual rate of 10,000 tons.

Progress at the Granduc copper property in British Columbia was seriously affected by 4½-month labor strike, which ended after a new labor contract was signed effective June 25, 1969. The work stoppage delayed start of production from the property until probably late in 1970. The Granduc property is leased from Granduc Mines Ltd. by the Granduc Operating Co. (a wholly owned subsidiary of Newmont Mining Corp.) and American Smelting and Refining Co., in equal shares, with Granduc Operating Co. being the operator and manager. The lessees report that the estimated ore reserve has been increased from 32.5 million tons of 1.93 percent copper to 43.3 million tons of 1.73 percent copper.

Brenda Mines Ltd., completed stripping 8.7 million tons of waste rock, construction of a concentrator, and other development work for initial December 1969 production from a large, low-grade, copper-molybdenum deposit in British Columbia. Rated mill capacity is 24,000 tons of ore per day. Reserves are 177 million tons averaging 0.183 percent copper and 0.049 percent molybdenum.

Financing was obtained for development of Lornex Mining Corporation Ltd.'s copper-molybdenum property in the Highland Valley of British Columbia. Six Japanese smelting companies and three trading companies agreed to supply US$26.5 million in return for a purchase contract for Lornex's entire output of copper concentrates for 12 years to be smelted in Japan. The Japanese companies involved are Dowa Mining Co., Ltd., Furukawa Mining Co. Ltd., Mitsubishi Metal Mining Co. Ltd., Mitsui Mining and Smelting Co. Ltd., Nippon Mining Co. Ltd., Sumitomo Metal Mining Co. Ltd., Mitsubishi Shoji Kaisha Ltd., Mitsui and Co. Ltd., and Sumitomo Shoji Kaisha Ltd. Three Canadian chartered banks agreed to provide Can$60 million secured by a first mortgage. The banks are the Canadian Imperial Bank of Commerce, the Toronto-Dominion Bank, and the Bank of Montreal. The balance of the required funds will be raised through the sale of income debentures and Lornex shares. Rio Algom Mines Ltd., a subsidiary of Rio Tinto Zinc Corp. Ltd., will own a controlling interest in Lornex after financing is completed. The Lornex mine, expected to begin production in 1972, will be the largest base-metal mine in Canada. The mill will concentrate 38,000 tons per day of ore and will produce 160,000 tons of copper concentrate and 2.5 million pounds of molybdenum in concentrates.

Negotiations continued toward development of the huge copper deposit underlying the boundary between Valley Copper Mines (controlled by Cominco) and Bethlehem Copper Corporation Ltd. In November, Grangesberg Company, Sweden's leading metal enterprise, acquired a 15-percent interest in Bethlehem Copper Corp. The largest stockholder in Bethlehem Copper Corp. is Sumitomo Metal Mining Co. of Japan.

Utah Construction & Mining Co. proceeded with plans to develop its Island Copper Property, near Port Hardy, Vancouver Island, British Columbia. Production at the rate of 33,000 tons of ore per day and about 230,000 tons of copper concentrates annually, plus a molybdenum byproduct is expected to begin during the latter half of 1971. Concentrates will be sold to Mitsui Mining and Smelting Co. Ltd., Dowa Mining Co., and Mitsubishi Shoji Kaisha Ltd. for smelting in Japan. The purchase price for copper in concentrates is based on the London Metal Market quotations, less smelting and refining charges, with an agreed floor price of $0.36 per pound.

Chile.—Copper output at the Chuquicamata mine increased 2 percent to 312,157 tons in 1969 despite a large landslide in the early part of the year which hampered operations. Production at El Teniente mine was 202,600 tons compared with 174,100 tons in 1968, when production was adversely affected by smelter problems and a severe drought. Total Chilean output for the year was 786,716 tons, an increase of almost 5 percent.

As an alternative to expropriation to its two subsidiary copper producers, Chile Exploration Co. (Chuquicamata) and Andes Copper Mining Co. (El Salvador), The Anaconda Co. entered into negotiations with the Government of Chile for transfer of ownership agreements. As of the end of 1969 substantially all of the assets of these two subsidiaries were transferred to two new Chilean corporations, Compañia de Cobre Chuquicamata S.A. and Compañia de Cobre Salvador S.A. In exchange Anaconda received $174 million in negotiable promissory notes, 51 percent of the agreed upon capitalization of the two new companies. Determination of the purchase price for the remaining 49-percent interest will be made after 1972 but before 1982, with settlement based on a formula of average annual earnings times variable multiples between six and eight, dependent upon date of settlement. In the interim Anaconda retains the rights and privileges of a 49-percent ownership. As part of the agreement, Anaconda also entered into contracts with the new companies to provide certain operational and technical services with remuneration equivalent to 1 percent of the gross proceeds of mine products. The Exotica mine is excluded from the agreement, and ownership continues to be 75-percent Anaconda and 25-percent Government of Chile.

At El Teniente, 49-percent owned by Kennecott Copper Corp., the expansion program, which will increase annual productive capacity to 280,000 tons, continued ahead of schedule with completion set for late 1970. Resettlement of company employees from the high Andes cities of Sewell and Calentones to Rancagua in the central valley was advanced in 1969 by completion of 1,400 and starts on 540 houses by the Chilean Housing Authority. The new highway connecting Rancagua with the new mine tunnel in Colon, north of Caletones, was also completed.

Compañia Minera Andina S.A. (70-percent owned by Cerro Corporation) has completed development of about 75 percent of the Río Blanco copper mine and related facilities, with anticipated production at an annual rate of 62,500 tons of copper in concentrates to begin in early 1971. The partially delimited ore body contains at least 120 million tons of ore averaging 1.58 percent copper. Japanese smelting interests, which assisted in financing, have undertaken to purchase about two-thirds of the first 10 years of production.

Small and medium-sized mines are contributing an increasing share of copper output, indicated to be 20 percent of the total in 1967, 22 percent in 1968, and estimated to be 300,000 tons, or 25 percent, of the expanded Chilean production by 1971 or 1972.[3]

Congo (Kinshasa).—An accord between Société Général des Minerais (S.G.M.),

[3] World Mining. Chile's Small Copper Mines Expand. V. 5, No. 4, April 1969, pp. 50–55.

Brussels, and Générale Congolaise des Minerais (GECOMIN), Kinshasa, for payment to the former for expropriated mining properties, was announced in September. The agreement involves the extension to 25 years of technical cooperation between S.G.M. and GECOMIN. For the first 15 years S.G.M. will receive an amount equal to 6 percent of the value of metals produced from GECOMIN's properties to cover compensation due to Union Minière and the fee for technical cooperation. At the end of the 15-year period, the amount paid to S.G.M. will be reduced to 1 percent for the remainder of the cooperation period.

The joint Japanese-Congolese concern, Sociéte de Development Industriel et Minier du Congo (SODIMICO), reported that reserves of copper ore in the Kinsenda area totaled 110 million tons of 2.1-percent copper ore. Plans call for a processing plant to begin production in 1972, at Mushoshi to produce 53,000 tons per year of copper in concentrates. Concentrates will be shipped to Japan for smelting.

Indonesia.—Freeport Indonesia, a subsidiary in which Freeport Sulphur Co. holds an 87-percent interest, continued development of the 11,500-foot-altitude Ertsberg copper deposit in Irian Barat and completed negotiations for financing and sales of concentrates from the operation.

Drilling of the deposit has disclosed the presence of about 33 million tons of ore with an average metal content of 2.5 percent copper, 0.025 ounces of gold, and 0.265 ounces of silver per ton. It is expected that the new mine will start producing early in 1973 at a rate of 2.5 million tons of ore per year and will produce 250,000 tons of copper sulfide concentrates containing 65,000 tons of copper and recoverable quantities of gold and silver.

The estimated cost of the project is $120 million. Major construction items include mine and mill facilities, electric power and water systems, a seaport, an airstrip, a surface access road, a concentrate slurry pipeline, and a mile-high townsite. The access road is being built 69 miles through swamps, jungle, and precipitous mountain inclines to the mine and mill site.

Freeport Indonesia has obtained loans for a group of five American insurance companies and seven banks for $58 million and from Japanese and West German sources for $42 million subject to fulfillment of several conditions, including Japanese Government approval of the Japanese financing. The balance of $20 million of the financing will be provided by equity funds. Freeport Sulphur's part of the equity financing will be about $16.9 million, of which about $7.4 million had been spent on the project by the start 1970. The Agency for International Development (AID) has granted specific risk guarantees of Freeport Sulphur's investment in Freeport Indonesia against loss due to war, expropriation, and conversion of currency.

The American insurance companies will provide $40 million of senior debt financing, which will be guaranteed by the U.S. Government through AID's extended risk guaranty program. The American banks will provide $18 million of senior debt financing, which will be guaranteed by the Export-Import Bank of the United States. The foreign financing consists of a $22 million loan by Kredittanstalt für Wiederaufbau, the West German development bank, and a $20 million subordinated loan by 13 Japanese smelting and trading companies.

The Japanese companies have contracted to purchase about two-thirds of the annual output of concentrates, and Norddeutsche Affinerie, Hamburg, West Germany, has contracted to buy about one-third. Sales prices under the contracts will be world prices for metals, less smelting and refining charges.

Freeport Indonesia has exploration and development rights in an area of approximately 38 square miles including and surrounding the Ertsberg deposit. There are surface indications of further copper mineralization within the rights area.

An agreement was signed between a newly formed Indonesian subsidiary of Kennecott Copper Corp. and the Indonesian Government, which granted exploration rights to six large concession areas in Java, Sumatra, and Irian Barat.

Muritania.—Société Minière de Mauritanie (SOMIMA), 44.6 percent owned by Charter Consolidated, Ltd., progressed on schedule in development of a copper mine situated near Akjoujt. Open pit mining of oxide ore is expected to start early in 1970 to produce 30,000 tons of copper in concentrates annually. The oxide ore will be concentrated in a plant using the Torco segregation process developed by the Anglo American Corp. group.

Mexico.—Exploration by Asarco Mexicana, S.A., at La Caridad copper property near Nacozari, Sonora, has indicated a major copper porphyry ore body containing about 650 million tons of 0.8-percent-copper ore which can be mined by open pit methods. A new company, Mexicana de Cobre, S.A., has been formed to develop and operate the property at a rate of about 30,000 tons of ore per day. Asarco Mexicana, S.A., is owned 51 percent by a Government company, Comisión de Fomento Minero, and 49 percent by American Smelting and Refining Company (Asarco). Asarco Mexicana will own 49 percent of the stock of Mexicana de Cobre, S.A. Partly as a result of the successful exploration at La Caridad, at least 30 companies are engaged in mine exploration in Sonora, mostly for copper.

Asarco Mexicana continued on schedule in construction of its Inguarán, Michoacán, mine. Work started late in 1968 with production planned during the first quarter of 1971. The underground mine is planned to produce 2,000 tons of ore per day that will be milled to produce concentrates containing 12,000 tons per year of copper.

To handle the increased output of copper from La Caridad, Inguarán, and other mines, Asarco Mexicana will build Mexico's second electrolytic copper refinery, possibly at a site near the San Luis Potosí smelter. Construction will start during the second quarter of 1970 and be completed in 1971 with an initial capacity of 45,000 tons of copper per year. It is planned to increase the capacity to 120,000 tons per year, probably by the time La Caridad starts production.

Compañia Minera de Cananea, S.A. de C.V., a subsidiary of The Anaconda Company produced a record 36,500 tons of copper, 100 tons more than production in 1968. Condumex, a wire and cable manufacturing subsidiary of The Anaconda Co. in Mexico City, announced the construction of a new plant at Guadalajara.

Peru.—Operations at the Southern Peru Copper Corp.'s mine at Toquepala were interrupted by a 42-day strike that resulted in closing the smelter at Ilo for 32 days during November and December. As a direct result of the interruption, production of blister copper declined to 134,200 tons compared with 147,700 tons in 1968. During 1969, 64.3 million tons of ore and waste was mined at Toquepala to produce 13.2 million tons of milling ore that averaged 1.18 percent copper.

On December 19, 1969, Southern Peru Copper Corp. signed a contract with the Government of Peru for the development of the Cuajone ore body and construction of ancillary facilities. Under the contract, a period of 6½ years is established for completion of the project. The contract provides that during the period of recovery of investment, earnings from the Cuajone project will be taxed at the rate of 47.5 percent and then, for a further period of 6 years at 54.5 percent, the rate in effect on the date of the contract. It also provides that the company shall be free to export and sell the production of the Cuajone mine in world markets after the needs of national consumption are met, and guarantees the free disposal of foreign exchange resulting from such sales in amounts required for recovery of invested capital, interest, and foreign services.

Southern Peru is obligated to spend $25 million for the project by October 1, 1971, and must complete in each succeeding calendar year not less than 60 percent of the investment program scheduled for that year. Failure to maintain this investment program, in the absence of force majeure, will result in termination of the concession for the Cuajone mine. During 1969 the permanent road linking Quellaveco and Cuajone with Toquepala was completed.

Philippines.—Thirteen mining companies produced 144,800 tons of copper in concentrates, an increase of 19 percent over production the year earlier. Atlas Consolidated Mining and Development Co. was the largest copper producer with an output of 56,000 tons. Lepanto Consolidated Mining Co. was second largest with an output of 28,500 tons. Marinduque Mining and Industrial Corp.'s Sipalay mine and Philex Mining Corp. were third and fourth, respectively, with outputs of 19,800 tons and 13,200 tons. Marcopper Mining Corp., owned 60 percent by the Philippine Government and 40 percent by Craigmont Mines Ltd., a subsidiary of Placer Development, Ltd., started production in 1969 and produced 7,800 tons of copper in concentrates during the last half of 1969.

A feasibility study by Arthur D. Little, Inc., funded by four major copper mining companies, found it inadvisable at present to construct a copper smelter in the Philippines.

South Africa, Republic of.—O'okiep Copper Co. Ltd. milled 3.13 million tons of ore containing 1.34 percent copper and produced 37,400 tons of blister copper. New outside discoveries and additions to reserves in known ore bodies added to ore reserves which at yearend totaled 31.1 million tons of 1.60-percent-copper ore, the highest tonnage on record since the company started operations in 1940.

Palabora Mining Co. Ltd. produced 86,600 tons of anode copper, 9 percent more than in 1968. Ore milled was 17.3 million tons of 0.6-percent-copper ore. Messina (Transvaal) Development Company, including subsidiary copper mines in Rhodesia, produced 32,500 tons of copper.

South-West Africa.—The Tsumeb mine and mill of Tsumeb Corp., Ltd., mined and milled 569,000 tons of oxide ore averaging 3.2 percent copper, 11.84 percent lead, 3.53 percent zinc, and 1.7 ounces silver per ton. The Kombat operation mined and milled 412,000 tons of ore averaging 1.65 percent copper, 1.79 percent lead, and 0.30 ounce silver per ton. Blister copper produced was 30,000 tons, down from 35,700 tons in 1968.

Spain.—Construction of the custom copper smelter, sulfuric acid plant, and electrolytic copper refinery at Huelva on the Atlantic coast was on schedule to begin operation by June 1970. The annual output capacity of the plant will be 60,000 tons of copper and 250,000 tons of sulfuric acid. The smelting and refining plant is owned by Rio-Tinto Patiño, S.A., a joint venture of Compañia Española de Minas de Rio-Tinto S.A. (55 percent), the Patiño Mining Corporation (40 percent), and Rio-Tinto Zinc Investment, Ltd. (5 percent). In addition to the smelting and refining plant, Rio-Tinto Patiño, S.A., is developing the Cerro Colorado open pit copper mine at Rio-Tinto, Spain, which is expected to start production by the end of 1970. Facilities will include a copper concentrating plant and a gold-silver cyanide plant with daily capacities of 11,000 and 5,000 tons, respectively. Ore reserves are estimated at 44 million tons of copper ore averaging after dilution 0.8 percent copper and 20 million tons of gossan ore averaging 0.07 ounce of gold and 1.5 ounces of silver per ton. The total investment in the mine, mills, and smelting and refining plants will be $77 million.

Sweden.—Production from the Aitik open pit copper mine in Arctic Sweden, will be expanded from 2 million tons of ore per year to 5 million tons. The grade of ore mined will be lowered from 0.5 percent to 0.4 percent copper, and the annual output will be doubled from 10,000 to 20,000 tons of copper. The mine is owned by the Boliden Mining Co., Ltd., and the copper concentrates are smelted at the company-owned Bonskar Works.

Uganda.—Kilembe Mines Limited, a subsidiary of Kilembe Copper Cobalt, Ltd., in which Falconbridge Nickel Mines, Ltd., owns a 72.8-percent interest, produced 18,000 tons of blister copper, 20 percent more than in 1968. Negotiations were started toward an agreement to comply with a request by Uganda Development Corporation Limited, a corporation owned by the Uganda Government, that Kilembe Copper Cobalt, Ltd., sell to the corporation 50 percent of its shares in Kilembe Mines Limited.

Zambia.—On August 11, 1969, President Kaunda announced that all rights of ownership or partial ownership of minerals must revert to the State and that royalty and export taxes based on the selling price of copper would be replaced by a single mineral tax of 51 percent of profits. He asked the owners of the mines to invite the Government to join their mining enterprises by offering 51 percent of their shares to the State.

Following extensive negotiation between representatives of the Government and the mine owners, an agreement was reached in November for a settlement as follows:

The State-owned Industrial Development Corporation (INDECO) will issue bonds, fully guaranteed by the Zambian Government, in return for 51 percent of the shares of the mine-operating companies. The value of the shares, based on the book value of the companies as of December 31, 1969, was agreed to be $150 million in the case of the Roan Selection Trust Ltd., (RST) group and $175 million in the case of the Anglo-American group. Interest at the rate of 6 percent per year, free of Zambian tax, will be paid on outstanding balances.

Repayment of the bonds will be in 16 semiannual installments in the case of RST and 24 semiannual installments for Anglo-American. Bonds will be repaid earlier to the extent that two-thirds of the dividends paid to INDECO in any year exceed the installments due.

Two new Zambian-based companies will be formed into which the operating mining companies will be consolidated, Roan Consolidated Mines Limited for the RST group, and Nchanga Consolidated Mines Limited ("New Nchanga") for the Anglo-American group. The RST group will include the Mufulira, Luanshya, Chibuluma, Chambishi, and Kalengwa mines and the Ndola copper refinery. The "New Nchanga" group will include Nchanga Consolidated Copper Mines Ltd., Rhokana Corporation Ltd., Bancroft Mines Ltd., and Rhokana Copper Refineries Ltd. The boards of each of the two new companies will consist of six members (including the chairman) appointed by INDECO and five members appointed by the remaining shareholders.

Two external companies will be formed to hold the bonds and the 49-percent share interests of the Zambian companies. Certain other external assets of the two operating groups will be owned by the external companies without Zambian participation.

During the year ended June 30, 1969, Rhokana Corporation Ltd. milled 5.78 million tons of ore that averaged 2.05percent copper and produced 108,200 tons of finished copper. Nchanga Consolidated Copper Mines Ltd. milled 8.93 million tons of ore averaging 3.76 percent copper and produced 242,400 tons of finished copper. Bancroft Mines Ltd. milled 1.95 million tons of ore averaging 3.49 percent copper and produced 52,600 tons of finished copper.

Of the RST group, the Mufulira, Chibulma, and Chambishi mines are operated as divisions of Mufulira Copper Mines Ltd. The Mufulira, Chibuluma, and the Chambishi mines produced 194,800; 30,200; and 24,800 tons, respectively, of finished copper. Each mine produced more than in the previous year; the total increase was 8 percent over production the previous year. Luanshya Mines Ltd. produced 117,200 tons of finished copper, an increase of 10 percent over output the previous year. During the year RST acquired the one-third interest in the Ndola Copper Refineries Ltd. owned by British Insulated Callender's Cables Ltd., which raised its ownership to 100 percent. The assets of the refinery company were transferred to Luanshya Mines, Ltd., and Ndola Copper Refineries Ltd. was placed in liquidation.

TECHNOLOGY

A study of enrichment of copper deposits by supergene oxidation emphasized the phase relationships of copper minerals and their oxidation sequence at relatively low formational temperatures.[4]

Geochemical maps showing the distribution of copper, lead, and zinc in relation to the geology in nearly 5,000 stream sediment samples taken over the whole of Northern Ireland have been compiled by the Applied Geochemistry Research Group at Imperial College, London.[5]

The research vessel *Prospector,* belonging to Deepsea Ventures, Inc., a subsidiary of Tenneco, Inc., continued exploration of ocean floor deposits of nodules containing copper, nickel, cobalt, and manganese. The abundance of nodules is determined by both sampling and ocean-bottom photography. A research paper reported on results of a preliminary investigation of the physical characteristics and extraction of values from the nodules.[6] Assessment of the commerical potential of these deposits will require extensive technical and economic feasibility studies.

Results of an open pit slope-stability research program conducted by Kennecott Copper Corp. since 1956, most notably at their Kimbley pit, were reported.[7] It was concluded that techniques to quantify the variables affecting slope stability have reached a level of reliability to significantly improve pit design for safe and efficient slopes.

The Bureau of Mines reported on results of research that demonstrated the fea-

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[4] Sillitoe, R. H., and A. H. Clark. Copper and Copper-Iron Sulfides as the Initial Products of Supergene Oxidation, Copiapo Mining District, Northern Chile. Am. Mineralogist, v. 54, Nos. 11–12, November–December 1969, pp. 1684–1710.

[5] Mining Journal (London). Geochemical Maps. V. 273, No. 7006, Nov. 28, 1969, p. 495.

[6] Brooke, J. N., and A. P. Prosser. Manganese Nodules as a Source of Copper and Nickel—Mineralogical Assessment and Extraction. Trans. Inst. Min. Met., v. 78, sec. C, No. 751, June 1969, pp. c64–c73.

[7] Broadbent, Carl D. Slope Stability Program of Kennecott Copper Corp. Trans. AIME, v. 244, No. 2, June 1969, pp. 209–218.

sibility of stabilizing copper mill tailings against wind erosion by means of a combination chemical-vegetative process.[8]

Research on extraction continued to be dominated by efforts to improve existing processes or devise new processes to meet increasingly stringent air pollution standards, particularly with respect to emission of sulfur gases at smelters. Various stack-gas control systems, with or without recovery of byproduct sulfur, were under investigation; however, most reported research was for chemical-processing systems which eliminate the pyrometallurgical step in the recovery of copper.

The Anaconda Company constructed a pilot plant in Tucson, Ariz., with a capacity of 6 tons of copper concentrate per day, to test the feasibility of a chemical process to produce copper under patents owned by the Treadwell Corp. In the process, sulfide concentrates are leached in a kiln with sulfuric acid to produce copper sulfate, sulfur, and sulfur dioxide. After purification to remove other metals, the copper sulfate is converted to a cyanide by reaction with hydrogen cyanide and sulfur dioxide, then reduced to copper by hydrogen. Studies indicate recovery of 99.6 percent of the copper values and 90.5 percent of the sulfur as elemental sulfur with favorable capitalization costs.[9] The same article also describes a hydrometallurgical method developed by Sherritt Gordon Mines Ltd. in which the sulfide concentrate is leached with dilute sulfuric acid in an autoclave at 500 pounds per square inch to yield copper sulfate in solution and leach residues of elemental sulfur, excess concentrates, and tailings. The copper can be recovered by any of the accepted copper-wining routes for leach solution, and the leach residues are separated by some combination of flotation, solvent extraction, and distillation. Another article[10] described an ion exchange-electrowinning process to recover copper from leach solutions with low concentrations. Reports of other research on leaching included a study of the reaction rates of synthetic chalcopyrite with a leaching agent of acidified aqueous ferric sulfate[11] and a review paper of research conducted on dump leaching.[12] A patent was granted to remove ferric ions from copper leach solutions by use of an insoluble alkaline solid and to thereby improve the economics of subsequent cementation or electrowinning processes.[13]

The control of variables in reverberatory furnace slag formation to achieve good matte-slag separation and reduced copper slag losses was the object of a copper smelter study.[14]

Anaconda American Brass Co. has developed direct-chill, semicontinuous molds made of copper with capabilities of casting copper or copper alloy billets 6 feet long with cross sections of 10 by 30, 7 by 40, and 12 by 48 inches. The metal is underpoured in the mold and has a protective cover to prevent oxidation which results in a sound casting free of entrapped gas. The company also announced completion of research to effectively improve the environment by recovery of copper from brass mill effluents. At Kennecott Refining Corp. a technical breakthrough established the feasibility of a cast hollow billet process for a more economical starting unit in the manufacture of copper tubing.

Papers presented at a meeting of the Society of Automotive Engineers described the improved performance and safety contributed by use of copper alloys for brake discs, drums, and hydraulic tubes in automotive vehicles.[15] A cadmium-copper alloy which achieves good strength characteristics by cold-rolling and does not soften significantly during soldering operations has found acceptance in heat exchanger applications, small motor and generator commu-

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[8] Dean, Karl C., Richard Havens, and Kimball T. Harper. Chemical and Vegetative Stabilization of a Nevada Copper Porphyry Mill Tailing. BuMines Rept. of Inv. 7261, May 1969, 14 pp.

[9] Chemical Engineering. Chemical Route to Copper? V. 77, No. 8, Apr. 20, 1970, pp. 64, 66.

[10] McGarr, H. J., N. H. Berlin, and W. F. A. Stolk. The Cost of Copper—Solvent Extraction and Electrowinning Look Great on Paper. Eng. and Min. J., v. 70, No. 12, December 1969, pp. 66–67.

[11] Dutrizac, J. E., R. J. MacDonald, and T. R. Ingraham. The Kinetics of Dissolution of Synthetic Chalcopyrite in Aqueous Acidic Ferric Sulfate Solutions. Trans. AIME, v. 245, No. 5, May 1969, pp. 955–959.

[12] Bhappu, Roshan B., P. H. Johnson, J. A. Brierley, and D. H. Reynolds. Theoretical and Practical Studies on Dump Leaching. Trans. AIME, v. 244, No. 3, September 1969, pp. 307–320.

[13] Spedden, H. R., and E. E. Malouf (assigned to Kennecott Copper Corp.). Process for Recovering Copper From Leach Solutions. U.S. Pat. 3,476,554, Nov. 4, 1969.

[14] Verney, L. R. Fluxing in Copper Reverberatory Furnaces and Copper Losses in Slag. Trans. Inst. Min. Met., v. 78, sec. C., No. 748, March 1969, pp. c28–c42.

[15] Hoffman, William E. Use of Copper Alloys in Car Brakes Studied. Am. Metal Market, v. 76, No. 103, June 3, 1969, p. 7.

tators, and in electrical contacts.[16] Research by the Bureau of Mines showed improved strength properties for copper that was dispersion-strengthened with yttria or alumina compared with oxygen-free copper.[17]

Use of hot gases to braze copper coil joints has a claimed advantage of quality process control on assembly line techniques with resultant uniformity of product and use of lower cost brazing alloys.[18]

Copper is being increasingly used as a base coat on steel, diecastings, and plastic for final coating with nickel or chromium. The copper acts in a leveling capacity to reduce buffing operations and provides a low-stress surface for final plating.[19]

Included in research activity reported by the International Copper Research Association (INCRA) are pilot testing of a clear polyvinyl fluoride film bonded adhesively to copper surfaces for a protective coating, a process to produce a bluish-green hue on copper surfaces for architectural use, a technique to apply insulating coatings to copper by electrophoresis (electrocoating), and development of organocopper compounds for various industrial applications.

[16] Johnston, W. E. New Copper Alloy Meets New Needs. Metal Progress, v. 96, No. 6, December 1969, pp. 76–77.
[17] Desy, D. H. Dispersion-Strengthened Copper. BuMines Rept. of Inv. 7228, March 1969, 24 pp.
[18] Iron Age. Brazing Copper Coils by Hot Gases. V. 203, No. 19, May 8, 1969, pp. 92–93.
[19] Iron Age. Bright New Idea in Copper Plate. V. 203, No. 23, June 5, 1969, pp. 58–59.

Table 2.—Copper produced from domestic ores, by source

(Thousand short tons)

Year	Mine	Smelter	Refinery
1965	1,352	1,403	1,336
1966	1,429	1,430	1,353
1967	954	841	847
1968	1,205	1,235	1,161
1969	1,545	1,547	1,469

Table 3.—Copper ore and recoverable copper produced, by mining method

(Percent)

Year	Open pit		Underground	
	Ore	Copper [1]	Ore	Copper [2]
1965	84	77	16	23
1966	85	80	15	20
1967	85	83	14	17
1968	87	82	13	18
1969	88	84	12	16

[1] Includes copper from dump leaching.
[2] Includes copper from in-place leaching.

Table 4.—Mine production of recoverable copper in the United States, by months

(Short tons)

Month	1968	1969
January	23,024	120,829
February	28,034	118,481
March	41,080	132,795
April	110,936	131,479
May	125,538	127,496
June	124,635	129,317
July	123,559	123,170
August	127,903	125,145
September	121,322	127,662
October	129,833	135,429
November	124,018	134,191
December	124,739	138,585
Total	1,204,621	1,544,579

Table 5.—Mine production of recoverable copper in the United States, by States

(Short tons)

State	1965	1966	1967	1968	1969
Alaska	32	W	W	W	---------
Arizona	703,377	739,569	501,741	627,961	801,363
California	1,165	1,078	788	1,182	1,129
Colorado	3,828	4,237	3,993	3,451	3,598
Idaho	5,140	4,961	4,210	3,525	3,332
Michigan	71,749	73,449	58,458	74,805	75,226
Missouri	2,331	3,913	3,215	5,494	12,664
Montana	115,489	128,061	65,483	69,480	103,314
Nevada	71,332	78,720	50,771	77,213	104,924
New Mexico	98,658	108,614	75,008	90,769	119,956
Pennsylvania	4,354	3,178	4,401	4,850	3,382
Tennessee	14,823	15,410	14,600	14,196	15,353
Utah	259,138	265,383	168,609	228,245	296,699
Washington	30	34	21	22	18
Wyoming	6	---------	---------	---------	W
Other States [1]	282	2,545	2,766	3,428	3,621
Total	1,351,734	1,429,152	954,064	1,204,621	1,544,579

W Withheld to avoid disclosing individual company confidential data; included in "Other States."
[1] Includes Maine, Oklahoma, Oregon, and Wyoming.

Table 6.—Twenty-five leading copper-producing mines in the United States in 1969, in order of output

Rank	Mine	County and State	Operator	Source of copper
1	Utah Copper	Salt Lake, Utah	Kennecott Copper Corp	Copper ore, copper precipitates, gold-silver ore.
2	Morenci	Greenlee, Ariz	Phelps Dodge Corp	Do.
3	San Manuel	Pinal, Ariz	Magma Copper Co	Copper ore.
4	Ray Pit	do	Kennecott Copper Corp	Copper ore, copper precipitates.
5	Chino	Grant, N. Mex	do	Do.
6	White Pine	Ontonagon, Mich	White Pine Copper Co	Copper ore.
7	Berkeley Pit	Silver Bow, Mont	The Anaconda Company	Do.
8	New Cornelia	Pima, Ariz	Phelps Dodge Corp	Copper, gold-silver ores.
9	Pima	do	Pima Mining Co	Copper ore.
10	Copper Queen-Lavender Pit	Cochise, Ariz	Phelps Dodge Corp	Copper ore, copper precipitates.
11	Inspiration	Gila, Ariz	Inspiration Consolidated Copper Co.	Do.
12	Yerington	Lyon, Nev	The Anaconda Company	Copper ore.
13	Mission	Pima, Ariz	American Smelting and Refining Co.	Do.
14	Veteran-Tripp Pit	White Pine, Nev	Kennecott Copper Corp	Do.
15	Butte Hill Copper Mines	Silver Bow, Mont	The Anaconda Company	Copper ore, copper precipitates.
16	Mineral Park	Mohave, Ariz	Duval Corp	Do.
17	Silver Bell	Pima, Ariz	American Smelting and Refining Co.	Do.
18	Copper Cities	Gila, Ariz	Tennessee Corp	Copper ore, copper precipitates.
19	Esperanza	Pima, Ariz	Duval Corp	Do.
20	Magma	Pinal, Ariz	Magma Copper Co	Copper ore.
21	Bagdad	Yavapai, Ariz	Bagdad Copper Corp	Copper ore, copper precipitates.
22	Tyrone	Grant, N. Mex	Phelps Dodge Corp	Copper ore.
23	Copperhill	Polk, Tenn	Tennessee Copper Co	Copper-zinc ore.
24	Copper Canyon	Lander, Nev	Duval Corp	Copper ore.
25	Twin Buttes	Pima, Ariz	The Anaconda Company	Do.

Table 7.—Mine production of recoverable copper in 1969, by method of treatment

Method of treatment	Ore treated (thousand short tons)	Recoverable copper: Thousand pounds	Recoverable copper: Percent yield	Remarks
Copper ore:				
By concentration	204,704	2,533,253	0.62	See table 9.
By smelting	485	21,062	2.17	See table 10.
By leaching	18,563	137,062	.37	See table 11.
	223,752	2,691,377	.60	
Dump and in-place leaching	---------	330,214	----	See table 11.
Miscellaneous from residues, tailings, and non-copper ores	---------	67,567	----	----------
Total	XX	3,089,158	XX	----------

XX Not applicable.

Table 8.—Copper ore shipped directly to smelters or concentrated in the United States by States in 1969 with copper, gold, and silver content in terms of recoverable metal

State	Ore shipped or concentrated (thousand short tons)	Copper: Thousand pounds	Copper: Percent	Gold (troy ounces)	Silver (troy ounces)	Value of gold and silver per ton of ore
Arizona	113,701	1,389,172	0.61	108,718	5,899,843	$0.13
Idaho	1	84	4.20	5	834	1.70
Michigan	8,200	150,452	.92	---------	1,009,022	.22
Montana	16,017	181,076	.57	15,420	2,555,970	.33
Nevada	14,345	153,725	.54	76,212	684,937	.31
New Mexico	12,558	172,174	.69	8,163	324,204	.07
Tennessee [1]	1,574	30,706	.98	126	78,614	.09
Utah	38,650	472,308	.61	370,632	3,009,099	.54
Other States	143	4,618	1.61	21	18,993	.24
Total	205,189	2,554,315	.62	579,297	13,581,516	.23

[1] Copper-zinc ore.

Table 9.—Copper ore concentrated [1] in the United States, by States in 1969 with content in terms of recoverable copper

State	Ore concentrated (thousand short tons)	Recoverable copper content	
		Thousand pounds	Percent
Arizona	113,357	1,369,287	0.60
Michigan	8,200	150,452	.92
Montana	16,017	181,072	.57
Nevada	14,270	152,807	.54
New Mexico	12,493	172,026	.69
Tennessee [2]	1,574	30,706	.98
Utah	38,650	472,237	.61
Other States	143	4,616	.61
Total	204,704	2,533,253	.62

[1] Includes following methods of concentration: "Dual process" (leaching followed by concentration); "LPF" (leach-precipitation-flotation); and froth flotation.
[2] Copper-zinc ore.

Table 10.—Copper ore shipped directly to smelters in the United States, by States in 1969, with content in terms of recoverable copper

State	Ore shipped to smelters		
	Short tons	Recoverable copper content	
		Pounds	Percent
Arizona	344,360	19,885,000	2.89
Idaho	682	84,500	6.20
Montana	57	3,900	3.42
Nevada	75,272	918,200	[1] .61
New Mexico	64,531	148,200	[1] .11
Utah	45	20,600	22.89
Other States	17	1,800	5.29
Total	484,964	21,062,200	2.17

[1] Primarily smelter fluxing material.

Table 11.—Copper precipitates (from dump or in-place leaching) shipped directly to smelters and copper ore leached (heap, vat, or tank) in the United States, by States in 1969, with content in terms of recoverable copper

State	Precipitates shipped (short tons)	Recoverable copper content (pounds)	Ore leached (short tons)	Recoverable copper content (pounds)	Percent
Arizona	83,418	116,022,800	14,147,958	88,348,800	0.31
Montana	16,693	25,264,400	----	----	----
Nevada	6,299	7,997,700	[1] 4,414,552	[1] 48,712,600	.55
New Mexico	41,458	66,952,000	----	----	----
Utah	69,225	113,977,200	(1)	(1)	
Total	217,093	330,214,100	18,562,510	137,061,400	.37

[1] Nevada and Utah combined to avoid disclosing individual company confidential data.

Table 12.—Copper ore smelted and copper ore concentrated in the United States, and average yield in copper, gold and silver

Year	Smelting ore		Concentrating ore		Total				
	Thousand short tons	Yield in copper, percent	Thousand short tons [1]	Yield in copper, percent	Thousand short tons [1]	Yield in copper, percent	Yield per ton in gold, ounce	Yield per ton in silver, ounce	Value per ton in gold and silver
1965	625	2.43	172,662	0.70	173,286	0.70	0.0033	0.074	$0.21
1966	549	2.34	[2] 186,417	.66	186,966	.67	.0029	.071	.19
1967	303	2.52	[2] 126,763	.63	127,066	.63	.0025	.066	.19
1968	383	2.46	[2] 169,671	.60	170,054	.60	.0024	.056	.21
1969	485	2.17	[3] 204,704	.62	205,189	.62	.0028	.065	.23

[1] Includes some ore classed as copper-zinc and minor amount of tailings (1969 excludes tailings).
[2] Includes all methods of concentration: "Dual process" (leaching followed by flotation concentration), LPF (leach-precipitation-flotation), tank or vat leaching, heap leaching, and froth flotation.
[3] Excludes tank or vat and heap leaching. (See tables 7 and 11).

Table 13.—Copper produced by primary smelters in the United States

(Short tons)

Year	Domestic	Foreign	Secondary	Total
1965	1,402,806	31,244	93,895	1,527,945
1966	1,429,863	36,573	114,671	1,581,107
1967	841,343	20,997	70,746	933,086
1968	1,234,724	31,754	84,821	1,351,299
1969	1,547,496	37,995	77,329	1,662,820

Table 14.—Primary and secondary copper produced by primary refineries in the United States

(Short tons)

	1965	1966	1967	1968	1969
PRIMARY					
From domestic ores, etc.:[1]					
Electrolytic	1,200,532	1,213,918	754,175	1,013,246	1,296,749
Lake	71,241	69,126	54,004	78,304	76,417
Casting	63,887	70,043	38,372	69,375	95,723
Total	1,335,660	1,353,087	846,551	1,160,925	1,468,889
From foreign ores, etc.:[1]					
Electrolytic	332,593	321,302	258,473	219,726	225,714
Casting and best select	43,540	36,595	27,958	56,735	48,212
Total refinery production of primary copper	1,711,793	1,710,984	1,132,982	1,437,386	1,742,815
SECONDARY					
Electrolytic[2]	368,232	409,986	318,709	327,549	410,749
Casting	19,879	27,977	24,568	15,869	2,094
Total secondary	388,111	437,963	343,277	343,418	412,843
Grand total	2,099,904	2,148,947	1,476,259	1,780,804	2,155,658

[1] The separation of refined copper into metal of domestic and foreign origin is only approximate, as accurate separation is not possible at this stage of processing.
[2] Includes copper reported from foreign scrap.

Table 15.—Copper cast in forms at primary refineries in the United States

	1968		1969	
	Thousand short tons	Percent	Thousand short tons	Percent
Billets	187	11	209	10
Cakes	93	5	131	6
Cathodes	198	11	234	11
Ingots and ingot bars	238	13	255	12
Wire bars	1,050	59	1,300	60
Other forms	15	1	27	1
Total	1,781	100	2,156	100

Table 16.—Production, shipments, and stocks of copper sulfate

(Short tons)

Year	Production		Shipments	Stocks Dec. 31[1]
	Quantity	Copper content		
1965	47,340	11,835	45,640	5,048
1966	51,676	12,919	51,816	4,464
1967	40,128	10,032	40,644	3,516
1968	43,784	10,946	43,648	3,380
1969	50,568	12,642	49,556	4,248

[1] Some small quantities are purchased and used by producing companies, so that the figures given do not balance exactly.

Table 17.—Byproduct sulfuric acid[1] (100-percent basis) produced in the United States

(Short tons)

Year	Copper plants[2]	Lead and Zinc plants[3]	Total
1965	369,321	961,591	1,330,912
1966	469,728	983,118	1,452,846
1967	348,497	900,170	1,248,667
1968	483,108	989,973	1,473,081
1969	685,775	1,086,938	1,772,713

[1] Includes acid from foreign materials.
[2] Includes acid produced at a lead smelter in 1965–68. Excludes acid made from pyrites concentrates in Arizona, Montana, Tennessee, and Utah.
[3] Excludes acid made from native sulfur.

Table 18.—Secondary copper produced in the United States
(Short tons)

	1965	1966	1967	1968	1969
Copper recovered as unalloyed copper	462,811	509,084	423,054	433,041	514,593
Copper recovered in alloys [1]	790,439	825,165	736,853	785,299	860,900
Total secondary copper	1,253,250	1,334,249	1,159,907	1,218,340	1,375,493
Source:					
New scrap	739,814	799,389	677,248	697,568	800,603
Old scrap	513,436	534,860	482,659	520,772	574,890
Percentage equivalent of domestic mine output	93	93	122	101	89

[1] Includes copper in chemicals, as follows: 1965—6,129; 1966—6,043; 1967—4,965; 1968—4,757; and 1969—3,824.

Table 19.—Copper recovered from scrap processed in the United States by kinds of scrap and form of recovery
(Short tons)

Kind of scrap	1968	1969	Form of recovery	1968	1969
New scrap:			As unalloyed copper:		
Copper-base	686,841	787,727	At primary plants	343,418	412,843
Aluminum-base	10,500	12,595	At other plants	89,623	101,750
Nickel-base	216	265			
Zinc-base	11	16	Total	433,041	514,593
Total	697,568	800,603			
			In brass and bronze	746,380	820,945
			In alloy iron and steel	3,527	2,570
Old scrap:			In aluminum alloys	30,124	32,826
Copper-base	515,530	568,769	In other alloys	511	735
Aluminum-base	4,600	4,973	In chemical compounds	4,757	3,824
Nickel-base	600	1,103			
Tin-base	17	15	Total	785,299	860,900
Zinc-base	25	30			
			Grand total	1,218,340	1,375,493
Total	520,772	574,890			
Grand total	1,218,340	1,375,493			

Table 20.—Copper recovered as refined copper, in alloys and in other forms from copper-base scrap processed in the United States
(Short tons)

Recovered by—	From new scrap		From old scrap		Total	
	1968	1969	1968	1969	1968	1969
Secondary smelters	65,683	72,515	262,806	277,240	328,489	349,755
Primary copper producers	185,752	215,561	157,666	197,282	343,418	412,843
Brass mills	414,891	480,093	36,214	38,541	451,105	518,634
Foundries and manufacturers	19,165	18,687	55,387	52,856	74,552	71,543
Chemical plants	1,349	871	3,457	2,850	4,806	3,721
Total	686,840	787,727	515,530	568,769	1,202,370	1,356,496

Table 21—Production of secondary copper and copper-alloy products in the United States

(Short tons)

Item produced from scrap	1968	1969
UNALLOYED COPPER PRODUCTS		
Refined copper by primary producers	343,418	412,843
Refined copper by secondary smelters	73,161	86,279
Copper powder	15,164	14,545
Copper castings	1,298	926
Total	433,041	514,593
ALLOYED COPPER PRODUCTS		
Brass and bronze ingots:		
Tin bronze	16,810	19,225
Leaded tin bronze	15,312	17,525
Leaded red brass and semired brass	172,918	177,323
High-leaded tin bronze	34,846	35,257
Leaded yellow brass	24,586	23,627
Manganese bronze	16,547	16,866
Aluminum bronze	12,022	11,367
Nickel silver	4,217	3,804
Low brass	2,980	1,255
Silicon and conductor bronze	7,677	7,754
Copper-base hardeners and special alloys	13,382	12,208
Total	321,297	326,211
Brass-mill products	585,808	683,676
Brass and bronze castings	52,869	52,154
Brass powder	1,187	1,106
Copper in chemical products	4,757	3,824
Grand total	1,398,959	1,581,564

Table 22.—Composition of secondary copper-alloy production

(Short tons)

	Copper	Tin	Lead	Zinc	Nickel	Aluminum	Total
Brass and bronze production [1]							
1968	253,578	14,128	19,917	32,785	806	83	321,297
1969	256,605	14,084	20,129	34,451	876	66	326,211
Secondary metal content of brass-mill products:							
1968	452,618	543	3,555	126,671	2,392	29	585,808
1969	518,401	739	4,650	156,550	3,321	15	683,676
Secondary metal content of brass and bronze castings:							
1968	42,190	1,873	5,353	3,382	13	58	52,869
1969	41,601	1,837	5,236	3,398	15	67	52,154

[1] About 94 percent from scrap and 6 percent from other than scrap.

Table 23.—Stocks and consumption of purchased copper scrap in the United States in 1969

(Short tons)

Class of consumer and type of scrap	Stocks Jan. 1	Receipts	Consumption: New scrap	Consumption: Old scrap	Consumption: Total	Stocks Dec. 31
SECONDARY SMELTERS						
No. 1 wire and heavy copper	2,102	47,572	7,791	39,237	47,028	2,646
No. 2 wire, mixed heavy and light copper	1,740	94,124	16,112	76,446	92,558	3,306
Composition or red brass	4,198	94,527	23,066	71,722	94,788	3,937
Railroad-car boxes	182	2,457	---------	2,474	2,474	165
Yellow brass	5,722	73,101	9,055	62,735	71,790	7,033
Cartridge cases and brass	222	1,719	---------	1,836	1,836	105
Auto radiators (unsweated)	3,425	61,624	---------	62,487	62,487	2,562
Bronze	2,852	33,623	6,176	27,749	33,925	2,550
Nickel silver	662	6,024	738	5,382	6,120	566
Low brass	583	6,242	5,259	1,030	6,289	536
Aluminum bronze	158	391	246	144	390	159
Low-grade scrap and residues	9,458	58,744	52,615	9,578	62,193	6,009
Total	31,304	480,148	121,058	360,820	481,878	29,574
PRIMARY PRODUCERS						
No. 1 wire and heavy copper	2,669	124,374	61,728	63,346	125,074	1,969
No. 2 wire, mixed heavy and light copper	14,591	222,837	142,650	71,554	214,204	23,224
Refinery brass	38	3,383	2,664	359	3,023	398
Low-grade scrap and residues	12,971	294,872	67,323	211,342	278,665	29,178
Total	30,269	645,466	274,365	346,601	620,966	54,769
BRASS MILLS [1]						
No. 1 wire and heavy copper	7,568	135,862	111,748	24,114	135,862	8,567
No. 2 wire, mixed heavy and light copper	3,788	33,729	32,777	952	33,729	2,005
Yellow brass	18,932	322,695	322,695	--------	322,695	25,382
Cartridge cases and brass	5,894	130,263	110,444	19,819	130,263	8,650
Bronze	730	5,705	5,705	--------	5,705	784
Nickel silver	7,054	15,563	15,563	--------	15,563	3,212
Low brass	3,452	47,840	47,840	--------	47,840	3,747
Aluminum bronze	222	150	150	--------	150	98
Mixed alloy scrap	3,510	3,143	3,143	--------	3,143	1,340
Total [1]	51,150	694,950	650,065	44,885	694,950	53,785
FOUNDRIES, CHEMICAL PLANTS, AND OTHER MANUFACTURERS						
No. 1 wire and heavy copper	2,302	30,413	10,891	19,440	30,331	2,384
No. 2 wire, mixed heavy and light copper	1,641	12,750	3,995	8,958	12,953	1,438
Composition or red brass	680	4,447	1,334	3,228	4,562	565
Railroad-car boxes	1,317	23,446	---------	24,262	24,262	501
Yellow brass	747	7,056	4,066	3,094	7,160	643
Auto radiators (unsweated)	974	6,601	---------	6,763	6,763	812
Bronze	528	1,184	373	1,072	1,445	267
Nickel silver	4	81	23	54	77	8
Low brass	32	424	224	213	437	19
Aluminum bronze	228	470	387	243	630	68
Low-grade scrap and residues	2,775	2,578	1,521	3,370	4,891	462
Total	11,228	89,450	[2] 22,814	[2] 70,697	[2] 93,511	7,167
GRAND TOTAL						
No. 1 wire and heavy copper	14,641	338,221	192,158	146,137	338,295	15,566
No. 2 wire, mixed heavy and light copper	21,760	363,440	195,534	157,910	353,444	29,973
Composition or red brass	4,878	98,974	24,400	74,950	99,350	4,502
Railroad-car boxes	1,499	25,903	---------	26,736	26,736	666
Yellow brass	25,401	402,852	335,816	65,829	401,645	33,058
Cartridge cases and brass	6,116	131,982	110,444	21,655	132,099	8,755
Auto radiators (unsweated)	4,399	68,225	---------	69,250	69,250	3,374
Bronze	4,110	40,512	12,254	28,821	41,075	3,601
Nickel silver	7,720	21,668	16,324	5,436	21,760	3,786
Low brass	4,067	54,506	53,323	1,243	54,566	4,302
Aluminum bronze	608	1,011	783	387	1,170	325
Low-grade scrap and residues [3]	25,242	359,577	124,123	224,649	348,772	36,047
Mixed alloy scrap	3,510	3,143	3,143	--------	3,143	1,340
Total	123,951	1,910,014	1,068,302	823,003	1,891,305	145,295

[1] Brass-mill stocks include home scrap; purchased scrap consumption assumed equal to receipts, so lines in brass-mill and grand total sections do not balance.
[2] Of the totals shown, chemical plants reported the following: Unalloyed copper scrap, 610 tons of new and 2,668 tons of old; copper-base alloy scrap 1,160 tons of new and 1,208 tons of old.
[3] Includes stocks of refinery brass.

Table 24.—Consumption of copper and brass materials in the United States, by principal consuming groups

(Short tons)

Year and item	Primary producers	Brass mills	Wire mills	Foundries, chemical plants, and miscellaneous users	Secondary smelters	Total
1968:						
Copper scrap	513,326	595,062	---------	102,922	450,264	1,661,574
Refined copper [1]	--------	652,450	1,189,274	32,222	6,354	1,880,300
Brass ingot	--------	5,213	---------	[2] 321,292	--------	326,505
Slab zinc	--------	146,689	---------	3,219	11,998	161,906
Miscellaneous	--------	--------	---------	150	2,436	2,586
1969:						
Copper scrap	620,966	694,950	---------	93,511	481,878	1,891,305
Refined copper [1]	--------	797,126	1,296,316	41,818	6,958	2,142,218
Brass ingot	--------	6,532	---------	[2] 330,019	--------	336,551
Slab zinc	--------	160,718	---------	2,915	15,836	179,469
Miscellaneous	--------	--------	---------	150	--------	150

[1] Detailed information on consumption of refined copper will be found in table 29.
[2] Shipments to foundries by smelters plus decrease in stocks at foundries.

Table 25.—Foundry consumption of brass ingot, by types, in the United States

(Short tons)

	1965	1966	1967	1968	1969
Tin bronze	9,999	11,174	10,691	11,745	11,954
Leaded tin bronze	31,331	31,699	28,048	30,013	31,818
Leaded red brass	181,773	174,270	145,579	149,139	155,895
High-leaded tin bronze	22,930	23,595	20,928	20,021	20,278
Leaded yellow brass	19,767	17,349	15,866	25,428	28,685
Manganese bronze	9,816	10,331	10,254	10,274	10,680
Hardeners	4,349	4,035	4,096	3,822	4,315
Nickel silver	3,398	3,577	4,094	3,870	4,041
Aluminum bronze	8,122	8,361	7,953	10,202	8,498
Low brass	2,503	3,575	2,761	3,611	4,313
Total	293,988	287,966	250,270	268,125	280,477

Table 26.—Foundry consumption of brass ingot by types, refined copper, and copper scrap, in the United States in 1969, by geographic divisions and States

(Short tons)

Geographic division and State	Tin bronze	Leaded tin bronze	Leaded red brass	High-leaded tin bronze	Leaded yellow brass	Manganese bronze	Hardeners	Nickel silver	Aluminum bronze	Low brass	Total brass ingot	Refined copper consumed	Copper scrap consumed
New England:													
Connecticut	212	596	3,912	151	1,659	133	10	7	42	146	6,868	203	1,089
Massachusetts	661	1,292	5,571	287	31	293	49	237	36	309	8,766	426	879
Maine, New Hampshire, Rhode Island, and Vermont	113	210	2,151	91	174	280	7	275	13	13	3,327	50	10
Total	986	2,098	11,634	529	1,864	706	66	519	91	468	18,961	679	1,978
Middle Atlantic:													
New Jersey	675	384	3,284	238	67	264	14	82	135	119	5,262	1,350	3,472
New York	964	1,373	13,990	1,041	543	1,236	36	117	678	166	20,144	1,842	8,277
Pennsylvania	1,077	6,861	16,476	1,800	1,245	935	1,364	375	1,550	848	32,531	6,426	8,918
Total	2,716	8,618	33,750	3,079	1,855	2,435	1,414	574	2,363	1,133	57,937	9,618	20,667
East North Central:													
Illinois	537	3,257	14,476	733	73	717	197	130	871	770	21,761	1,478	3,440
Indiana	62	472	14,659	614	318	401	929	353	71	108	17,987	1,410	7,659
Michigan	1,226	2,979	9,630	380	12,000	2,194	174	7	1,293	471	30,354	5,637	1,199
Ohio	1,848	7,365	14,962	9,519	480	1,476	365	61	604	275	36,955	5,567	8,782
Wisconsin	792	382	7,516	2,485	1,051	143	731	1,054	323	413	14,890	9,490	669
Total	4,465	14,455	61,243	13,731	13,922	4,931	2,396	1,605	3,162	2,037	121,947	23,582	21,749
West North Central:													
Iowa, Kansas, and Minnesota	423	231	6,241	323	63	391	90	31	216	201	8,196	373	1,781
Missouri, Nebraska, and South Dakota	45	196	1,479	739	1,566	223	10		739		5,011	739	9,122
Total	468	427	7,720	1,062	1,629	614	100	31	955	201	13,207	1,112	10,903
South Atlantic:													
Delaware, District of Columbia, Florida, Georgia, and Maryland	578	118	1,252	35	121	126	6	697	102	22	3,050	280	119
North Carolina, South Carolina, Virginia, and West Virginia	210	3,836	6,097	309	329	225		------	285		11,298	1,977	7,055
Total	788	3,954	7,349	344	450	351	6	697	387	22	14,348	2,257	7,174
East South Central:													
Alabama, Kentucky, Mississippi, and Tennessee	398	636	10,363	1,033	6,359	731	58	134	34	98	19,844	251	8,330
West South Central:													
Arkansas, Louisiana, Oklahoma, and Texas	1,366	557	10,051	318	1,011	332	8	288	977	139	15,047	539	2,101
Mountain:													
Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, and Utah	158	68	288	18	1	114	5	1	21	86	760	146	604
Pacific:													
California	584	988	13,226	62	1,419	330	262	192	326	124	17,513	462	11,034
Oregon and Washington	25	17	271	102	175	136	------	------	182	5	913	77	3,325
Total	609	1,005	13,497	164	1,594	466	262	192	508	129	18,426	539	14,359
Grand Total	11,954	31,818	155,895	20,278	28,685	10,680	4,315	4,041	8,498	4,313	280,477	38,723	87,865

Table 27.—Primary refined copper supply and withdrawals on domestic account

(Short tons)

	1965	1966	1967	1968	1969
Production from domestic and foreign ores, etc	1,711,793	1,710,984	1,132,982	1,437,386	1,742,815
Imports [1]	137,443	162,602	330,347	400,278	131,171
Stocks Jan. 1 [1]	37,000	35,000	43,000	27,000	48,000
Total available supply	1,886,236	1,908,586	1,506,329	1,864,664	1,921,986
Copper exports [1]	324,965	273,071	159,353	240,745	200,269
Stocks Dec. 31 [1]	35,000	43,000	27,000	48,000	39,000
Total	359,965	316,071	186,353	288,745	239,269
Apparent withdrawals on domestic account [2]	1,526,000	1,593,000	1,320,000	1,576,000	1,683,000

[1] May include some copper refined from scrap.
[2] Includes copper delivered by industry to the Government stockpiles.

Table 28.—Refined copper consumed, by class of consumers

(Short tons)

Year and class of consumer	Cathodes	Wire bars	Ingots and ingot bars	Cakes and slabs	Billets	Other	Total
1968:							
Wire mills	16,632	1,164,933	6,716	-------	-------	993	1,189,274
Brass mills	141,836	26,610	140,658	122,367	220,504	475	652,450
Chemical plants	-------	---------	520	-------	-------	1,123	1,643
Secondary smelters	3,583	---------	2,583	-------	-------	188	6,354
Foundries	501	65	12,278	10	143	1,096	14,093
Miscellaneous [1]	1,959	69	6,872	(2)	[3] 930	6,656	16,486
Total	164,511	1,191,677	169,627	122,377	221,577	10,531	1,880,300
1969:							
Wire mills	50,631	1,237,939	(4)	(4)	-------	[5] 7,746	1,296,316
Brass mills	183,644	31,847	152,529	172,264	256,714	128	797,126
Chemical plants	-------	---------	471	-------	-------	2,624	3,095
Secondary smelters	3,866	---------	3,025	-------	-------	67	6,958
Foundries	1,434	224	13,134	12	117	1,280	16,201
Miscellaneous [1]	1,574	790	10,643	226	1,542	7,747	22,522
Total	241,149	1,270,800	179,802	172,502	258,373	19,592	2,142,218

[1] Includes iron and steel plants, primary smelters producing alloys other than copper, consumers of copper powder and copper shot, and miscellaneous manufacturers.
[2] Included with "Billets" to avoid disclosing individual company confidential data.
[3] Includes "Cakes and slabs" to avoid disclosing individual company confidential data.
[4] Included with "Other" to avoid disclosing individual company confidential data.
[5] Includes "Ingots and ingot bars" and "Cakes and slabs" to avoid disclosing individual company confidential data.

Table 29.—Stocks of copper at primary smelting and refining plants in the United States, Dec. 31

(Thousand short tons)

Year	Refined copper [1]	Blister and materials in process of refining [2]
1965	35	246
1966	43	270
1967	27	220
1968	48	272
1969	39	291

[1] May include some copper refined from scrap.
[2] Includes copper in transit from smelters in the United States to refineries therein.

Table 30.—Stocks of copper in fabricators' hands Dec. 31
(Short tons)

Year	Stocks of refined copper [1] (1)	Unfilled purchases of refined copper from producers (2)	Working stocks (3)	Unfilled sales to customers (4)	Excess stocks over orders booked [2] (5)
1965	462,519	129,349	395,396	288,681	−92,209
1966	558,599	134,732	407,345	361,559	−75,573
1967	479,572	98,716	415,765	269,474	−106,951
1968	514,553	128,919	420,186	273,469	−50,183
1969	502,300	99,232	412,734	256,299	−67,501

[1] Includes in-process metal and primary fabricated shapes. Also includes small quantities of refined copper held at refineries for fabricators' account.
[2] Columns (1) plus (2) minus (3) and minus (4) equal column (5).
Source: United States Copper Association.

Table 31.—Dealers' monthly average buying price for copper scrap and consumers' alloy-ingot prices at New York in 1969
(Cents per pound)

Grade	Jan.	Feb.	Mar.	Apr.	May	June
No. 2 copper scrap	37.69	39.34	39.78	43.95	42.12	42.79
No. 1 composition scrap	32.95	33.50	34.78	35.14	37.12	37.79
No. 1 composition ingot	47.07	48.75	48.75	51.52	52.75	52.75

Grade	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
No. 2 copper scrap	41.09	44.17	44.88	44.00	44.88	49.81	42.88
No. 1 composition scrap	36.09	39.09	39.38	38.50	38.62	41.50	37.04
No. 1 composition ingot	51.32	52.04	52.75	52.75	54.59	58.00	51.92

Source: Metal Statistics, 1970.

Table 32.—Average weighted prices of copper deliveries [1]
(Cents per pound)

Year	Domestic copper	Foreign copper
1965	35.4	36.5
1966	36.6	50.5
1967	38.6	48.2
1968	42.2	51.4
1969	47.9	63.2

[1] Covers copper produced in the United States and delivered here and abroad and copper produced abroad and delivered in the United States.

Source: Bureau of Mines reports from copper selling agencies in 1965 and Metals Week, 1966–68.

Table 33.—Average monthly quoted prices of electrolytic copper for domestic delivered in the United States and for spot copper at London
(Cents per pound)

Month	1968			1969		
	Domestic delivered		London spot [1]	Domestic delivered		London spot [1]
	American Metal Market	Metals Week	Metals Week	American Metal Market	Metals Week	Metals Week
January	38.12	(2)	64.08	43.03	43.90	56.61
February	38.12	(2)	78.22	44.12	44.23	58.04
March	38.68	(2)	77.06	44.12	44.79	57.75
April	42.12	(2)	56.92	44.12	44.95	62.74
May	42.12	(2)	49.47	45.50	45.89	62.74
June	42.12	42.50	51.16	46.12	46.42	66.88
July	42.12	42.11	47.58	46.12	46.45	65.64
August	42.12	42.10	47.71	48.03	48.32	72.38
September	42.12	42.12	50.06	51.55	51.76	71.11
October	42.12	42.11	48.74	52.12	52.48	70.19
November	42.12	42.11	49.56	52.12	52.52	73.84
December	42.12	42.11	53.35	52.12	52.89	76.96
Average	41.17	42.25	56.13	47.43	47.93	66.24

[1] Based on average monthly rates of exchange by Federal Reserve Board.
[2] Suspended.

Table 34.—U.S. exports of copper by classes and countries

Year and country	Ore, concentrates, and matte (copper content)		Refined		Scrap	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1968	64,990	$46,902	240,745	$235,450	34,109	$30,053
1969:						
Africa	--	--	62	74	3	3
Argentina	--	--	191	202	--	--
Belgium-Luxembourg	150	159	2,206	2,620	1,593	1,293
Brazil	--	--	17,065	19,040	--	--
Canada	978	980	20,428	21,802	1,834	1,644
Chile	--	--	3	3	--	--
Colombia	--	--	2	3	--	--
France	--	--	17,055	19,543	--	--
Germany, West	--	--	26,282	31,074	870	788
India	--	--	12,955	13,904	27	23
Italy	--	--	37,953	41,910	243	177
Japan	--	--	14,942	16,539	1,204	1,068
Mexico	--	--	18	16	22	19
Netherlands	48	55	8,295	9,849	71	86
Oceania	--	--	50	58	--	--
Peru	--	--	3	4	--	--
Spain	--	--	2,705	3,209	479	406
Sweden	--	--	4,605	5,461	20	27
Switzerland	--	--	2,350	2,783	--	--
United Kingdom	--	--	24,436	29,831	82	83
Yugoslavia	--	--	2,713	3,167	1,083	1,110
Other	1	1	5,950	6,980	61	66
Total	1,177	1,195	200,269	228,072	7,592	6,793

Year and country	Blister		Pipes and tubing		Plates and sheets	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1968	15,749	$11,579	598	$1,219	144	$292
1969:						
Africa	--	--	17	39	1	2
Argentina	--	--	--	--	1	1
Belgium-Luxembourg	1,606	1,326	3	6	3	6
Brazil	--	--	5	15	--	--
Canada	127	107	376	667	333	588
Chile	--	--	6	24	--	--
Colombia	--	--	185	348	--	--
France	--	--	33	58	12	24
Germany, West	2,435	2,315	1	3	23	37
India	55	53	14	35	--	--
Italy	60	60	9	16	1	2
Japan	27	32	2	12	6	11
Mexico	--	--	15	40	14	27
Netherlands	29	24	10	25	1	3
Oceania	--	--	[1]	[1]	--	--
Peru	--	--	7	22	2	7
Spain	--	--	1	1	1	7
Sweden	--	--	2	4	--	--
Switzerland	--	--	1	2	--	--
United Kingdom	--	--	6	14	3	6
Yugoslavia	--	--	1	1	--	--
Other	1	1	258	593	24	42
Total	4,340	3,918	952	1,925	425	763

See footnotes at end of table.

Table 34.—U.S. exports of copper by classes and countries—Continued

Year and country	Wire and cable, bare: Short tons	Wire and cable, bare: Value (thousands)	Wire and cable, insulated: Short tons	Wire and cable, insulated: Value (thousands)	Other copper manufactures [2]: Short tons	Other copper manufactures [2]: Value (thousands)
1968	2,450	$3,082	19,946	$38,002	4,669	$5,681
1969:						
Africa	875	1,303	2,869	3,849	9	11
Argentina	4	6	44	223	1	1
Belgium-Luxembourg	14	18	44	336	5	6
Brazil	65	78	93	531	2	2
Canada	626	835	8,204	25,180	448	697
Chile	83	135	1,059	1,802	2	3
Colombia	117	138	79	224	205	1,118
France	153	206	105	733	39	78
Germany, West	33	75	323	1,966	100	117
India	---	---	13	55	---	---
Italy	18	39	173	1,115	1	1
Japan	4	17	250	845	24	48
Mexico	229	370	2,077	3,992	18	133
Netherlands	(1)	1	81	423	11	36
Oceania	31	46	224	785	(1)	(1)
Peru	5	8	66	169	(1)	1
Spain	3	5	135	453	---	---
Sweden	76	113	161	719	1	5
Switzerland	46	64	93	301	1	3
United Kingdom	18	39	282	1,787	14	28
Yugoslavia	1	1	19	52	160	178
Other	2,295	2,959	6,586	13,837	3,561	3,694
Total	4,696	6,456	22,980	59,377	4,602	6,160

[1] Less than ½ unit.
[2] Does not include wire cloth: 1968: 975,618 square feet ($635,269); 1969: 842,072 square feet ($480,389).

Table 35.—U.S. exports of copper by classes

Year	Ore, concentrates, and matte (copper content): Short tons	Ore, concentrates, and matte (copper content): Value (thousands)	Blister: Short tons	Blister: Value (thousands)	Refined copper and semimanufactures: Short tons	Refined copper and semimanufactures: Value (thousands)
1967	38,710	$22,928	20,982	$10,023	200,084	$213,644
1968	64,990	46,902	15,749	11,579	297,992	308,098
1969	1,177	1,195	4,340	3,918	236,914	303,386

Year	Other copper manufactures [1]: Short tons	Other copper manufactures [1]: Value (thousands)	Total: Short tons	Total: Value (thousands)
1967	6,570	$7,472	266,346	$254,067
1968	4,669	5,681	383,400	372,260
1969	4,602	6,160	247,033	314,659

[1] Does not include wire cloth: 1967: 1,394,086 square feet ($1,013,363); 1968: 975,618 square feet ($635,269), 1969: 842,072 square feet ($480,389).

Table 36.—U.S. exports of copper-base alloy (including brass and bronze), by classes

Class	1968: Short tons	1968: Value (thousands)	1969: Short tons	1969: Value (thousands)
Ingots	772	$1,232	333	$1,030
Scrap and waste	85,949	60,667	78,338	64,517
Bars, rods, and shapes	1,629	2,898	2,078	4,019
Plates, sheets, and strips	1,229	4,342	2,326	7,744
Pipes and tubing	1,520	2,966	1,762	3,317
Pipe fittings	2,757	8,813	3,520	10,699
Plumbers' brass goods	1,156	2,697	1,195	3,142
Welding rods and wire	1,079	2,430	1,228	2,723
Castings and forgings	564	833	1,110	1,620
Powder and flakes	1,154	1,807	1,751	2,837
Foil	725	2,279	1,162	3,566
Articles of copper and copper-base alloys, n.e.c.	(1)	7,358	(1)	5,834
Total	98,534	98,322	94,803	111,048

[1] Quantity not reported.

Table 37.—U.S. exports of unfabricated copper-base alloy[1] ingots, bars, rods, shapes, plates, sheets, and strips

Year	Short tons	Value (thousands)
1967	4,503	$8,322
1968	3,630	8,472
1969	4,737	12,793

[1] Includes brass and bronze.

Table 38.—U.S. exports of copper sulfate

(Blue vitriol)

Year	Short tons	Value (thousands)
1967	979	$776
1968	927	718
1969	3,127	2,385

Table 39.—U.S. exports of copper scrap, by countries

Country	Unalloyed copper scrap				Copper alloy scrap			
	1968		1969		1968		1969	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Austria	------	------	------	------	------	------	692	$524
Belgium-Luxembourg	1,278	$900	1,593	$1,293	10,887	$7,377	15,936	12,590
Canada	28,436	25,372	1,834	1,644	18,866	14,799	4,250	3,685
France	20	20	------	------	272	250	43	44
Germany, West	1,131	1,002	870	788	8,736	6,900	17,494	16,260
India	------	------	27	23	77	67	98	91
Israel	(1)	(1)	------	------	------	------	362	262
Italy	163	135	243	177	10,412	6,630	7,740	5,576
Japan	1,385	1,038	1,204	1,068	25,934	16,993	24,702	19,131
Mexico	342	386	22	19	143	146	253	283
Netherlands	38	26	71	86	643	510	719	890
Spain	554	521	479	406	3,372	2,450	2,833	2,656
Sweden	2	2	20	27	1,721	1,186	1,931	1,319
United Kingdom	120	101	82	83	3,018	2,002	547	506
Yugoslavia	583	501	1,083	1,110	593	467	93	119
Other	57	49	64	69	1,275	890	645	583
Total	34,109	30,053	7,592	6,793	85,949	60,667	78,338	64,519

[1] Less than ½ unit.

Table 40.—U.S. imports for consumption of copper scrap, by countries

Country	Unalloyed copper scrap (copper content)			
	1968		1969	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Bahamas	68	$38	28	$20
Canada	9,385	10,235	3,446	3,222
Chile	------------	------------	81	97
Dominican Republic	------------	------------	104	87
France	------------	------------	7	9
Germany, West	11	17	2	3
Honduras	107	81	65	64
Japan	385	474	6	7
Mexico	899	697	1,958	1,648
Netherlands	1	3	1	2
Panama	------------	------------	20	18
United Kingdom	405	329	47	68
Other	310	243	124	110
Total	11,571	12,117	5,889	5,355

Country	Copper alloys scrap					
	1968			1969		
	Short tons gross weight	Short tons copper content	Value (thousands)	Short tons gross weight	Short tons copper content	Value (thousands)
Bahamas	4	3	$2	25	20	$16
Canada	2,529	1,726	1,733	2,346	1,493	1,685
Dominican Republic	86	65	55	109	81	65
Japan	3	1	2	--------	--------	--------
Mexico	220	198	130	421	385	296
Netherlands	32	25	21	--------	--------	--------
Panama	r 59	r 39	r 32	33	22	21
United Kingdom	22	19	22	27	9	5
Other	67	55	45	33	25	21
Total	r 3,022	2,131	r 2,042	2,994	2,035	2,109

r Revised.

Table 41.—U.S. imports [1] of copper (unmanufactured), by classes and countries
(Short tons, copper content, and thousand dollars)

Year and country	Ore, concentrates		Matte		Blister	
	Quantity	Value	Quantity	Value	Quantity	Value
1967	32,891	$28,323	80	$110	269,322	$215,064
1968:						
Australia	942	742	-	-	-	-
Canada	6,711	5,776	503	487	155	145
Chile	-	-	-	-	136,320	108,256
Mexico	217	95	2	(2)	5,067	4,960
Peru	4,637	4,409	-	-	89,033	81,912
Philippines	14,543	15,258	1	1	-	-
South Africa, Republic of	-	-	-	-	38,243	30,696
Other	-	-	3	2	1,900	1,845
Total	27,050	26,280	509	490	270,718	227,814
1969:						
Australia	1,662	1,534	-	-	558	599
Canada	8,862	8,523	319	414	71	72
Chile	-	-	-	-	100,768	82,980
Mexico	89	80	-	-	2,816	2,990
Peru	9,664	12,003	-	-	107,385	120,367
Philippines	18,267	23,807	2	2	-	-
South Africa, Republic of	-	-	-	-	25,160	21,184
Other	180	128	3	3	1,191	1,673
Total	38,724	46,075	324	419	237,949	229,865

Year and country	Refined		Scrap		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1967	330,571	$310,304	16,363	$14,551	649,227	$568,352
1968:						
Australia	4,036	4,938	-	-	4,978	5,680
Belgium-Luxembourg	57,859	67,395	-	-	57,859	67,395
Canada	135,115	121,656	8,050	8,692	150,534	136,756
Chile	42,860	47,193	1,362	1,508	180,542	156,957
Germany, West	55,263	67,038	11	17	55,274	67,055
Mexico	1,121	1,592	899	697	7,306	7,344
Netherlands	3,699	4,290	1	3	3,700	4,293
Peru	18,525	19,617	-	-	112,195	105,938
Philippines	-	-	-	-	14,544	15,259
South Africa, Republic of	4,648	5,645	-	-	42,891	36,341
United Kingdom	22,572	29,098	405	329	22,978	29,429
Yugoslavia	9,740	11,986	-	-	9,740	11,986
Zambia	22,898	27,301	-	-	22,898	27,301
Other	21,942	27,508	692	706	24,536	30,059
Total	400,278	435,257	11,420	11,952	709,975	701,793
1969:						
Australia	5,601	6,062	(2)	(2)	7,821	8,195
Belgium-Luxembourg	473	634	22	22	495	656
Canada	84,941	80,781	3,446	3,222	97,639	93,012
Chile	21,470	19,980	81	97	122,319	103,057
Germany, West	2,574	3,619	2	3	2,576	3,622
Mexico	248	333	1,958	1,648	5,111	5,051
Netherlands	222	320	1	2	223	322
Peru	4,372	5,658	-	-	121,421	138,028
Philippines	-	-	-	-	18,269	23,809
South Africa, Republic of	-	-	-	-	25,160	21,184
United Kingdom	3,950	5,217	47	68	3,997	5,285
Yugoslavia	1,663	2,145	-	-	1,663	2,145
Zambia	999	1,339	-	-	999	1,339
Other	4,658	6,485	332	293	6,364	8,582
Total	131,171	132,573	5,889	5,355	414,057	414,287

[1] Data are general imports; that is, they include copper imported for immediate consumption plus material entering the country under bond.
[2] Less than ½ unit.

Table 42.—U.S. imports [1] of copper (unmanufactured), by countries

Country	1968 Short tons	1968 Value (thousands)	1969 Short tons	1969 Value (thousands)
Australia	4,978	$5,680	7,821	$8,195
Belgium-Luxembourg	57,859	67,395	473	634
Canada	150,534	136,756	94,193	89,790
Chile	180,542	156,957	122,238	102,960
Germany, West	55,274	67,055	2,574	3,619
Mexico	7,306	7,344	3,153	3,403
Netherlands	3,700	4,293	222	320
Peru	112,195	105,938	121,421	138,028
Philippines	14,544	15,259	18,269	23,809
South Africa, Republic of	42,891	36,341	25,160	21,184
United Kingdom	22,978	29,429	3,950	5,217
Yugoslavia	9,740	11,986	1,663	2,145
Zambia	22,898	27,301	999	1,339
Other	24,536	30,059	6,032	8,289
Total	709,975	701,793	408,168	408,932

[1] Data are general imports; that is, they include copper imported for immediate consumption plus material entering the country under bond.

Table 43.—U.S. imports for consumption of copper (copper content) by classes

Year	Ore and concentrates Short tons	Ore and concentrates Value (thousands)	Matte Short tons	Matte Value (thousands)	Blister Short tons	Blister Value (thousands)
1967	35,673	$28,820	2	$35	270,728	$217,473
1968	71,884	66,291	8	4	274,180	224,013
1969	3,588	3,274	6	17	241,712	233,265

Year	Refined Short tons	Refined Value (thousands)	Scrap Short tons	Scrap Value (thousands)	Total value (thousands)
1967	332,290	$311,415	16,717	$14,802	$572,545
1968	403,630	438,608	11,571	12,117	741,033
1969	131,171	132,573	5,889	5,355	374,484

Table 44.—World mine production of copper, by countries [1] [2]

(Short tons)

Country	1967	1968	1969 p
North America:			
Canada [3]	r 613,318	633,313	551,427
Haiti	2,590	1,760	1,980
Mexico	61,725	67,362	72,936
Nicaragua	10,291	12,695	4,583
United States [3]	954,064	1,204,621	1,544,579
South America:			
Argentina	552	465	465
Bolivia [4]	6,710	7,861	8,800
Brazil e	2,369	2,976	4,078
Chile	731,789	734,870	768,716
Dominican Republic	36	116	525
Ecuador	457	614	588
Peru	r 212,402	234,282	227,235
Europe:			
Albania e	6,600	6,600	6,600
Austria [3]	2,156	2,328	2,595
Bulgaria	38,700	41,116	42,000
Czechoslovakia	4,300	4,960	5,300
Finland	32,227	33,271	36,650
France	446	e 450	450
Germany:			
East	22,000	22,000	22,000
West	1,300	1,475	1,592
Ireland	3,887	7,275	6,614
Italy	1,851	2,540	2,648
Norway [5]	15,927	18,492	22,962
Poland	e 18,132	29,321	53,200
Portugal [5]	4,037	4,984	4,593
Spain [5]	9,437	9,220	11,239
Sweden	16,849	e 20,100	27,778
U.S.S.R. e [6]	880,000	936,963	992,100
Yugoslavia	69,593	77,698	98,100
Africa:			
Algeria	r 1,175	e 936	688
Congo (Kinshasa)	351,511	357,700	399,274
Morocco	2,784	3,358	3,342
Rhodesia, Southern e	r 19,840	19,840	26,450
South Africa, Republic of e	r 165,350	160,937	163,100
South-West Africa [3] [7]	35,591	34,690	30,450
Uganda	19,181	20,560	21,825
Zambia	729,789	733,115	824,711
Asia:			
Burma e	80	44	44
China, mainland e	88,000	99,000	110,000
Cyprus e	17,089	18,778	21,968
India	9,462	10,220	11,089
Iran	660	660	660
Israel e	7,812	8,500	8,800
Japan	130,878	132,202	132,584
Korea:			
North e	13,200	13,200	13,200
South e	1,542	1,323	1,466
Philippines	94,161	121,557	144,873
Taiwan e	2,530	2,600	2,600
Turkey	34,707	31,771	30,060
Oceania:			
Australia	r 102,705	120,456	143,345
Fiji (exports)	----------	e 925	402
Total [8]	5,551,797	6,012,100	6,612,276

e Estimate. p Preliminary. r Revised.

[1] Figures shown represent copper content (recoverable where indicated) of ores mined when available data are adequate. If data for ores are incomplete or lacking, the figures include the nonduplicative copper content of concentrates, matte, metal, or other copper-bearing products, measured at the least stage of processing represented.

[2] Angola, Congo (Brazzaville), Cuba, Hungary, Kenya, and Malaysia also produce copper, but production data are not available.

[3] Recoverable.

[4] COMIBOL production plus exports by small and medium mines.

[5] Includes copper content of cupriferous pyrites.

[6] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.

[7] Output of Tsumeb Corp. Ltd.

[8] Totals are of listed figures only.

Table 45.—World smelter production of copper, by countries [1]

(Short tons)

Country	1967	1968	1969 p
North America:			
Canada	r 499,845	524,955	450,654
Mexico	60,012	65,816	62,468
United States [2]	862,340	1,351,299	1,585,491
South America:			
Brazil e [3]	3,850	3,850	3,850
Chile	695,437	691,646	726,577
Peru	r 177,650	205,167	186,033
Europe: [4]			
Albania	4,620	e 6,600	6,600
Austria [3] [5]	19,223	19,962	21,302
Bulgaria	36,950	40,234	44,000
Czechoslovakia	12,210	12,956	13,400
Finland [3]	37,659	39,567	37,342
Germany:			
East e [3]	44,000	44,000	44,000
West [3]	r 392,056	449,078	443,274
Norway [3] [6]	22,373	25,995	30,699
Poland [3]	r 46,517	48,060	60,300
Spain	31,961	50,313	41,468
Sweden [3]	r 52,570	51,478	57,100
U.S.S.R. e	880,000	937,000	992,000
Yugoslavia [3]	r 72,961	77,221	90,392
Africa:			
Congo (Kinshasa)	351,512	357,700	399,274
South Africa, Republic of	140,544	141,351	139,095
South-West Africa [7]	37,400	35,706	30,293
Uganda	15,897	17,192	18,267
Zambia	679,762	733,775	823,969
Asia:			
China, mainland e	90,000	110,000	110,000
India	9,812	10,236	9,657
Japan	517,986	604,513	693,523
Korea:			
North e	13,000	13,000	13,000
South [3]	4,075	5,022	6,856
Taiwan [8]	3,301	2,802	3,184
Turkey	27,980	26,036	21,242
Oceania: Australia	79,303	102,520	127,407
Total [9]	5,922,806	6,805,050	7,292,717

e Estimate. p Preliminary. r Revised.

[1] Data include blister copper, refined copper of nonblister origin, and refined copper derived from unreported quantities of domestically smelted blister copper. Data are presumed to represent primary copper unless otherwise indicated. Copper is also produced in Southern Rhodesia, but output data are not available.

[2] Smelter output from domestic and foreign ores, exclusive of scrap. Production from domestic ores only, exclusive of scrap, was as follows: 1967—841,343; 1968—1,233,951; and 1969—1,547,494.

[3] Includes secondary copper.

[4] Belgium reports a large output of refined copper which is believed to be produced principally from crude copper from the Congo (Kinshasa); it is not shown here, as that would duplicate output reported under latter country.

[5] May include some scrap in raw materials; excludes fire-refined copper.

[6] In Norway copper is derived from Canadian copper-nickel matte, copper content of which may be included in production figure for Canada. Norwegian smelter output from domestic ores was approximately 6,800 tons in 1967, 6,000 tons in 1968, and 6,400 tons in 1969.

[7] Output of Tsumeb Corp. Ltd.

[8] Secondary copper only.

[9] Totals are of listed figures only.

Table 46.—Chile: Exports of copper, by principal types

(Short tons, copper content)

Destination	1968 r Refined Electrolytic	1968 r Refined Fire-refined	1968 r Blister	1968 r Total	1969 p Refined Electrolytic	1969 p Refined Fire-refined	1969 p Blister	1969 p Total
Argentina	17,608	5,088	-------	22,696	25,775	6,237	-------	32,012
Australia	-------	336	-------	336	-------	-------	-------	-------
Austria	931	-------	-------	931	1,159	-------	-------	1,159
Belgium	-------	1,400	9,568	10,968	10,515	1,340	1,013	12,868
Brazil	7,497	1,444	-------	8,941	11,063	485	-------	11,548
Colombia	-------	712	-------	712	111	380	-------	491
Denmark	1,092	-------	-------	1,092	1,847	-------	-------	1,847
Finland	3,527	-------	-------	3,527	1,343	-------	-------	1,343
France	23,645	13,928	-------	37,573	34,701	21,203	-------	55,904
Germany, West	88,367	14,536	20,463	123,366	90,605	15,164	27,938	133,707
Italy	35,400	18,057	1,315	54,772	48,933	21,187	1,982	72,102
Japan	25,467	-------	19,998	45,465	24,556	-------	28,586	53,142
Netherlands	1,216	-------	-------	1,216	967	-------	-------	967
Norway	3,527	-------	-------	3,527	5,081	-------	-------	5,081
Spain	6,823	1,344	675	8,842	6,383	1,344	4,274	12,001
Sweden	18,513	9,801	8,542	36,856	19,011	9,279	7,773	36,063
Switzerland	1,719	1,702	-------	3,421	1,788	1,456	-------	3,244
United Kingdom	63,551	19,224	39,035	121,810	65,071	19,102	39,821	123,994
United States	28,191	1,560	147,711	177,462	25,900	-------	95,893	121,793
Other	-------	205	-------	205	-------	101	-------	101
Total	327,074	89,337	247,307	663,718	374,809	97,278	207,280	679,367

p Preliminary. r Revised.
Source: Corporatión del Cobre de Chile.

Table 47.—Peru: Copper production

(Short tons)

	Blister	Refined	Other	Total
1967 r	138,394	39,257	34,751	212,402
1968 r	162,729	42,439	29,114	234,282
1969	148,043	37,991	41,201	227,235

r Revised.

Table 48.—Canada: Copper production (all sources) by Provinces [1]

(Short tons)

Provinces	1968 r	1969 p
British Columbia	80,561	81,344
Manitoba	34,583	37,042
New Brunswick	8,265	7,062
Newfoundland	23,299	19,389
Northwest Territories	866	536
Nova Scotia	140	82
Ontario	290,618	228,944
Quebec	167,601	157,959
Saskatchewan	22,081	18,011
Yukon Territories	5,299	7,859
Total	633,313	558,228

r Revised. p Preliminary.
[1] Blister copper plus recoverable copper in matte and concentrate exported.

Source: Dominion Bureau of Statistics, Department of Trade and Commerce, Dominion of Canada, Canada's Mineral Production, Preliminary Estimate. 1969.

Diatomite

By J. M. West [1]

Production and sales of diatomite rose 3 percent in quantity and 8 percent in value in 1969, owing mainly to increased demands for filtration and filler products. The United States continued as the worlds' largest producer of diatomite and as the dominant source of filtration quality materials.

DOMESTIC PRODUCTION

Production of prepared diatomite in 1969 was higher in California and Nevada but declined in Washington. Oregon and Arizona continued to report small outputs for pozzolan and fillers, and Maryland recorded initial small production of a product designated for miscellaneous uses. California remained the largest producing State, with Nevada second. During the year, 12 companies with 13 plants produced diatomite.

Johns-Manville Corp., with facilities near Lompoc, Calif., was the leading producer, followed by GREFCO, Inc., with operations in California and Nevada, and Eagle-Picher Industries, Inc., the principal Nevada producer. Equipment expansions and plant improvements were completed by producers in both States. In addition to the usual line of products, synthetic silicates were produced from diatomite at the Johns-Manville operations in California.

Table 1.—Diatomite sold or used by producers in the United States, 3-year totals and 1969

Year	Domestic production (sales), short tons	Average value per ton
1957–59	1,349,340	$45.73
1960–62	1,446,625	50.08
1963–65	1,740,833	50.40
1966–68	1,881,877	54.18
1969	598,482	60.96

CONSUMPTION AND USES

Demand for filtration products continued to grow both in quantity and in proportion to total diatomite products purchased in 1969. Use of diatomite for fillers also expanded, although not enough to maintain a proportionate share of the total sales. However, the statistical decline of 1 percent was not considered significant. Use in insulation and abrasives remained about the same; quantities for other uses, including pozzolans and light-weight aggregates, declined.

Table 2.—Domestic consumption of diatomite, by principal uses

(Percent of total consumption)

Use	1965	1966	1967	1968	1969
Filtration	44	46	48	55	58
Fillers	20	20	18	21	20
Insulation	6	5	4	4	4
Miscellaneous	30	29	30	20	18

[1] Physical scientist, Bureau of Mines, San Francisco, Calif.

PRICES

Prices of virtually all products except those in the miscellaneous category rose substantially in 1969 because of higher production costs, as reflected in the average unit values given in table 3. Market prices for diatomite products varied according to the quotations of individual producers.

Table 3.—Average annual value per ton of diatomite, by uses

Use	1968	1969
Filtration	$67.74	$70.14
Insulation	44.50	46.12
Abrasives	128.70	134.19
Fillers	57.20	61.26
Miscellaneous	35.34	35.05
Weighted average	57.98	60.96

FOREIGN TRADE

U.S. prepared diatomite, mainly filtration grade, was exported to countries throughout the world. Canada received about one-fourth of such exports. The average value of all exports was $77 per ton. Imports totaled 47 short tons with an average value of $180 per ton. Sources were Canada, Mexico, the United Kingdom, and West Germany. Based on unit values, part of the imported material was probably abrasives or related products.

Table 4.—U.S. exports of diatomite

(Thousand short tons and thousand dollars)

Year	Quantity	Value
1967	148	$11,324
1968 r	164	11,993
1969	176	13,510

r Revised.

WORLD REVIEW

World production continued to rise, following established trends. Major producers, in order of importance, were the United States, the U.S.S.R., France, Italy, and West Germany. Many countries produced relatively small tonnages of impure diatomite not suited for processing to the higher quality products.

Expansion of the Johns-Manville Government-of-Iceland diatomite plant at Myvatin, Iceland to 25,000 tons per year capacity was slated for completion in 1970. The name given this combined enterprise was Kisilidjan, h.f. The Johns-Manville Diatomica San Nicolas operation in Mexico was reported to have increased capacity by 50 percent during the year. Deposits near Quesnel, British Columbia, were under investigation for a possible large scale development by a major U.S. firm. The area is north of Williams Lake. In the same area, Crownite Industrial Minerals Ltd., a subsidiary of Dome Petroleum Ltd., developed a mine and erected a plant designed for a capacity of 80,000 tons per year. Production was to begin in early 1970.[2] Products from the operation were to consist chiefly of pozzolans, fillers, and anticaking agents for fertilizer prills.

[2] Western Miner. Diatomaceous Earth at Quesnel. V. 42, No. 12, December 1969, pp. 24, 26.

Table 5.—World production of diatomite, by countries [1]

(Short tons)

Country	1967	1968	1969 p
North America:			
Canada	NA	521	487
Costa Rica e	11,023	11,023	16,535
Mexico	7,921	10,961	12,318
United States [2]	627,292	627,292	598,482
South America:			
Argentina	8,979	7,217	NA
Peru	r 4,043	3,746	NA
Europe:			
Austria:	4,031	3,284	e 3,307
Denmark:			
Diatomite e	r 22,046	22,046	16,535
Moler e [3]	220,462	220,462	220,462
Finland	1,785	2,183	e 2,205
France [4]	r 175,955	NA	NA
Germany, West (marketable) e [4]	98,106	191,364	127,197
Iceland	---------	3,031	e 11,023
Italy	66,088	66,139	e 66,139
Portugal	4,308	3,871	e 3,417
Spain [4]	18,884	e 11,464	11,023
Sweden	r 4,136	e 4,409	4,409
U.S.S.R. e	396,832	396,832	396,832
United Kingdom	r 13,982	16,464	15,432
Africa:			
Algeria	r 20,131	23,553	e 24,251
Kenya	2,079	2,265	e 2,315
South Africa, Republic of	645	688	e 772
United Arab Republic	---------	1,346	1,433
Asia: Korea, South	2,467	2,441	3,214
Oceania:			
Australia	r 12,435	14,765	e 14,330
New Zealand	1,577	2,277	e 2,204
Total [5]	r 1,725,207	r 1,649,644	1,554,321

e Estimate. p Preliminary. r Revised. NA Not available.
[1] Diatomaceous earth is produced in Brazil, Bulgaria, Colombia, Hungary, Japan, Mozambique, Rumania, and Yugoslavia, but quantities are insignificant or data not available.
[2] Average annual production in 1967 and 1968 from 3-year total for 1966–68.
[3] Moler earth used as a raw material in making refractory bricks plus exports in bulk form.
[4] Includes tripoli.
[5] Totals are of listed figures only.

TECHNOLOGY

A series of reports was issued describing the diatomite industry, in general, and providing history and operational information on most of the major producers.[3]

Plastic gummed tape was used to remove a thin layer of diatomite particles from the surface of a section of a stratigraphic bed in a unique method to provide a suitable sample for microscopic examination of diatom assemblages.[4]

A diatomaceous earth filtration plant was reported to have a lower initial cost and less maintenance than a sand filter plant for use in purification of swimming pool water.[5] Current developments in diatomite processing by Johns-Manville were discussed.[6] Diatomite compositions were patented for use in repelling rain on car windshields,[7] as an absorbent for urea in ammonium nitrate-based explosives,[8] in a coating for grains and stored milo to prevent infestation by insects,[9] and in a mixture with asbestos and sodium silicate to form a moisture- and expansion-resistant insulation product.[10]

[3] Industrial Minerals. Diatomite: Its Production, Uses and Potential: Celite Diatomite, Johns-Manville Corp.; Dicalite Diatomite, GREFCO, Inc.; Celatom Diatomite, Eagle-Picher Industries, Inc.; Danamol Diatomite, Ludolph Struve and Co., G.m.b.H.; Other World Sources of Diatomite. No. 18, March 1969, pp. 9–27.
———.United Sierra's Diatomite. No. 23, August 1969, p. 42.
[4] Cleveland, George B. Rapid Method of Sampling Diatomaceous Earth. Calif. Div. of Mines and Geol., Min. Inf. Serv., v. 22, No. 3, March 1969, pp. 67–68.
[5] South African Mining & Engineering Journal. Sand Versus Diatomaceous Earth Filter Systems. V. 80, pt. 1, No. 3963, Jan. 17, 1969, pp. 132–134.
[6] American Paint Journal. Johns-Manville Increasing Diatomite Production Facilities. V. 53, No. 46, May 5, 1969, pp. 77–84.
[7] Stadman, D. F. (assigned to Canadian Patent & Development Co., Ottawa, Canada). Rain Repellent Composition. U.S. Pat. 3,449,135, June 10, 1969.
[8] Minnick, J. J. (assigned to Commercial Solvents Corp., New York). Ammonium Nitrate Having Diatomaceous Earth Dispersed Therein and Method of Making Same. U.S. Pat. 3,447,982, June 3, 1969.
[9] Lisle, A. L. (assigned to Phoeniz Gems, Inc., Arizona). Storage of Seeds To Produce a Cereal Product Free of Frag Count and Toxic Residue. U.S. Pat. 3,476,568, Nov. 4, 1969.
[10] Sams, R. H., and N. W. McCready (assigned to Philadelphia Quartz Co., Pennsylvania. Expanded Silicate Particles. U.S. Pat. 3,450, 547, June 17, 1969.

Feldspar, Nepheline Syenite, and Aplite

By J. Robert Wells [1]

FELDSPAR

Domestic production of crude feldspar in 1969, as measured by the quantity sold or used by producers, was at the highest level, in regard to both tonnage and total value, in the history of the industry. All-time high figures were attained in three of the major producing States, among which North Carolina and California both reported increases of almost 10 percent; South Carolina, against a smaller base, recorded a 25-percent increase.

The Feldspar Corp., with operations in several States and the nation's foremost feldspar supplier, announced plans for the expenditure of at least $1 million to provide additional producing capacity.

Prominent in the list of minerals identified in rock specimens brought back from the moon was plagioclase feldspar.

Under the provisions of the Tax Reform Act signed by the President on December 30, 1969, the depletion allowance applicable to feldspar, domestic or foreign, was reduced by one percent—that is, from 15 percent to 14 percent. The Act makes the new rate effective for taxable years beginning after October 9, 1969.

DOMESTIC PRODUCTION

Crude Feldspar.—North Carolina, California, Connecticut, and South Carolina, leading the 12 States that reported production of crude feldspar in 1969, jointly accounted for 87 percent of the total domestic output for the year. After several years of steady increases, the fraction of total crude production classified as flotation concentrate dropped sharply in 1969, and the proportion of hand-cobbed material continued its 4-year decline. The quantity of feldspar contained in feldspar-silica mixtures, on the other hand, showed a major gain, both relatively and in absolute tonnage.

Ground Feldspar.—In 1969, there were 17 merchant mills grinding feldspar in nine States, among which North Carolina, California, Connecticut, and South Carolina, in that order, were the leaders both in quantity and total value of product. Those four States turned out about 87 percent of the total 1969 domestic production of ground feldspar.

[1] Physical scientist.

Table 1.—Salient feldspar statistics

	1965	1966	1967	1968	1969
United States:					
Crude:					
Sold or used by producers ---- long tons	624,598	655,452	615,397	667,679	673,985
Value ---- thousands	$6,263	$7,020	$7,086	$8,265	$8,869
Average value per long ton	$10.03	$10.71	$11.51	$12.38	$13.16
Imports for consumption ---- long tons	16	---	280	---	46
Value ---- thousands	$2	---	$8	---	$7
Average value per long ton	$95.00	---	$28.04	---	$158.36
Consumption, apparent[1] ---- long tons	624,614	655,452	615,677	667,679	674,031
Ground:					
Sold by merchant mills ---- short tons	664,138	703,587	663,220	730,737	793,052
Value ---- thousands	$7,757	$8,944	$8,843	$9,242	$10,465
Average value per short ton	$11.68	$12.71	$13.33	$12.65	$13.20
Imports for consumption ---- long tons	3,439	3,243	2,783	3,377	4,644
Value ---- thousands	$92	$86	$72	$91	$128
Average value per long ton	$26.87	$26.52	$26.00	$26.86	$27.72
World: Production ---- thousand long tons	1,974	2,116	2,005	2,170	2,267

[1]Measured by quantity sold or used by producers plus imports.

Table 2.—Crude feldspar sold or used by producers in the United States

Year	Derivation of feldspar[1]							
	Hand-cobbed		Flotation concentrate		Feldspar-silica mixtures[2]		Total	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)
1965	126,811	$1,072	369,585	$3,974	128,202	$1,217	624,598	$6,263
1966	116,936	997	407,450	4,803	131,066	1,220	655,452	7,020
1967	97,409	848	385,005	4,900	132,983	1,338	615,397	7,086
1968	78,401	670	427,770	5,845	161,508	1,750	667,679	8,265
1969	60,685	494	331,519	4,912	281,781	3,462	673,985	8,869

[1] Partly estimated.
[2] Feldspar content.

Table 3.—Ground feldspar sold by merchant mills[1] in the United States

Year	Mills	Domestic feldspar	
		Short tons	Value (thousands)
1965	20	664,138	$7,757
1966	19	703,587	8,944
1967	19	663,220	8,843
1968	17	730,737	9,242
1969	17	793,052	10,465

[1] Excludes potters and others who grind for consumption in their own plants.

Table 4.—Ground feldspar sold by merchant mills in the United States, by derivation[1] and uses
(Short tons)

Year	Glass	Pottery	Enamel	Other	Total	Glass	Pottery	Enamel	Other	Total
	Hand-cobbed					Flotation concentrate				
1965	W	32,535	W	75,055	107,590	256,000	W	W	162,014	418,014
1966	W	54,678	W	61,090	115,768	281,595	W	W	203,819	485,414
1967	W	38,539	W	61,473	100,012	282,861	W	---	178,754	461,615
1968	W	[r]25,300	W	[r]59,543	[r]84,843	[r]286,895	W	---	[r]223,412	[r]510,307
1969	W	26,538	W	49,592	76,130	312,045	W	W	212,597	524,642
	Feldspar-silica mixtures[2]					Grand total[3]				
1965	W	W	---	138,534	138,534	368,120	174,537	42,268	79,213	664,138
1966	W	W	---	102,405	102,405	378,464	207,209	36,151	81,763	703,587
1967	W	W	---	101,593	101,593	379,660	208,626	15,304	59,630	663,220
1968	W	W	---	135,587	135,587	396,758	240,251	20,759	72,969	730,737
1969	W	W	---	192,280	192,280	445,548	241,800	26,005	79,699	793,052

[r] Revised. W Withheld to avoid disclosing individual company confidential data; included with 'Other.'
[1] Partly estimated.
[2] Feldspar content.
[3] "Other" includes soaps, abrasives, and other ceramic and miscellaneous uses.

CONSUMPTION AND USES

Crude feldspar.—In 1969, almost all the commercial supply of feldspar was, as usual, processed to some extent before being sold or used in industry. A few users, however, continued their customary practice of acquiring minor quantities of the crude mineral for grinding in their own mills to suit their particular needs.

Ground Feldspar.—Of the total quantity of ground feldspar sold in 1969 by U.S. merchant mills, 56 percent was used in making glass, 30 percent in pottery, 3 percent in enamel, and 11 percent in other uses—only minor changes from the comparable figures of the past few years. In terms of tons, however, the total quantity consumed in glassmaking, compared with the figure for 1968, was 12 percent higher—an obvious reflection of the constant efforts of the bottle makers to keep up with the rocketing demand for ever greater numbers of disposable containers.

Table 5.—Ground feldspar shipped from merchant mills in the United States
(Short tons)

Destination	1965	1966	1967	1968	1969
California	111,174	109,126	100,235	W	W
Illinois	66,160	63,038	59,837	64,628	51,899
Indiana	W	W	W	25,897	21,944
Kentucky	3,775	7,052	15,433	10,180	9,077
Maryland	W	W	W	W	5,057
Massachusetts	4,787	3,980	3,539	3,896	4,072
Michigan	W	W	W	W	1,438
Mississippi	-----	-----	7,845	8,685	8,931
New Jersey	57,096	71,057	W	W	W
New York	26,037	W	W	20,311	19,668
Ohio	87,873	70,294	72,701	87,202	120,756
Oklahoma	W	W	W	18,385	31,203
Pennsylvania	30,281	30,628	26,188	27,333	23,566
Tennessee	33,851	36,002	32,998	26,898	29,153
Texas	W	26,183	23,269	24,449	21,776
West Virginia	W	W	W	34,720	29,465
Other destinations [1]	243,104	286,227	321,175	[r] 378,153	415,047
Total	664,138	703,587	663,220	730,737	793,052

[r] Revised. W Withheld to avoid disclosing individual company confidential data; included with "Other destinations."
[1] Includes Arkansas; Colorado; Connecticut; Georgia (1965); Arkansas; Colorado (1967–69); Idaho (1965); Kansas (1966); Louisiana; Michigan; Minnesota; Missouri (1967–68); Louisiana; Minnesota; Missouri (1969); Maryland (1965–68); Oklahoma (1965–67); Rhode Island (1967–69); South Carolina (1965 and 1969); Vermont (1965); Virginia (1966); Washington; Wisconsin (1967–69); shipments that cannot be separated by states and shipments indicated by symbol W. Also includes exports to Africa (1965–67); Canada (1967–69); Panama (1966–67); Mexico and Philippines (1966–69); Venezuela (1968); and small quantities to other countries.

PRICES

Average values per ton for crude feldspar reported by producers in 1969, increasing for the fifth year in succession, were substantially higher than in 1968. Feldspar prices were quoted in the Markets section of Engineering and Mining Journal, December 1969, as follows:

Feldspar, f.o.b. mine or mill, carload lots, per short ton, depending on grade:

North Carolina:	
20 mesh, flotation	$11.00
40 mesh, dry ground	21.00
200 do	$20.50–21.50
200 mesh, flotation	20.50–26.00
Georgia:	
40 mesh, granular	20.00
200 mesh	23.50
325 do	24.50
Connecticut:	
20 mesh, granular	13.50
30 mesh, granular	13.50
200 mesh	20.50
325 do	21.50
Maine:	
200–325 mesh	19.50–25.00

Although such quotations were probably representative, actual sales of feldspar were made, as customarily, at prices arrived at in buyer-seller negotiations and not publicly recorded.

FOREIGN TRADE

According to information furnished by the U.S. Department of Commerce, 1969 exports in the composite category of feldspar, leucite, nepheline and nepheline syenite totaled about 5,600 long tons, less than half the quantity reported in the preceding year, but only slightly lower in total value.

U.S. imports of feldspar for consumption in 1969 were markedly higher in both volume and total value than in 1968. Cornwall stone, an altered pegmatite consisting mainly of feldspar and quartz, formerly shipped from England for ceramic purposes but now replaced by other feldspathic materials, has not been imported since 1963.

Table 6.—U.S. imports for consumption of feldspar

Year	Crude [1]		Ground [2]	
	Long tons	Value (thousands)	Long tons	Value (thousands)
1967	280	$8	2,783	$72
1968	---	---	3,377	91
1969	46	7	4,644	128

[1] Crude feldspar 1967: all from Mexico; 1969: all from Canada.
[2] Ground feldspar 1967: 2,761 tons ($71,601) from Canada, 22 tons ($767) from Sweden; 1968: 3,256 tons ($85,956) from Canada, 121 tons ($4,770) from Sweden; 1969: 4,544 tons ($123,589) from Canada, 100 tons ($4,178) from Sweden.

WORLD REVIEW

Australia.—A new plant is being constructed near Sydney at a cost of $13 million for the production of glass containers.

Stimulation of feldspar mining in Australia—currently carried on at a rate of some 6,000 tons annually—is a foreseeable consequence of that country's enthusiastic acceptance of the convenient throwaway bottle. It is the experience of U.S. manufacturers that feldspar or a similar feldspathic material, equivalent to about 5 percent of the total batch weight, is a very desirable ingredient in furnace feeds for the making of machine-blown bottles.

Austria.—In a program backed by the Government of Styria Province, the Oberzeiring mine in the Austrian Alps, once a significant producer but six centuries idle because of flooding, is being rehabilitated for the production of both silver and feldspar.

Table 7.—World production of feldspar, by countries [1]

(Long tons)

Country [2]	1967	1968	1969 [p]
North America:			
Canada (shipments)	9,280	9,482	10,485
Mexico	62,600	79,007	82,174
United States (sold or used)	615,397	667,679	673,985
South America:			
Argentina	20,028	20,179	[e] 20.000
Chile	857	[r] 960	974
Colombia	[r] 17,700	21,700	21,653
Peru	2,461	1,859	1,019
Uruguay	1,242	[r] 434	1,218
Europe:			
Austria	2,441	2,140	1,777
Finland	[r] 53,880	[r] 53,567	62,005
France [3]	[r] 177,000	168,000	167,000
Germany, West	261,464	283,256	285,000
Italy	145,133	165,722	207,844
Norway [4]	96,000	[e] 100,000	115,000
Poland [e]	28,000	28,000	29,000
Portugal	29,842	20,903	23,650
Spain	46,709	46,522	50,000
Sweden	[r] 35,010	26,689	28,000
U.S.S.R. [e]	235,000	235,000	245,000
Yugoslavia	36,412	43,342	45,000
Africa:			
Ethiopia	[r] 3,690	7,017	11,459
Kenya	396	527	1,535
Mozambique	118	98	80
South Africa, Republic of	24,498	19,574	21,688
United Arab Republic	NA	1,691	2,953
Asia:			
Ceylon	252	577	594
Hong Kong	1,135	1,582	1,909
India	27,093	32,964	33,618
Japan [5]	49,906	65,101	58,092
Korea, South	16,551	20,661	23,000
Philippines	NA	41,655	34,832
Oceania: Australia	4,450	4,473	6,000
Total [6]	[r] 2,004,545	2,170,361	2,266,544

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.
[1] Compiled mostly from data available May 1970.
[2] Feldspar is produced in Brazil, Czechoslovakia, Rumania, and South-West Africa but data are not available.
[3] Includes pegmatite.
[4] Not including nepheline syenite (1967, 64,000; 1968, [e]70,000; 1969, [e]70,000).
[5] In addition, the following quantities of aplite and other feldspathic rock were produced: 1967, 319,000; 1968, 333,300 tons; 1969, 427,065.
[6] Totals are of listed figures only.

Greece.—The U.S. firm Owens-Illinois, Inc., is collaborating with a Greek corporation and the National investment Bank for Industrial Development in building a new glass-container plant near Elefsis at an estimated final cost of $13 million. Suppliers of raw materials for the new facility have not been named.

Guinea.—Feldspar, in deposits described as extensive, was one of several commercially valuable pegmatite minerals discovered by a team of geologists and added to the already impressive catalog—iron, bauxite, gem and industrial diamond—of Oregon-sized Guinea's rich mineral resources.

Malaysia.—National and Japanese investors are collaborating at Kuala Lumpur in the launching of an $8 million glass-manufacturing enterprise. Annual capacity planned for the new facility is 35 million square feet of sheet glass, of which about 12 million square feet will be reserved for export to the United States, Japan, the Philippines, India, and South Korea are all current major producers of feldspar. Vast quantities of the mineral are known to exist in many other parts of Asia, but as yet there has been no public mention of any proposed sources of raw materials for the new plant.

Sweden.—Good-quality feldspar in the Muodoslompolo area was listed among the more significant discoveries made during a continuing geological reconnaissance of Sweden's northern counties. Feldspar is thus another of the valuable minerals known to exist in this region, where the cost of transportation is one of the principal influences restricting industrial development.

United Kingdom.—It was forecast that within 2 years British supermarkets will be providing outlets for non-returnable soft-drink bottles at the rate of about 3.5 million gross per year, an increase of 100 percent over the present level. This expansion, reinforced by the anticipated growth in the demand for single-use beer bottles, can be expected to create a decided upturn in the consumption of glass-grade feldspathic materials. It is possible that part of the increased need will be met from internal sources, but a rising volume of imports (of Canadian nepheline syenite, for example) is a safe prediction.

Yugoslavia.—This nation currently produces sufficient feldspar to satisfy the internal demand while exporting an approximately equal tonnage to neighboring countries. The quantity available for export is expected to show a sharp increase with the start of production from the large potash feldspar deposit—said to contain at least 3 million tons of exploitable mineral—that was discovered recently in the Kukavica Mountains of Serbia. It has been rumored that Poland, already a major purchaser of Yugoslavia's exported feldspar, is participating financially in the new enterprise in exchange for the right to receive an important share of the mineral to be produced.

TECHNOLOGY

Development of improved methods for recovering usable feldspar from the fines that, at present, are wasted in the quarrying and crushing of granite was one of the goals of a continuing minerals beneficiation research program at the Bureau of Mines, Tuscaloosa Ala. laboratory. Work on this project in 1969 included exploratory batch flotation tests on samples of fines from commercial granite operations in Georgia and South Carolina. Heavy minerals were removed in rougher concentrates, after which feldspar concentrates were floated and then subjected to wet magnetic separation. Preliminary results appeared favorable.

A published article that provided a major contribution to theoretical crystallography dealt at length with homogeneous equilibria in the alkali feldspars.[2]

Examples of the numerous and noteworthy technological innovations that in 1969 affected the glass industry—by a substantial margin the largest outlet for feldspathic materials—included the use of glass-ceramic discs as key components in gas-turbine automotive engines, the development of virtually unbreakable glass bricks ("nothing gets through but light"), and the proposed application of glass-ceramic implants for the correction of defects, congenital or acquired, in the human skeleton.[3] Feldspar or an alternate feldspathic material is desirable as an ingredient in glass formulations, particularly those for the automated machine production of glass containers. Two important journal articles were devoted to technological aspects of the glass-container industry.[4] A published article described the equipment used in a plant turning out glass containers at a rate approaching 1,000 tons per day and outlined some of the techniques successfully applied there for handling the necessary raw materials—sand, soda ash, limestone, and feldspar.[5] A possible solution for at least part of the litter predicament generated by the disposable beverage bottle was the proposal of

[2] Thompson, James B., Jr. Chemical Reaction in Crystals. Am. Miner., v. 54, Nos. 3–4, March-April 1969, pp. 341–375.

[3] Ceramic Industry. Cercor Regenerators in Gas Turbine Bus; Vandal-Proof Glass Bricks; Ceramic Glass Implants Studied. V. 94, No. 1, January 1970, pp. 19, 21.

[4] Allen, Alfred C. Curved Conveyers Boost Container Yield Rate. Ceram. Ind., v. 92, No. 2, February 1969, pp. 35–37.
Svec, J. J. Glass Research—Objectives Obtained—Lower Costs—Better Methods. Ceram. Ind., v. 92, No, 6, June 1969, pp. 58–60, 80.

[5] Allen, Alfred C. Northwestern Glass Zeros In on 1000 Tons per Day. Ceram. Ind., v. 93, No. 4, October 1969, pp. 31–33.

Raymond Joplin, a student in the University of Missouri at Rolla. in experiments on the campus parking lot, he showed that the troublesome throwaways can be crushed and blended with asphalt to yield an excellent patching material for holes in black-top paving.[6] Joplin further surmised that perhaps the crushed-glass and asphalt mixture could serve as well for building road surfaces as for patching parking lots. The U.S. Department of Health, Education and Welfare made a grant too Joplin's university for a continuation of this promising line of research.[7] Attacking the waste-glass problem from a slightly different angle, the Bureau of Mines Tuscaloosa Metallurgy Research Laboratory continued exploring possible means of reusing this major component of every city's discarded rubbish. Work in progress was being directed toward a search for advantageous methods to incorporate the scrap glass in salable products such as glazes, insulating material (glass wool), and building blocks. Similarly inspired, two major papers and a prominent part of a panel discussion at the 30th Annual Conference on glass problems, held at the University of Illinois, Urbana, November 20–21, 1969, reflected the growing attention being devoted to the technology of averting the dangers of a landscape being covered by glass containers. One of the most encouraging omens of a trend toward the betterment of this situation was the decision by Keep America Beautiful, Inc., that the 1969 business award had been earned by an organization that some might regard as an unlikely recipient—The Glass Container Manufacturers Institute. The citation was for "an outstanding example of what an industry can do to arouse public support for preservation of our nation's beauty."

Reasons underlying the large number of items in the news concerning installation of new glass fiber facilities (or major expansions of those already in existence) were evident. Notes concerning glass fiber briefly mentioned in various issues of Ceramic Industry magazine in 1969 referred to the use of this versatile material in applications as varied as surgical casts, self-lubricated bearings, indoor and outdoor furniture, seaplane floats, helicopter-rotor blades, hulls for deep-dive submersibles, car bodies, rifle stocks, and space suits. Equipping new cars with tires featuring bias belts of polyester-bonded glass fiber turned into a major trend. Other announced innovations included the development of electrically conducting glass fibers, of a device employing glass fibers in a novel way for the focusing and transmission of light, and of an improved process for the deep-tone coloring of glass fixers for textile purposes.

[6] Ceramic Industry. Glass Road Passes Test. V. 93, No. 5, November 1969, pp. 60–61.

[7] Ceramic Industry. HEW Allots Grant to U. of Mo. for Research. V. 93, No. 2, August 1969, p. 17.

NEPHELINE SYENITE

Nepheline syenite is a coarsely crystalline rock resembling granite but consisting principally of feldspathoid minerals with little or no free quartz. This raw material is a helpful accessory in the manufacture of glass and ceramics. For those applications, the entire U.S. requirement of nepheline syenite has been supplied for many years by imports from Canada; about one-fourth more was imported in 1969 than in any previous year. Canada's output of this material in 1968, the last year for which final figures have been released, totaled 425,463 short tons, valued at slightly over $4.9 million, of which approximately 70 percent was exported to the United States. According to Canadian Minerals Yearbook, 1968 per-ton prices for nepheline syenite in Canada, depending upon purity and degree of preparation, ranged from $5 to $24.

Table 8.—U.S. imports for consumption of nepheline syenite

Year	Crude		Ground	
	Long tons	Value (thousands)	Long tons	Value (thousands)
1967	---	---	256,837	$3,104
1968	15	(1)	271,966	3,558
1969	166	$2	346,513	4,449

1 Less than ½ unit.

APLITE

Aplite, a granitic rock of indefinite composition containing a high proportion of plagioclase feldspar, is used chiefly as an ingredient in glass batch mixtures. Aplite, because of its relatively high iron content, was formerly considered suitable for making only strongly colored glasses; however, advances in beneficiation technology have made it possible to produce aplite in grades acceptable also to manufacturers of clear or light-colored glass, especially for containers. Production of aplite in the United States increased substantially in 1969 in tonnage and total value. Glass-grade aplite was produced domestically in 1969 only from mines in Virginia, by M & T Chemicals, Inc., and The Feldspar Corp, both operating in Hanover County, and by International Minerals & Chemical Corp. in Nelson County. Aplite prices published in Ceramic Industry Magazine, January 1970, were $7.80 per ton, high, and $5 per ton, low. These figures were unchanged from the corresponding quotations of January 1969, and notably lower than the unit values reported in a canvass of the producers. Specific output and value figures are individual company confidential data and cannot be published.

Ferroalloys

By Horace T. Reno [1]

The ferroalloy industry experienced little change in 1969. Researchers apparently were inactive, or were in the middle of projects and did not publish their work. Ferroalloy consumption in the United States and in the rest of the world was high, following steel production. Supply was adequate to meet the demand for all ferroalloys except ferronickel and ferrosilicon in the European markets. Ferroalloy prices except for ferrosilicon and ferrochromium remained relatively stable through most of the year, although the price of ferronickel was raised 25 percent the last of November.

The structure of the domestic ferroalloy producing industry was unchanged from 1968. International trade in ferroalloys was influenced more than in past years by a trend to processing metal resources within the country of origin.

Detailed information concerning the more significant ferroalloys may be found in the chapters for individual alloying elements.

[1] Mineral specialist, Division of Ferrous Metals.

Table 1.—Government inventory of ferroalloys (stockpile grade), December 31, 1969

(Thousand short tons)

Alloy	National (strategic) stockpile	CCC and supplemental stockpile	Total
Ferrochromium:			
High-carbon	126	276	402
Low-carbon	107	191	298
Ferrochromium-silicon	25	31	56
Ferrocolumbium (contained columbium)	(1)	-----	(1)
Ferromanganese:			
High-carbon	143	1,033	1,176
Medium-carbon	19	-----	19
Ferromolybdenum (contained molybdenum)	4	-----	4
Ferrotungsten (contained tungsten)	1	-----	1
Ferrovanadium (contained vanadium)	1	-----	1

[1] Less than ½ unit.

Table 2.—Ferroalloys produced and shipped from furnaces in the United States

	1968				1969			
	Production		Shipments		Production		Shipments	
	Gross weight (short tons)	Alloy element contained (average percent)	Gross weight (short tons)	Value (thousands)	Gross weight (short tons)	Alloy element contained (average percent)	Gross weight (short tons)	Value (thousands)
Ferromanganese:[1]								
Blast furnace	562,541	77.9	529,571	$73,455	510,925	77.0	503,983	$67,863
Electric furnace[2]	317,421	78.2	303,589	54,654	341,094	77.8	332,734	51,445
Total	879,962	78.0	833,160	128,109	852,019	77.3	836,717	119,308
Silicomanganese	284,499	66.0	261,842	41,755	222,877	66.0	217,543	35,152
Ferrosilicon	665,383	56.6	609,158	102,647	715,172	57.8	675,381	112,293
Silvery iron:								
Blast furnace	28,414	8.6	41,676	3,425	39,275	9.6	42,913	3,538
Electric furnace	166,181	18.2	174,747	13,598	164,752	18.4	160,728	12,353
Total	194,595	16.8	216,423	17,023	204,027	16.7	203,641	15,891
Chromium alloys:								
Ferrochromium[3]	281,697	69.2	271,679	71,701	296,305	69.8	293,367	81,343
Other chromium alloys[4]	107,875	45.6	88,665	19,496	122,733	43.8	94,388	26,067
Total	389,572	62.6	360,344	91,197	419,038	62.2	387,755	107,410
Ferrotitanium	4,130	26.6	4,400	3,656	4,441	26.9	4,222	3,937
Ferrophosphorus	116,723	23.0	80,186	2,490	130,582	24.7	164,360	4,784
Ferrocolumbium and ferrotantalum-columbium	2,148	55.4	1,981	7,695	2,301	55.5	2,202	9,298
Other[5]	84,049	40.6	76,220	r 61,193	78,046	36.3	102,182	79,171
Grand total	2,621,061	60.6	2,443,714	r 455,764	2,628,503	60.0	2,594,003	[6] 487,244

r Revised.
[1] Includes briquets.
[2] Includes fused-salt electrolytic.
[3] Includes low- and high-carbon ferrochromium and chromium briquets.
[4] Includes ferrochrome-silicon, exothermic chromium additives, and other chromium alloys.
[5] Includes Alsifer, ferroboron, ferronickel, ferromolybdenum, ferrotungsten, ferrovanadium, Simanal, speigeleisen, zirconium-ferrosilicon, ferrosilicon-zirconium, and other miscellaneous ferroalloys.
[6] Data may not add to totals shown because of individual rounding.

DOMESTIC PRODUCTION

The structure of the domestic ferroalloy producing industry was not changed significantly in 1969. The same 31 producers, listed in table 3, reported production about as in 1968. Total shipments of ferroalloys were 10 percent more than in 1968, as was the value of shipments. Shipments rather than production are the measure of activity in the industry, as production in the high-volume ferroalloys is irregular and intermittent.

Table 3.—Producers of ferroalloys in the United States in 1969

Producer	Plant location	Product [1]	Type of furnace
Agrico Chemical Co	Pierce, Fla	FeP	Electric.
Airco Alloys & Carbide	Calvert City, Ky; Charleston, S.C; Niagara Falls, N.Y	FeCr, FeMn, FeSi, SiMn, silvery iron.	Do.
Bethlehem Steel Co	Bethlehem, Pa	FeMn	Blast.
Calumet & Hecla Corp	Selma, Ala	FeSi	Electric.
Chromium Mining & Smelting Co.	Woodstock, Tenn	FeMn, SiMn, FeSi, FeCr	Do.
Climax Molybdenum Co	Langeloth, Pa	FeMo	Aluminothermic.
FMC Corp	Pocatello, Idaho	FeP	Electric.
Foote Mineral Co	Cambridge, Ohio; Graham, W. Va; Keokuk, Iowa; Vancoram, Ohio; Wenatchee, Wash	FeB, FeCb, FeTi, FeV, FeCr, FeMn, FeSi, SiMn, silvery iron, other. [2]	Do.
Hanna Furnace Corp	Buffalo, N.Y	Silvery iron	Blast.
Hanna Nickel Smelting Co	Riddle, Oreg	FeNi	Electric.
Hooker Chemical Corp	Columbia, Tenn	FeP	Do.
Interlake Steel Corp	Beverly, Ohio	FeCr, FeSi, SiMn	Do.
Jackson Iron & Steel Co	Jackson, Ohio	Silvery iron	Blast.
Kawecki Chemical Co	Easton, Pa	FeCb	Aluminothermic.
E. J. Lavino & Co	Sheridan, Pa	FeMn	Blast.
Manganese Chemical Corp	Kingwood, W. Va	do	Electric.
Mobil Chemical Co	Charleston, S.C; Mt. Pleasant, Tenn; Nichols, Fla	FeP	Do.
Molybdenum Corp. of America.	Washington, Pa	FeMo	Electric and aluminothermic.
Monsanto Chemical Co	Columbia, Tenn; Soda Springs, Idaho	FeP	Electric.
National Lead Co	Niagara Falls, N.Y	FeCbTi, FeTi, other [2]	Do.
New Jersey Zinc	Palmerton, Pa	Spln	Do.
Ohio Ferro-Alloys Corp	Brilliant, Ohio	FeCr, FeSi, FeB, FeMn	Do.
	Philo, Ohio	SiMn	Blast.
	Powhatan, Ohio	do	Electric.
	Tacoma, Wash	do	Do.
Reading Alloys	Robesonia, Pa	FeB, FeCb, FeV, NiCb, FeMo.	Aluminothermic.
Shieldalloy Corp	Newfield, N.J	FeV, FeTi, FeB, FeMo, FeCb, FeCbTa, other. [2]	Do.
Stauffer Chemical Co	Mt. Pleasant, Tenn; Silver Bow, Mont; Tarpon Springs, Fla	FeP	Electric.
Tennessee Alloys Corp	Bridgeport, Ala	FeSi	Do.
Tennessee Valley Authority	Muscle Shoals, Ala	FeP	Do.
Tenn-Tex Alloy Corp of Houston.	Houston, Tex	FeMn, SiMn	Do.
Union Carbide Corp	Alloy, W. Va	FeB, FeCr, FeCb, FeSi	Aluminothermic.
	Ashtabula, Ohio	FeMn, FeTi, FeW, FeV	
	Marietta, Ohio	SiMn, other [2]	
	Niagara Falls, N.Y	do	
	Portland, Oreg	do	
	Rockwood, Tenn	do	
	Sheffield, Ala	do	
United States Steel Corp	Birmingham, Ala; Clairton, Pa; Duquesne, Pa	FeMn	Blast.
Woodward Iron Co	Woodward, Ala	FeSi	Electric.

[1] FeMn, ferromanganese; Spln, spiegeleisen; SiMn, silicomanganese; FeSi, ferrosilicon; FeP, ferrophosphorus; FeCr, ferrochromium; FeMo, ferromolybdenum; FeNi, ferronickel; FeTi, ferrotitanium; FeW, ferrotungsten; FeV, ferrovanadium; FeB, ferroboron; FeCbTa, ferrocolumbium-tantalum; FeCb, ferrocolumbium; NiCb, nickel columbium; Si silicon metal; FeCbTi, ferrocarbontitanium.

[2] Includes Alsifer, Simanal, zirconium alloys, ferrosilicon boron, aluminum silicon alloys, and miscellaneous ferroalloys.

CONSUMPTION

According to consumers' reports to the Bureau of Mines, the quantities of ferroalloys consumed domestically as steel additives in 1969 totaled slightly more than in 1968, and those consumed as alloying elements totaled 5 percent more. These data are indicative of trends in usage of primary ferroalloy materials, but cannot be correlated directly with the elements of steel production because of the wide variation in the proportions of secondary metals consumed. For example, domestic production of stainless steel in 1969 was 10 percent more than in 1968, but reported consumption of ferroalloys in stainless steel was only 6 percent more.

The Bureau of Mines has changed the format for canvassing and reporting ferroalloys consumption to obtain data on their use in "superalloys" and in other alloys excluding alloy steels. The new format apparently has not changed the pattern of reported ferroalloy usage in stainless, alloy, carbon, and tool steels, and in cast irons. Apparently, most respondents considered the new superalloy category equivalent to the previously used category of high-temperature alloys. However, analysis of individual reports indicates that this is not so in all instances. The new series undoubtedly will improve with time and provide significant data on the use of ferroalloys in aerospace age materials. A panel on ferroalloys of the Materials Advisory Board, National Academy of Sciences and Engineering will meet during 1970, and probably clarify the meaning of superalloys to describe those metal combinations applied to provide strength at high temperatures in corrosive environments.

Table 4.—Consumption by end use of ferroalloys as additives in the United States in 1969

(Short tons)

Alloy	Stainless steels	Other alloy steels	Carbon steels	Tool steels	Cast irons	Superalloys	Alloys (excludes alloy steels and superalloys)	Other uses [1]	Total
Ferromanganese [2]	13,087	145,153	868,085	564	22,297	1,232	15,363	55,050	1,120,831
Silicomanganese	10,599	29,064	96,630	(3)	5,991	(3)	1,860	8,247	152,391
Silicon alloys [4]	27,116	95,783	177,584	2,980	415,367	434	54,068	43,457	816,789
Ferrotitanium	400	721	1,405	5	(3)	525	1,196	1,620	5,872
Ferrophosphorus	15	1,797	11,762	-----	740	-----	85	336	14,735
Ferroboron	3	72	244	-----	14	5	(3)	15	353
Total	51,220	272,590	1,155,710	3,549	444,409	2,196	72,572	108,725	2,110,971

[1] Includes unspecified uses.
[2] Includes spiegeleisen, manganese metal, and briquets.
[3] Included with "Other uses."
[4] Includes silicon metal and silvery iron.

Table 5.—Consumption by end uses of ferroalloys as alloying elements in the United States in 1969

(Short tons of contained elements)

	Stainless steels	Other alloy steels	Carbon steels	Tool steels	Cast irons	Superalloys	Alloys (exclude alloy steels and superalloys)	Other uses [1]	Total
Ferrochromium [2]	160,542	45,017	6,215	2,997	5,543	10,098	3,756	6,188	240,356
Ferromolybdenum [3]	942	1,155	234	602	1,570	299	235	533	5,570
Ferrotungsten	89	147	-----	465	W	38	18	32	789
Ferrovanadium [4]	36	2,730	1,227	588	51	61	66	434	5,193
Ferrocolumbium	252	593	354	-----	-----	351	14	2	1,566
Ferrotantalum-columbium	W	W	-----	-----	-----	------	-----	14	14
Total	161,861	49,642	8,030	4,652	7,164	10,847	4,089	7,203	253,488

W Withheld to avoid disclosing individual company confidential data; included in "Other uses".
[1] Includes unspecified uses.
[2] Includes other chromium ferroalloys and chromium metal.
[3] Includes calcium molybdate and molybdenum silicide.
[4] Includes other vanadium-carbon-iron ferroalloys.

STOCKS

Producers' stocks of ferroalloys at the end of 1969 were 20 percent less than at yearend 1968, and consumers' stocks were almost 20 percent more. The percentage balance, however, does not have special significance, because the large-volume alloys are produced intermittently. Consumer stocks of all the ferroalloys at yearend were about normal, considering the record production of carbon and alloy steels in 1969.

Table 6.—Stocks of ferroalloys held by producers and consumers in the United States, December 31, 1969

(Short tons)

	Producer		Consumer	
	1968, gross weight	1969, gross weight	1968, gross weight	1969, gross weight
Manganese ferroalloys [1]	r 257,044	194,144	141,672	180,507
Silicon alloys [2]	82,718	94,994	67,352	64,638
Ferrochromium [3]	58,869	46,977	29,176	39,687
Ferrotitanium	1,084	1,283	712	871
Ferrophosphorus	91,320	57,586	2,270	2,327
Ferroboron	167	228	70	62
Total	r 491,202	395,212	241,252	288,092
	1968, contained element	1969, contained element	1968, contained element	1969, contained element
Ferromolybdenum [4]	W	W	1,049	796
Ferrotungsten	W	W	172	147
Ferrovanadium	2,591	594	942	1,272
Ferrocolumbium	597	584	281	425
Ferrotantalum-columbium	-------	-------	8	8
Total	3,188	1,178	2,452	2,648

r Revised. W Withheld to avoid disclosing individual company confidential data.
[1] Includes ferromanganese, silicomanganese, spiegeleisen, manganese metals and briquets.
[2] Includes ferrosilicon, silvery iron, and miscellaneous silicon alloys. Consumers' stocks also include silicon metal.
[3] Includes other chromium ferroalloys and chromium metal.
[4] Includes calcium molybdate and molybdenum silicide.

PRICES

The price of domestically produced standard, high-carbon ferromanganese was unchanged in 1969 at $164.50 per long ton for lump, bulk material, in carload lots. The price of high-carbon ferrochromium, lump, bulk, in carload lots, ranged from 19.7 cents per pound of contained chromium in January to 21.7 cents per pound in December. The price of low-carbon ferrochromium ranged from 26.1 cents per pound in January to 28.6 cents per pound in December.

The price of 50-percent-grade ferrosilicon, lump, bulk, in carload lots, f.o.b. shipping point, freight equalized to nearest main producer, was 13.8 cents per pound of contained silicon in the first half of 1969 and 14.1 cents per pound in the last half. The price increase in all probability reflected a shortage of ferrosilicon in European markets caused by an electric power shortage in Norway.

Ferrovanadium prices in a split market were unchanged in 1969 at $2.90 and $3.12 per pound of contained vanadium, f.o.b. The ferronickel price was unchanged at $1.005 per pound of contained nickel in wholesale lots, f.o.b. shipping point, from January 2 to November 26, when the only domestic producer raised its price to $1.28 per pound to conform with that of Canadian nickel producers. The price was $1.28 per pound of contained nickel through the remainder of the year.

The quoted price for low-carbon ferrotitanium was unchanged in 1969 at $1.35 per pound of contained titanium, delivered. Ferromolybdenum's quoted price of $2.17 per pound of contained molybdenum, f.o.b., in lots of 5,000 pounds or more, was raised to $2.27 per pound on May 5. The quoted price was unchanged through the remainder of the year. Low-alloy, standard ferrocolumbium prices ranged from $2.45 per pound of contained columbium in ton lots, delivered, to $3.52 per pound. Ferrotungsten was quoted at $3.20 to $3.40 per pound of contained tungsten, delivered, through March and at $3.65 per pound thereafter.

FOREIGN TRADE

Judging by U.S. trade in the ferroalloys and record steel production throughout the world, more ferroalloys moved in international trade than ever before. The value of U.S. exports of the ferroalloys exceeded the 1968 record by 9 percent; volume was up 8 percent. The value of U.S. imports at $70.7 million was 28 percent higher than reported in 1968. Total tonnage imported was 13 percent higher. Exports of ferromolybdenum, ferrovanadium, and unclassified ferroalloys accounted for most of the increased value of exports. Imports of ferromanganese, ferronickel, and unclassified ferroalloys accounted for most of the increased value of imports.

Although total domestic exports and imports of ferroalloys in the last decade indicates an increasing trend, the trends in exports and imports of individual ferroalloys with few exceptions are not easily identified. Imports of ferronickel have increased rapidly, and that trend is definitely established, but it has been the result of changing technology in that ferronickel has been replacing nickel metal for use in steels. Other apparent trends could be just the result of temporary change in business practice, or fluctuations in the level of industrial activity. Nevertheless, 1969 import and export data may offer some clue to a possible change in ferroalloy trade patterns.

The increased value of imports resulted from receipts of ferroalloys made from metals that do not occur in economic concentrations in the United States, whereas the increased value of exports was due to the shipment of ferroalloys made from ferrometals of which the United States has ample reserves. Although the change in ferrosilicon trade in 1969 undoubtedly was caused principally by a shortage of electrical power in Norway, the long-discussed tendency of countries to process their own mineral resources to a product closer to end use may have caught up with the ferroalloys trade.

Some clue as to the future pattern of all ferroalloy trade lies in the pattern of U.S. exports. By far the largest part of the ferrophosphorus went to West Germany; ferrosilicon went principally to Canada, the United Kingdom, and West Germany; and ferrochromium went principally to West Germany and the United Kingdom. Relatively insignificant quantities of these alloys went to other countries. However, exports of ferrovanadium and unclassified ferroalloys in significant amounts went to many of the industrialized countries of the free world in addition to Canada, the United Kingdom, and West Germany. Thus, the United States supplied indigenous ferroalloys to have-not nations around the world, and those ferroalloys produced from abundant or foreign raw materials went almost entirely to countries that do not have the economic power sources to convert raw materials to ferroalloys.

Table 7.—U.S. exports of ferroalloys

Alloys	1967		1968		1969	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Ferrocerium and alloys	71	$303	45	$303	52	$351
Ferrochromium	13,453	3,479	27,127	5,735	24,573	5,679
Ferromanganese	1,861	760	3,710	645	1,759	483
Ferromolybdenum	767	2,436	432	1,194	728	2,381
Ferrophosphorous	22,901	847	36,708	930	37,351	912
Ferrosilicon	11,774	3,228	18,372	4,481	6,487	1,666
Ferrovanadium	351	1,398	278	1,052	644	2,834
Ferroalloys, n.e.c	7,976	5,757	11,288	7,814	34,057	9,720
Total	59,154	18,208	97,960	22,154	105,651	24,026

Table 8.—U.S. imports for consumption of ferroalloys and ferroalloy metals

Alloy	1968			1969		
	Gross weight (short tons)	Content (short tons)	Value (thousands)	Gross weight (short tons)	Content (short tons)	Value (thousands)
Chromium metal	1,366	(1)	$2,053	1,491	(1)	$2,072
Ferrocerium and other cerium alloys	12	(1)	77	9	(1)	91
Ferrochrome and ferrochromium—						
Containing 3 percent or more carbon	8,259	5,229	1,239	16,561	10,741	2,318
Containing less than 3 percent carbon	51,557	r 35,773	12,958	45,086	30,738	10,640
Ferromanganese—						
Containing not over 1 percent carbon	3,269	2,845	r 1,101	2,955	2,531	929
Containing over 1 and less than 4 percent carbon	r 17,657	r 14,651	r 3,559	35,474	29,030	6,727
Containing not less than 4 percent carbon	r 182,286	r 140,808	r 16,518	263,527	203,002	24,052
Ferromolybdenum, molybdenum metal, compounds, alloys, and scrap (molybdenum content)	238	218	1,043	70	12	413
Ferronickel	10,553	(1)	5,450	15,696	(1)	9,507
Ferrosilicon	r 24,890	r 10,612	r 3,207	33,614	16,944	4,577
Ferrosilicon-chromium	1,932	(1)	339	795	(1)	49
Ferrosilicon-manganese (manganese content)	25,412	16,885	2,680	32,040	21,337	3,532
Ferrotitanium and ferrosilicon-titanium	199	(1)	143	552	(1)	259
Ferrovanadium	r 599	(1)	r 1,710	382	(1)	1,185
Ferrozirconium	292	(1)	105	440	(1)	167
Ferrophosphorous	-------	-------	-------	28	(1)	2
Manganese metal	3,183	(1)	1,253	1,371	(1)	513
Tungsten metal (lump, grains, or powder) and tungsten carbide (tungsten content)	(1)	8	105	(1)	10	138
Tungsten alloys (unwrought) and scrap (tungsten content)	5	2	15	(2)	(2)	7
Tungstic acid and other alloys of tungsten n.s.p.f. (tungsten content)	22	14	172	54	37	417
Ferroalloys not elsewhere classified	692	(1)	1,507	1,228	(1)	3,095

r Revised.
1 Not recorded.
2 Less than ½ unit.

WORLD REVIEW

India.—A Government-owned ferroalloy plant at Jaipas Road, Oressa, began trial operations in November. When in full operation, the plant will have capacity to produce 11,000 short tons of ferrochromium and 800 short tons of ferrosilicon annually, reportedly enough to make India self-sufficient in these two ferroalloys. India produced approximately 1,350 short tons of ferrochromium and 23,000 short tons of ferrosilicon in 1969.[2]

South Africa, Republic of.—Palmiet Chrome Corporation Limited amalgamated with Middleburg Steel and Alloys (Pty.) Limited, a subsidiary of Rand Mines Limited, on July 1, 1969. Until that time, Palmiet Chrome had been a subsidiary of General Mining and Finance Corp. Limited of Johannesburg. Middleburg Steel acquired the entire issue of Palmiet shares in exchange for its own. Under the new organization, Rand Mines has slightly less than 50 percent of the new Middleburg Co., and General Mining has about 13 percent. Anglo American Corp. of South Africa Ltd. and Eastern Stainless Steel Corp. of Baltimore, Md. are among the major shareholders. The new Middelburg Co. supplied 20 percent of the free world's need for low-carbon ferrochromium in the last half of the year.[3]

TECHNOLOGY

Technical developments dealing with the ferroalloy metals are discussed in the individual chapters. There was little reported research in ferroalloys as a group. However, an analytical laboratory method for identifying most ferroalloys and selected iron and steel additives, and their components and dissolution techniques, were

[2] Bureau of Mines. Mineral Trade Notes. V. 67, No. 6, June 1970, p. 6.
[3] Bureau of Mines. Mineral Trade Notes. V. 67, No. 1, January 1970, pp. 8, 9.

described by H. Green, scientist of the British Cast Iron Research Association.[4]

Green proposed treating unknown alloys with a series of reagents and noting the results to infer the nature of the alloys. He lists the following 17 alloys and additives commonly used in the foundries of Great Britain to which the identification scheme is applicable:

High-carbon ferromanganese
Low-carbon ferromanganese
Ferrosilicon
High-carbon ferrochromium
Low-carbon ferrochromium
Ferrotungsten
Ferrovanadium
Ferrotitanium
Ferroboron
Ferrophosphorus
Ferroniobium (columbium)
Ferromolybdenum
Silicon-zirconium
Silicon-manganese-zirconium
Ferrosilicon-magnesium
Nickel magnesium
Mischmetal

The method is qualitative but not quantitative. Major elements can be identified without much trouble, but care must be taken if two major elements are present in approximately equal quantities.

In a companion paper,[5] Green gave the range of compositions of the above-named materials normally used in Great Britain and solution techniques available for the analysis of the alloys. The ranges of composition differ little from those used in the United States, so the procedures described should be applicable for use with domestic alloys.

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[4] Green, H. A Scheme for the Laboratory Identification of Ferro-Alloys and Inoculants. Metallurgia, v. 80, No. 480, October 1969, pp. 167–172.

[5] Green, H. Compositions and Dissolution Techniques for Ferro-Alloys and Foundry Additives. Metallurgia, v. 80, No. 482, December 1969, pp. 255–258.

Fluorspar and Cryolite

By Charles L. Readling [1]

FLUORSPAR

A prolonged labor dispute during the first half of 1969 affecting the two major domestic fluorspar producers aggravated an already tightening supply situation. Demand for both acid and metallurgical grades of fluorspar continued an upward trend to end the year at a level 9 percent higher than in 1968. Over one-half of the fluorspar consumed during the year was acid-grade flourspar used in the manufacture of hydrofluoric acid, which in turn, was utilized mainly in the manufacture of fluorocarbon compounds, aluminum fluoride, and synthetic cryolite. Growing use of the basic oxygen furnace (BOF) in steelmaking was mainly responsible for the 10-percent increase in consumption of metallurgical-grade fluorspar in 1969. Imports for consumption (all grades) totaled over 1.1 million tons, or nearly 85 percent of the Nation's total requirements for the year.

Legislation and Government Programs.—No contracts for fluorspar exploration were made by the Office of Minerals Exploration during 1969. The Tax Reform Act of 1969, signed by the President on December 30, 1969, reduced the percentage depletion rates for domestic and foreign fluorspar 1 percentage point each, effective with taxable years beginning after October 9, 1969. The new depletion rates are as follows: Domestic, 22 percent; foreign, 14 percent. In December, the Office of Emergency Preparedness announced that 212,942 tons of fluorspar in inventory was considered excess to stockpile requirements. Of this excess, disposal plans for 200,000 tons were to be submitted early in the second session of the 91st Congress. During 1969, the General Services Administration (GSA) disposed of 9,331 short dry-tons of subspecification acid-grade fluorspar from government stockpiles. Government inventories as

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Table 1.—Salient fluorspar statistics

	1965	1966	1967	1968	1969
United States:					
Production:					
Crude:					
Mine production_____short tons__	772,765	737,411	838,631	749,219	533,030
Material milled or washed_do____	825,867	796,418	914,616	765,531	520,084
Beneficiated material recovered short tons__	236,800	250,200	284,300	237,000	160,000
Finished (shipments)_________do____	240,932	253,068	295,643	252,411	182,567
Value_____________thousands__	$10,889	$10,841	$13,164	$11,656	$8,411
Exports__________________short tons__	9,385	5,732	10,345	12,614	3,605
Value_________________thousands__	$315	$301	$517	$496	$213
Imports for consumption_____short tons__	816,546	878,546	911,870	1,050,107	1,149,546
Value_________________thousands__	$19,958	$21,968	$24,485	$28,699	$32,818
Consumption______________short tons__	930,127	1,065,124	1,091,158	1,243,414	1,356,624
Stocks Dec. 31:					
Domestic mines:					
Crude_____________short tons__	274,011	207,338	126,716	97,522	82,177
Finished________________do____	19,664	26,589	22,522	12,557	9,751
Consumer plants____________do____	235,657	254,726	303,718	323,121	290,470
World: Production_________________do____	3,052,970	3,131,203	3,498,755	3,906,042	4,173,551

of December 31, 1969 included 1,102,942 tons of stockpiled acid-grade fluorspar and 411,788 tons of metallurgical-grade material. In late 1969, the National Research Council formed a special panel to study available reserves of world fluorspar and fluorine as well as U.S. consumer needs for the next 10 years. The study will be used to guide various government agencies in handling stockpile policies and in areas where fluorspar has strategic importance.

DOMESTIC PRODUCTION

Labor disputes stopped production at operations of the two major fluorspar producers in Southern Illinois during the first half of 1969. Employees of Ozark-Mahoning Co. were on strike from January 6 to June 28, and those of Minerva Oil Co. were on strike from January 6 to May 27. Shipments of finished fluorspar dropped 27 percent from the 1968 total of 252,411 to 182,567 tons, the lowest level since 1959. Domestic mine production in 1969 also was substantially below that of 1968.

The Illinois-Kentucky fluorspar mining district consists of Hardin and Pope Counties in Southern Illinois, and Crittenden, Livingston, and Caldwell Counties in neighboring Kentucky. In spite of the strike, the area continued as the major producer of domestic fluorspar in 1969 providing 50 percent of the total shipments for the year. The coproduct relationship of fluorspar, lead, and zinc was important to the operations of the area. About 70 percent of the ore value was in recovered fluorspar, with the remainder in recovered lead and zinc concentrates. Colorado, Montana, Nevada, New Mexico, and Utah, involving no coproducts, provided the remainder of the total fluorspar shipments.

Besides the lengthy strike affecting the two major producers, the marked reduction in domestic shipments was also attributed partly to the discontinuance of fluorspar milling in Rosiclare, Ill., by Aluminum Company of America (Alcoa) in 1968, and the temporary discontinuance of milling in November 1968 and continuing through 1969 at the Calvert City Chemical Co. at Mexico, Ky.

Production losses resulting from these closures were expected to be more than offset by the resumption of mining and milling activities at the properties of the Ozark-Mahoning Co. at Northgate, Colo. The company began development work and mining in May 1968, stockpiling the fluorspar until rehabilitation of the mill was completed. The mill operated throughout most of 1969, though not at full capacity.

Increasing demand for both acid and metallurgical-grade fluorspar briquets and pellets led to expansion of existing pellet plants and construction of additional facilities during the year. Three new plants at Brownsville, Tex., were scheduled to begin production early in 1970, operated by Delhi Fluorspar Co., Oglebay-Norton Co., and Pennwalt Corp. Ozark-Mahoning Co. began operating a new pellet plant at Cowdrey, Colo., capable of pelletizing all of the production at their newly enlarged Northgate mine and mill. Mercier Corp. at Detroit and Cametco Corp. in Pittsburgh enlarged their pellet plant facilities during the year. Seaforth Minerals began fluorspar pellet production in mid-1969

Table 2.—Shipments of finished fluorspar, by States

State	1968			1969		
	Short tons	Value		Short tons	Value	
		Total (thousands)	Average per ton		Total (thousands)	Average per ton
Illinois	188,325	$9,134	$48.50	88,480	$4,676	$52.85
Kentucky	17,050	878	51.48	W	W	W
Utah	8,762	213	24.32	6,667	207	31.05
Other States[1]	38,274	1,431	37.40	87,420	3,528	40.36
Total	252,411	11,656	46.18	182,567	8,411	46.07

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes Colorado, Kentucky (1969), Montana, New Mexico, and Nevada.

and Ozark-Mahoning Co. and Minerva Oil Co. continued pelletizing operations in Hardin County, Ill.

Calvert City Chemical Co. performed exploration and development operations at their Babbguill and Shouse mines in Livingston County, Ky. The Babbguill mine was formerly owned by Kentucky Fluorspar Co., and the Shouse mine was purchased from Alcoa. Resumption of mining and milling operations was planned to begin late in 1970.

Minerva Oil Co. neared completion of a 600-foot truck incline from the Renault level to the Fredonia level at its No. 1 mine at Cave-in-Rock, Ill.

CONSUMPTION AND USES

Domestic consumption of all grades of fluorspar in 1969 reached a record level of 1.4 million tons, 9 percent greater than that of the previous year. Consumption of acid-grade fluorspar accounted for 53 percent of the total, although uses of other grades showed a slightly greater rate of increase—10 percent over the 1968 total as compared with a 9-percent increase in acid-grade use for the same period.

Table 3.—Consumption, by end use and stocks, by grade of fluorspar (domestic and foreign) in the United States in 1969

(Short tons)

End use or product	Containing more than 97 percent calcium fluoride	Containing not more than 97 percent calcium fluoride	Total
Hydrofluoric acid	720,984	-------	720,984
Glass	7,068	15,498	22,566
Enamel	377	2,678	3,055
Welding rod coatings	(1)	7,897	7,897
Primary aluminum	2,105	(2)	2,105
Primary magnesium } Other nonferrous metals }	1,334	10,684	12,018
Iron and steel castings	929	21,526	22,455
Open-hearth furnaces	-------	108,965	108,965
Basic oxygen furnaces	-------	379,462	379,462
Electric furnaces	2,912	[3] 72,101	75,013
Other uses or products	-------	[4] 2,104	2,104
Total	735,709	620,915	1,356,624
Stocks December 31	57,740	232,730	290,470

[1] Included with welding rod coatings containing less than 97 percent calcium fluoride.
[2] Included with primary aluminum containing more than 97 percent calcium fluoride.
[3] Includes a small amount of fluorspar containing less than 97 percent in the manufacture of other furnaces.
[4] Includes fluorspar used in the manufacture of ferroalloys containing less than 97 percent.

Table 4.—Fluorspar shipped from mines in the United States, by grade and use

Grade and use	1968				1969			
	Quantity		Value		Quantity		Value	
	Short tons	Percent of total	Total (thousands)	Average per ton	Short tons	Percent of total	Total (thousands)	Average per ton
Ground and flotation concentrates:								
Hydrofluoric acid	88,782	40.6	$4,460	$50.23	71,225	51.0	$3,586	$50.34
Glass	34,495	15.8	1,675	48.57	18,415	13.2	990	53.78
Ceramic and enamel	7,791	3.6	303	38.83	7,289	5.2	250	34.29
Nonferrous	3,234	1.5	158	48.87	2,146	1.6	115	53.36
Ferrous[1]	79,578	36.4	3,763	47.29	37,964	27.2	1,961	51.66
Miscellaneous[1]	4,547	2.1	224	49.21	2,517	1.8	136	53.84
Total[2]	218,427	100.0	10,582	48.47	139,556	100.0	7,037	50.42
Fluxing gravel and foundry lumps:								
Ferrous	31,927	93.9	1,054	33.01	42,869	100.0	1,372	32.00
Miscellaneous	2,057	6.1	20	9.76	142	----	2	13.82
Total	33,984	100.0	1,074	31.60	43,011	100.0	1,374	31.94

[1] Includes exports.
[2] Data may not add to totals because of independent rounding.

Table 5.—Fluorspar (domestic and foreign) consumed in the United States, by States

(Short tons)

State	1969
Alabama, Kentucky, and Tennessee	76,307
Arizona, Colorado, and Utah	23,189
Arkansas, Kansas, Louisiana, and Missouri	198,885
California	31,999
Connecticut, Massachusetts, New York, Rhode Island, and Vermont	43,936
Delaware	1,018
Florida, Georgia, Maryland, North Carolina, and Virginia	44,172
Illinois	78,727
Indiana	46,644
Iowa, Minnesota, Nebraska, and Wisconsin	3,066
Michigan	74,801
Mississippi	138
New Jersey	136,554
Ohio	143,832
Oklahoma	1,453
Oregon and Washington	2,212
Pennsylvania	142,900
Texas	253,920
West Virginia	52,871
Total	1,356,624

Table 6.—Stocks of fluorspar at mines or shipping points in the United States, by States, Dec. 31

(Short tons)

State	1968		1969	
	Crude	Finished	Crude	Finished
Illinois	58,722	5,939	39,600	2,558
Utah	150	150	400	400
Other States [1]	38,650	6,468	42,117	6,793
Total	97,522	12,557	82,177	9,751

[1] Includes Colorado, Kentucky, and Montana.

Table 7.—U.S. exports of fluorspar

Year	Short tons	Value (thousands)
1967	10,345	$517
1968	12,614	496
1969	3,605	213

Increased requirements by the steel industry can be expected as basic oxygen furnaces gradually replace open-hearth furnaces in steelmaking. The basic oxygen process requires an average of three to four times more fluorspar per ton (8–12 pounds) of steel produced than does the traditional open-hearth method. Fluorspar used in basic oxygen furnaces in 1969 was 74,000 tons (or 24 percent) greater than the previous year; the total used in open-hearth furnaces increased less than 1 percent.

Water fluoridation entered its 25th year in 1969. According to the United States Public Health Service, 2,550 water systems serving approximately 4,500 communities supplied fluoridated water to 76 million persons. About 8 million more live in communities served by naturally fluoridated water supplies.[2]

PRICES

Quoted fluorspar prices at yearend increased 6 to 24 percent over prices quoted in 1968, depending on grades and origins. The December 1969 issue of Engineering and Mining Journal quoted the following prices per short ton for the principal commercial grades of fluorspar:

Domestic, f.o.b. Illinois-Kentucky:	
Metallurgical-grade, 72½ percent effective CaF_2	$47.50–$48.50
Pellets, 70 percent effective CaF_2	50.00–57.00
Acid-grade concentrates, dry basis, 97 percent CaF_2:	
Carloads	57.50
Less than carloads	59.50
Bags, extra	5.00
Pellets, 90 percent effective CaF_2	56.00–60.00
Ceramic-grade, 95 to 96 percent CaF_2	55.50
European:	
Acid-grade, duty paid, dry basis	47.50–50.00
Mexican:	
Metallurgical-grade, 70 percent effective CaF_2:	
Border, all rail, f.o.b. cars	30.15
Tampico, Mexico, f.o.b. vessel	31.15
Acid-grade, 97+ percent, Eagle Pass, Tex., bulk	47.00–51.00

FOREIGN TRADE

The United States exported only 3,605 short tons of fluorspar in 1969, about 29 percent of the total exported in 1968.

Imports of all grades of fluorspar totaled almost 1.2 million tons in 1969, an increase of 9 percent over the previous year and accounted for 85 percent of domestic consumption. Mexico provided 75 percent of the total fluorspar imported into the United States. Spain supplied 14 percent of the imports, and Italy supplied 8 percent. Other fluorspar suppliers were the Republic of South Africa, Brazil, Canada, the United Kingdom, and France.

The average value per ton of imported fluorspar rose from $27.33 in 1968 to $28.55 in 1969. Acid-grade fluorspar imported from Mexico rose from an aver-

[2] Journal of American Water Works Association. 25 years of Fluoridation. V. 62, No. 1, January 1970, pp. 3–6.

age of $27.59 to $30.82 per ton. The average value of acid-grade fluorspar imported from Spain declined from $38.81 per ton in 1968 to $37.32 in 1969; that from Italy declined from $35.49 to an average of $34.78 per ton.

The duty on imported fluorspar has remained unchanged since January 1, 1963. Fluorspar containing more than 97 percent CaF_2 was subject to a duty of $1.875 per short ton, and material containing not over 97 percent CaF_2 had a duty of $7.50 per short ton.

Table 8.—U.S. imports for consumption of fluorspar, by countries and customs district

Country and customs district	1968 Short tons	1968 Value (thousands)	1969 Short tons	1969 Value (thousands)
CONTAINING MORE THAN 97 PERCENT OF CALCIUM FLUORIDE				
France: New York City	---	---	110	$8
Germany, West: Detroit, Mich	9,574	$296	---	---
Italy:				
Cleveland, Ohio	5,040	166	13,635	507
Detroit, Mich	14,734	610	---	---
Galveston, Tex	22,786	717	31,875	1,023
New Orleans, La	28,402	922	37,880	1,326
Philadelphia, Pa	26,580	1,047	5,952	251
Total	97,542	3,462	89,342	3,107
Mexico:				
El Paso, Tex	81,569	2,050	69,957	2,073
Houston, Tex	206	5	796	24
Laredo, Tex	255,908	6,879	304,364	9,152
New Orleans, La	35,812	1,308	43,884	1,615
Philadelphia, Pa	8,478	296	12,795	444
Total	381,973	10,538	431,796	13,308
Spain:				
Cleveland, Ohio	12,682	483	30,268	1,131
Detroit, Mich	21,514	620	29,270	885
New Orleans, La	4,536	147	11,210	387
New York City	2	4	---	---
Philadelphia, Pa	94,759	3,927	95,417	3,798
Total	133,493	5,181	166,165	6,201
South Africa, Republic of: Galveston, Tex	---	---	5,606	187
United Kingdom:				
Buffalo, N.Y	---	---	17	1
Cleveland, Ohio	7,260	264	---	---
Detroit, Mich	---	---	1,441	58
New Orleans, La	8,136	252	---	---
Ogdensburg, N.Y	---	---	50	4
San Juan, Puerto Rico	155	7	151	10
Total	15,551	523	1,659	73
Grand total	638,133	20,000	694,678	22,884
CONTAINING NOT OVER 97 PERCENT CALCIUM FLUORIDE				
Brazil: New Orleans, La	---	---	11,346	319
Canada:				
Buffalo, N.Y	12,438	291	67	3
Cleveland, Ohio	---	---	2,238	69
Total	12,438	291	2,305	72
Greenland: Laredo, Tex	76	1	---	---
Mexico:				
Baltimore, Md	38,924	1,002	28,762	743
Buffalo, N.Y	14,398	370	38,949	1,041
Chicago, Ill	---	---	1,295	34
Cleveland, Ohio	27,589	751	32,870	1,034
Detroit, Mich	28,380	720	23,790	752
El Paso, Tex	69,257	1,385	65,387	1,312
Laredo, Tex	147,250	2,188	189,138	2,989
Los Angeles, Calif	676	14	---	---
Mobile, Ala	9,498	248	---	---
New Orleans, La	33,476	924	36,509	959
Philadelphia, Pa	29,962	802	17,431	501
San Francisco, Calif	---	---	66	1
Total	399,410	8,404	434,197	9,366
South Africa, Republic of: New Orleans, La	---	---	6,944	172
Spain: Philadelphia, Pa	---	---	6	(1)
United Kingdom:				
Buffalo, N.Y	---	---	20	1
San Juan, Puerto Rico	50	3	50	4
Total	50	3	70	5
Grand total	411,974	8,699	454,868	9,934

[1] Less than ½ unit.

WORLD REVIEW

Canada.—Most fluorspar production in Canada during 1969 came from the Burin Peninsula mines of Newfoundland Fluorspar Ltd., a wholly owned subsidiary of the Aluminum Company of Canada, Ltd. (Alcan). Minor tonnages were recovered as a byproduct at the silica operations of Pacific Silica Ltd. near Oliver, British Columbia.

Newfoundland Fluorspar Ltd. operates two mines, the Director and the Tarefare, located near the village of St. Lawrence. The Tarefare mine was brought into production in August 1968, but the Director mine has operated continuously for 27 years. Fluorspar shipments went to Alcan's aluminum smelter at Arvida, Quebec.

India.—Fluorspar production totaled 2,385 short tons in 1969, compared with 1,305 tons in 1968. At Ambadungar, Gujarat State, completion of the Nation's first fluorspar processing plant was plagued by delays. The plant, proposed by the State-owned Gujarat Mineral Development Corporation, is scheduled to go on stream in 1971.[3]

[3] Bureau of Mines. Mineral Trade Notes. V. 66, No. 10, October 1969, p. 18.

Table 9.—World production of fluorspar, by countries [1]
(Short tons)

Country	1967	1968	1969 p
North America:			
Canada e	r 72,752	105,000	110,000
Mexico	865,439	1,021,000	1,089,417
United States (shipments)	295,643	252,411	182,567
South America:			
Argentina	21,225	21,853	e 22,000
Chile	502	------	------
Europe:			
France (marketable)	269,000	297,600	330,693
Germany:			
East e	88,000	88,000	88,000
West (marketable)	r 108,063	110,000	101,743
Italy	226,190	247,944	284,490
Spain (marketable)	268,000	282,000	e 353,000
United Kingdom [2]	r 163,142	218,000	e 220,000
U.S.S.R. e	420,000	420,000	440,000
Africa:			
Rhodesia, Southern	e 165	e 165	e 165
South Africa, Republic of	105,058	119,667	165,650
Tunisia	2,756	6,008	e 6,000
Asia:			
China, mainland e	275,000	275,000	275,000
India	1,778	1,305	2,385
Japan	16,871	17,335	13,133
Korea:			
North e	33,000	33,000	33,000
South	62,796	51,372	e 43,000
Mongolia e	55,000	66,000	83,000
Thailand	146,775	270,173	328,000
Turkey	1,600	2,209	2,308
Total [1] [3]	r 3,498,755	r 3,906,042	4,173,551

e Estimate. p Preliminary. r Revised.
[1] Fluorspar is also produced in Brazil, Bulgaria, and Morocco, but details are not available.
[2] Excludes recovery from lead and zinc mine dumps.
[3] Totals are of listed figures only.

Table 10.—World trade in fluorspar[1] in 1968

(Short tons)

Sources	Destinations: Australia	Austria	Belgium-Luxembourg	Canada	Germany, West	Italy	Japan	Netherlands	Poland	Sweden	U.S.S.R.	United States	Other[2]	Total receipts by listed destinations	Total recorded exports
Argentina	----	----	----	----	----	----	551	----	----	----	----	----	----	551	1,081
Bulgaria	----	----	----	----	----	----	1,086	----	498	----	----	----	516	2,100	NA
Canada	----	----	----	XX	----	----	----	----	----	----	----	12,438	----	12,438	NA
China, mainland	878	----	2,081	----	31,586	331	122,621	8,619	22,908	----	35,164	----	1,767	225,955	NA
Czechoslovakia	----	----	----	----	2,389	----	----	----	----	----	----	----	----	2,389	NA
France	----	936	9,638	----	89,226	16,716	----	1,492	----	2,321	----	----	1,176	121,505	129,258
Germany:															
East	----	7,390	1,286	----	----	746	----	1,628	10,407	892	----	----	2,226	24,575	NA
West	----	5,734	1,435	----	----	----	----	467	----	459	----	9,574	1,478	19,147	10,297
Italy	----	2,900	----	----	----	XX	----	----	----	----	----	97,542	93	100,535	92,420
Korea:															
North	----	----	----	----	----	----	15,478	----	2,948	4,443	----	----	----	22,869	NA
South	----	----	----	----	----	----	55,192	----	----	----	----	----	----	55,192	54,821
Mexico	9,520	----	----	97,618	1,319	5,172	23,275	1,994	----	----	----	781,383	----	920,281	1,028,191
Mongolia	----	----	----	----	----	----	----	----	----	----	74,406	----	----	74,406	NA
Mozambique	----	----	----	----	----	----	1,141	----	----	499	----	----	----	1,640	----
South Africa, Republic of	3,567	----	----	----	3,358	----	84,087	----	----	3,176	----	----	1,523	95,711	96,453
Spain	----	----	----	----	35,233	----	----	4,049	----	----	----	133,493	1,102	173,877	153,303
Thailand	321	----	----	----	----	----	213,147	----	----	----	----	----	295	213,763	225,831
Tunisia	----	----	----	----	----	860	----	----	----	----	----	----	551	1,411	NA
U.S.S.R.	----	----	----	----	----	----	19,223	----	----	----	XX	----	----	19,223	NA
United Kingdom	8,713	----	116	7,908	2,482	----	8,470	5,600	----	3,751	----	15,601	4,301	56,942	NA
United States	----	----	----	9,939	----	----	----	----	----	----	----	XX	1,797	11,736	12,614
Other and unspecified	141	44	40	----	3,596	----	325	1,071	----	28	2,866	76	7,913	16,100	NA
Total	23,140	17,004	14,596	115,465	169,189	23,825	544,596	24,920	36,761	15,569	112,436	1,050,107	24,738	2,172,346	NA

NA Not available. XX Not applicable.

[1] Details on origin are derived from import statistics of listed countries of destination, and total receipts by listed destinations represents simply a summation of such detail for each source country. Total recorded exports are taken from export statistics of source countries. Differences between import and export figures recorded are attributed chiefly to time lag between dated shipment and date of receipt.

[2] Countries included and total imports by each, in metric tons, are: Denmark—3,998; Finland—6,924; France—402; India—5,577; Israel—734; Mexico—14; Norway—8,107; Turkey—1,322; Venezuela—222; Yugoslavia—2,438. Totals for Israel, Mexico, Turkey, and Venezuela are not available distributed by origin, but instead are simply entered under "Other and unspecified."

Mexico.—An article concerning the largest producer of metallurgical fluorspar in Mexico was published.[4] Ore production by Cía Minera Las Cuevas, an affiliate of Noranda Mines Ltd., was increased by 10 percent to 317,000 tons, and shipments of 347,000 tons were 26 percent higher than in 1968. Mexicanization of Las Cuevas was completed by Noranda Mines during 1969 by selling a 51-percent interest to Mexican nationals for a total consideration of $3,060,000 (U.S.).[5] Fluoresqueda SA., two-thirds owned by Mexican nationals and one-third owned by Aluminum Company of Canada, Ltd., planned to reopen the fluorspar mill at Esqueda, in Sonora, which was shut down in 1965.

South Africa, Republic of.—Consolidated Gold Fields of South Africa Ltd. will spend approximately $4.1 million to bring into production the Swaartkloof fluorspar deposit near Warmbaths, Transvaal, South Africa. Proved reserves there are estimated at 1 million tons. The mine will initially be an open pit operation, although an underground mine will be developed when open pit operations become impracticable. Consolidated Gold Fields, which holds an 85-percent interest in Swaartkloof, has contracted to supply a Swiss company with 40,000 short tons of fluorspar per year with a maximum of 50,000 tons per year, for a period of 5 years beginning October 1, 1970.[6]

Thailand.—Production of metallurgical-grade fluorspar in 1969 increased 21 percent over 1968 to 328,000 tons. The Department of Mineral Resources sponsored a second conference on July 17–18, 1969 at Chiangmai concerning the industry's mechanization and modernization. Research and Resource Co., Ltd., which produces fluorspar in the Khao Yoi area of Petchaburi Province, was granted permission to set up a flotation plant for production of acid-grade fluorspar at a capacity of 24,000 to 30,000 tons per year. T. W. Mining Co. proposed to establish a 20,000 ton-per-year plant in the Ban Hong district of Lampoon Province.[7]

TECHNOLOGY

Fluorine chemistry was hardly known outside the laboratory, until it was used in developing the uranium hexafluoride diffusion process to obtain material for the first atomic bomb. Today it is assisting mankind in his push into space through use in rocket fuels, new lubricants, refrigerants, and temperature-resistant plastic coatings that withstand extremes of both heat and cold with almost no change in size or in physical or electric properties. In the manufacture of hydrofluoric acid, the basic ingredient used in a multitude of important fluorocarbons, there is no satisfactory substitute for acid-grade fluorspar. Similarly, in the second largest use as fluxing material in the manufacture of steel, there are no suitable materials available to replace metallurgical-grade fluorspar.

A potential source for substantial fluorine supplies that could relieve rising costs and the tightening fluorspar supply is in recovery of waste or byproduct fluosilicic acid (H_2SiF_6) in phosphate fertilizer manufacture. Alcoa began building the first plant in the United States (in Polk County, Fla.) to make aluminum fluoride and synthetic cryolite from fluosilicic acid. Two companies have applied for patents on processes to manufacture hydrofluoric acid from fluorsilicic acid. Two technically feasible processes for converting waste fluosilicic acid generated by the sulfuric acid processing of phosphate rock were developed at the Bureau of Mines Albany Metallurgy Research Center in Oregon. One process is the conversion of H_2SiF_6 into acid-grade calcium fluoride, and the second process involves the production of anhydrous hydrofluoric acid from H_2SiF_6. A report describing the two processes was to be issued after cost evaluations of the processes were completed.

Several journal articles described new uses, medical research, and chemical processes concerning fluorine.[8]

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[4] Industrial Minerals (London). Las Cuevas: Largest Producer of Metallurgical Fluorspar in Mexico. No. 23, August 1969, pp. 22–24.

[5] Noranda Mines Ltd. Annual Report, Toronto, 1969, p. 11.

[6] Mining Journal (London). The Industry in Action. V. 274, No. 7014, Jan. 23, 1970, p. 79.

[7] Industrial Minerals (London). Thailand's Fluorspar Industry. No. 17, February 1969, pp. 31–32.

[8] Chemical and Engineering News. Fluorinated Nitrogen-Ring is Brain Depressant. V. 47, No. 39, Sept. 15, 1969, pp. 50–51.

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——. Dibeler, V. H., J. A. Walker, and K. E. McCulloh. Dissociation Energy of Fluorine. J. of Chemical Physics, V. 50, No. 10, May 15, 1969, pp. 4592–4593.

———. Kelley, Gordon E. A New Procedure for Self Application of Topical Fluoride, J. Water Works Assoc. No. 1, January 1970, p. 9.

CRYOLITE

Mining of natural cryolite ceased in 1969 at Ivigtut, Greenland, the world's only supplier of natural cryolite for over 100 years. Shipments were made from stocks or from reworked dumps, and ore stocks are sufficient to support capacity operation of the concentrating plant in Copenhagen, Denmark, for at least 5 years.

Pennwalt Corp. closed its flotation mill at Natrona, Pa., where formerly all crude natural cryolite imported into the United States had been concentrated for many years. Synthetic cryolite was produced from fluorspar or salvaged from scrapped aluminum-smelter pot linings by Alcoa at Point Comfort, Tex., and by Kaiser Aluminum & Chemical Corp. at Chalmette, La., and Spokane, Wash.

PRICES

Prices quoted in the Oil, Paint and Drug Reporter, December 29, 1969, for cryolite were as follows: Natural, industrial, in bags, at works, carlots, $15 per 100 pounds; less than carlots, $16.75 per 100 pounds. These prices were unchanged from the respective listings for 1968.

FOREIGN TRADE

The import figures compiled by the Bureau of the Census (table 11) do not differentiate between natural and synthetic cryolite. No cryolite was received from Greenland in 1969, but in 1968 and prior years, it was assumed that the only natural cryolite shipments were those from Greenland and that essentially all of the remainder was synthetic cryolite. Since cessation of cryolite mining at Ivigtut, Greenland, the only source for natural cryolite has been Kryolitselskabet Oresund's flotation plant in Copenhagen.

Table 11.—U.S. imports for consumption of cryolite

Year and country	Short tons	Value (thousands)
1966	31,655	$3,199
1967	36,319	4,118
1968:		
Canada	3,128	573
Denmark	220	46
France	6,415	1,227
Germany, West	108	25
Greenland [1]	7,570	347
Italy	15,943	3,163
Japan	112	22
Spain	265	51
Switzerland	11	1
Total	33,772	5,455
1969:		
Canada	2,535	476
Denmark	11	3
France	3,144	648
Germany, West	987	220
Italy	13,317	2,824
Japan	110	21
Spain	280	56
Switzerland	22	3
Total	20,406	4,251

[1] Crude natural cryolite.

Gem Stones

By Jerry J. Gray [1]

Estimated gem stone production of $2.4 million was 4 percent less than the previous year because output dropped at the Star garnet deposit, Clarkia, Idaho. The decrease would have been larger except for initiation of production from a new commercial jade mine in Washington and increased visitor days at a precious opal fee site in Idaho. Domestic gem stone production continued to be principally the result of recreational mining by private individuals at free or fee sites. Only a few deposits were operated to produce rough material for direct sale to wholesale or retail outlets. The semiprecious gem industry of Oregon was reviewed with reasons given why it developed into a significant activity for the State. [2]

DOMESTIC PRODUCTION

Gem stone production was reported from 38 States. The following States supplied 78 percent of the total: Oregon, $750,000; California, $200,000; Arizona, $153,000; Texas, $150,000; Washington, $150,000; Wyoming, $129,000; Colorado, $122,000; Montana, $109,000; and Nevada, $100,000.

Activities involving all of the precious gem stones (except ruby) were reported. The Murfreesboro, Ark., diamond pipe, 60 years after its discovery, was consolidated under one owner, General Earth Minerals. The Dallas, Tex., firm opened the whole pipe to fee digging; formerly, only a small portion was available to the public. [3] Both the largest emerald crystal (3-1/16 inches by 2½ inches, 1,438 carats) and the longest (6 inches by ½ inch) ever found in North America were collected at the newly opened Rist mine. This fee site and the older Ellis mine fee site are located near Hiddenite, N.C., and were operated by American Gem, Inc. [4] Two Montana sapphire deposits were described. One, a placer deposit, was open to the public for a straight fee,[5] and the other, a dike, 5 miles long with an average width of 8 feet, was to be worked partially commercial and partially by individuals who gained digging rights by buying a lot in a vacation real estate development situated near the dike. [6] The precious opal deposit near Spencer, Idaho, had its first full season as a fee site. The mine had been operated as a commercial mine until late in the 1968 season. [7]

Concerning semiprecious gem stones, jade was in danger of being in oversupply. Two new jade provinces were supplying the market, one in Washington [8] and the other in Alaska, [9] along with continued production from two mines in

[1] Geologist, Albany Mineral Supply Field Office, Bureau of Mines, Albany, Oreg.

[2] Shaffer, Leslie L. D., and Steve T. Hashimoto. The Semiprecious Gem Industry of Oregon. Oreg. Bus. Rev., v. 28, No. 7, July 1969, pp. 1–4.

[3] Leiper, Hugh. Crater of Diamonds is Reopened to the Public. Lapidary J. v. 23, No. 7, October 1969 pp. 970–974.

[4] Trapp, Francis W. Green Bolts are Found Again Near Hiddenite, N.C. Lapidary J. v. 24, No. 1, April 1970, pp. 116–126.

[5] Williams, Marjorie. Sapphires on the Eldorado Bar. Gems and Minerals, No. 383, August 1969, pp. 28–31.

[6] Leiper, Hugh. "Five Miles of Sapphires" Famous Yogo Montana Sapphire Mine to be Reopened. Lapidary J., v. 22, No. 10, January 1969, pp. 1278–1286.

[7] Cuthbert, Donna L. Precious Opal, Queen of Gems, in Idaho. Lapidary J. v. 23, No. 7, October 1969, pp. 928–930.

[8] McLeod, D. L. Nephrite Jade Has Been Discovered in Washington. Lapidary J. v. 22, No. 8, November 1968, pp. 1034–1037.

[9] Munz, William. Hundreds of Tons of Nephrite Jade. Lapidary J. v. 24, No. 1, April 1970, pp. 18–26.

California[10] and a small output from Wyoming.[11] Jade imported from a new mine in British Columbia added to the oversupply.[12] Demand for jade probably did not keep pace with supply because demand had been a function of population growth and affluence, which did not exhibit a sudden growth surge.

Output of star garnet, from Clarkia, Idaho, dropped sharply after the U.S. Forest Service stopped the free collecting on several square miles of its acquired lands. Collecting was restriced to a 40-acre fee site concession.[13]

CONSUMPTION

The domestic gem stone output generally went to rock, mineral, and gem stone collections, objects of art, and jewelry. Apparent consumption of gem stones (domestic production plus imports minus exports and reexports) declined to $343 million, compared with $355 million revised in 1968, because of greater exports.

Total consumption was measured primarily by reported import-export data. The reported values contain mainly high-value-per-unit-weight rough and cut stones. The cut stones inflate the total consumption value figure by that amount added by foreign cutting and polishing. Gem diamond consumption, both rough and cut, continuing an upward trend, reached $505 million, a 6-percent increase over that of 1968 and 163 percent over the $192 million of 1962. Value of synthetic and imitation gem stones including imitation pearl was $12.7 million, an increase of 2 percent over that of 1968; value of natural and cultured pearls declined to $12.7 million, a 5-percent decline from that of 1968 and a 43-percent decline from that of 1965.

If gem stone consumption were viewed from the standpoint of quantity instead of value, it would change from 1 ton of imported diamonds to hundreds of tons of domestically produced semiprecious materials. Consumption, in terms of quantity, equates to domestic production of semiprecious materials; however, there is no good estimate available for domestic quantitative output.

PRICES

During the year, price ranges for cut and polished, unmounted gem diamond were 0.25 carat, $100 to $400; 0.50 carat, $250 to $800; 1 carat, $650 to $2,750; 2 carats, $1,500 to $9,000; and 3 carats, $3,900 to $17,000. The medium price for each range was 0.25 carat, $200; 0.5 carat, $500; 1 carat, $1,600; 2 carats, $4,250; and 3 carats, $8,000.

FOREIGN TRADE

Precious and semiprecious gem stone exports were valued at $128.0 million, compared with $99.2 million in 1968. Diamond, over one-half carat in weight, cut but unset, made up the bulk of the exports. Reexport of all varieties of gem stones was valued at $97.6 million, compared with $85.6 million the previous year. Rough or uncut gem-quality diamond formed the major portion of reexports.

Imports of gem material increased 5 percent in value over those of 1968; gem diamond supplied from 26 countries accounted for 89 percent of the total.

The total value of emeralds imported was 14 percent less than the previous year. Although originating from 33 countries, Brazil, Colombia, and India supplied 86 percent of the total carats and 68 percent

[10] Davis, Fenelon F. Some Highlights of 1969, California Mining Review. Mineral Information Service, v. 23, No. 4, April 1970, p. 75.

Draper, James W. Botryoidal Jade of the California Coast. Lapidary J. v. 23, No. 5, August 1969, pp. 684–686.

Hemrich, Gerald I. Botryoidal Jade in California. Lapidary J. No. 386, November 1969, pp. 42–47.

[11] Gregory, Gardiner E. Jade Hunting at Jeffrey City, Wyoming. Lapidary J. v. 22, No. 11, February 1969, pp. 1476–1481.

[12] Cavenaile, Rene. Surrey, B.C., Housewife-Prospector Finds British Columbia "Mountain of Jade." Lapidary J. v. 22, No. 12, March 1969, p. 1562.

[13] Gems and Minerals. National Forest Service Announces New Arrangements for Garnet Collecting at Emerald Creek, Idaho. No. 382, July 1969, pp. 11–12.

of the total value. Imports of rubies and sapphires remained at about the same level with Thailand, India, and Ceylon supplying 69 percent of the total value. The value of imported pearls decreased 5 percent from that of 1968 and 40 percent from that of 1965. India was the major source of natural pearl, 69 percent; Japan the major source of cultured pearls, 92 percent.

Table 1.—U.S. imports for consumption of precious and semiprecious gem stones

(Thousand carats and thousand dollars)

Stones	1968		1969	
	Quantity	Value	Quantity	Value
Diamonds:				
Rough or uncut carats	2,514	$252,653	2,932	$287,566
Cut but unset do	1,834	222,478	1,758	217,081
Emeralds: Cut but unset do	365	10,644	309	9,175
Rubies and sapphires: Cut but unset	NA	9,175	NA	9,201
Marcasites	NA	1	NA	6
Pearls:				
Natural	NA	525	NA	475
Cultured	NA	12,865	NA	12,238
Imitation	NA	403	NA	672
Other precious and semiprecious stones:				
Rough and uncut	NA	5,062	NA	4,847
Cut but unset	NA	11,038	NA	12,799
Other, n.s.p.f	NA	374	NA	559
Synthetic:				
Cut but unset number	5,085	2,404	4,886	2,793
Other	NA	166	NA	282
Imitation gem stones	NA	9,405	NA	8,999
Total	NA	537,193	NA	566,693

NA Not available.

Table 2.—U.S. imports for consumption of diamond (exclusive of industrial diamond), by countries

(Thousand carats and thousand dollars)

Country	1967				1968				1969			
	Rough or uncut		Cut but unset		Rough or uncut		Cut but unset		Rough or uncut		Cut but unset	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Belgium-Luxembourg	47	$6,111	775	$96,676	46	$7,455	954	$119,396	59	$6,729	916	$113,114
Brazil	21	1,009	2	169	10	594	(1)	8	29	1,033	1	58
Canada	5	847	(1)	64	9	1,256	5	205	8	1,307	(1)	54
Central African Republic	183	9,002	---	---	218	11,818	1	61	232	9,806	---	---
France	1	101	17	2,085	22	1,004	22	2,514	10	379	20	2,484
Germany, West	2	227	11	1,039	(1)	2	5	556	1	13	5	507
Ghana	5	68	---	---	---	---	(1)	46	(1)	9	---	---
Guyana	31	1,370	---	---	14	830	(1)	5	20	1,020	---	---
India	---	---	14	1,239	---	---	30	2,714	---	---	30	2,663
Ireland	132	571	3	240	---	---	3	305	---	---	2	220
Israel	46	4,079	533	55,033	50	5,245	666	70,217	36	4,155	658	73,777
Japan	(1)	14	2	150	(1)	52	1	100	(1)	5	1	71
Liberia	26	3,946	---	---	7	1,898	---	---	13	2,976	---	---
Netherlands	39	8,566	14	2,065	46	9,953	19	3,073	48	12,810	27	3,561
Sierra Leone	180	5,921	3	307	61	1,892	9	1,310	224	8,331	10	1,447
South Africa, Republic of	333	39,852	32	7,766	434	46,380	35	9,076	361	41,585	28	8,713
Switzerland	7	1,524	(1)	174	20	2,039	4	785	6	1,043	3	919
U.S.S.R.	(1)	17	39	5,918	---	---	63	9,588	---	---	43	6,629
United Kingdom	1,339	122,000	10	1,395	1,439	152,881	17	2,239	1,697	185,278	9	1,496
Venezuela	64	2,347	---	---	95	3,468	---	---	157	5,439	---	---
Western Africa, n.e.c.	35	4,260	(1)	6	36	5,614	(1)	5	27	5,210	---	---
Other countries	10	1,070	(1)	244	7	272	(1)	275	4	438	5	1,368
Total	2,506	212,902	1,455	174,570	2,514	252,653	1,834	222,478	2,932	287,566	1,758	217,081

[1] Less than ½ unit.

WORLD REVIEW

Table 3.—World production of gem diamond, by countries

(Thousand carats)

Country	1967	1968	1969 p
Africa: [1]			
Angola	983	1,316	e 1,536
Central African Republic	e 260	e 305	e 330
Congo, (Kinshasa)	r 263	551	491
Ghana	254	e 245	e 238
Ivory Coast	e 105	e 110	e 121
Liberia [2]	r 262	537	e 550
Sierra Leone e	560	560	600
South-West Africa e [3]	1,531	1,636	1,700
Tanzania	r 433	356	e 380
South Africa, Republic of: e			
Premier	594	580	NA
De Beers Group [4]	2,128	2,170	NA
Other	334	446	NA
Total, South Africa, Republic of	3,056	3,196	3,380
Total Africa	r 7,707	8,812	9,326
Other areas:			
Brazil e	160	160	160
Guyana e	41	28	31
India	5	7	e 7
Indonesia e	14	14	14
U.S.S.R. e	1,400	1,400	1,500
Venezuela	38	60	118
Total [5]	r 9,365	10,481	11,156

e Estimate. p Preliminary. r Revised. NA Not available.
[1] Gem diamond is also produced in Guinea but data are not available.
[2] Exports, fiscal year ending August 31.
[3] Output of Consolidated Diamond Mines of South-West Africa Ltd.
[4] Includes some alluvial from De Beers properties.
[5] Totals are of listed figures only.

Angola.—Exports of gem and industrial diamonds, totaling 2 million carats valued at $70 million, continued to provide a major portion of the country's total export value. Only one company, Companhia de Diamantes Angola (DIAMANG), mined for diamond; however, two new companies were granted concessions for the exploration and exploitation of diamond and other precious stones.[14]

Australia.—A 220-ounce opal found at Andamooka sold for a world record price of $188,000.[15]

Botswana.—De Beers Consolidated Mines Ltd. established that one of the diamondiferous kimberlite pipes discovered during 1968 at Orapa, in the central part of the country, could become a major source of diamonds. Initial ore production of 8,000 tons per day is scheduled for 1971 with a doubling of production by 1974–75. Output to date indicated a ratio of 70 percent industrial stones to 30 percent gem-quality stones. The National Assembly of Botswana passed the "Precious Stone Industry (Protection) Act, 1969" to regulate and control the new industry. A mineral resource and mining activities review of the Republic was published.[16]

Burma.—The Burmese Government held its fifth annual Gem, Jade, and Pearl Emporium March 5–13, 1969, and sold $2.4 million worth of material. Cultured pearls accounted for 44 percent of total sales. All gem stone prospecting, mining, and marketing was nationalized March 12, and all private gem-mining operations and equipment were appropriated without promise of compensation. The justification for the action was that it would provide greater benefits to the gem workers and to the people of Burma generally, and that it

[14] Bureau of Mines. Mineral Trade Notes. Diamond. V. 66, No. 8, August 1969, pp. 8–10.
———. Gem Stones. V. 66, No. 12, December 1969, pp. 13–14.
[15] The Mining Journal. The Industry in Action: World Record-Priced Opal. V. 273, No. 7008, Dec. 12, 1969, p. 541.
[16] Boocock, C. Review of Mineral Resources and Mining Activities in the Republic of Botswana. Geological Survey—Botswana, Jan. 15, 1969, 12 pp.

would curb smuggling. The claim was made that the gem trade had enriched only a few individuals, largely persons of foreign origin, and had brought only poor revenue to the Government.[17]

Canada.—A new type opal gem stone with prismatic reflective colors was discovered in the Province of Alberta. The stone, suitable for doublets, was the opalized conchiolin of the fossil ammonite.[18] Two lode deposits of jade were reported to have been discovered in British Columbia.[19]

Colombia.—An emerald weighing 7,025 carats (almost 3 pounds) was reported to have been found at the Las Cruces mine in Cundinamarca. It was the largest ever found in Colombia.[20]

Southern Rhodesia.—A portion of an emerald crystal weighing 1,160 carats was found at the Chikwanda mine near Fort Victoria. The area may have possibilities as a new emerald source.[21]

Tanzania.—Tanzania exported 780,210 carats of diamond (gem and industrial combined) valued at $24.9 million and 514 kilograms of other gem stones valued at $200,000. Gem-corundum, ruby, and sapphire exports totaled 296 kilograms valued at $140,000. A new source of ruby and sapphire was reported to have been located and was being mined.[22]

Exports of gem zoisite totaled 20 kilograms valued at $30,000. During 1967, a deposit of gem-quality violet-blue zoisite crystals (given the varietal name tanzanite) was discovered. The crystals, because of a striking red, blue, yellow-green pleochroism, quickly gained popularity in the gem market. A 122.7 carat faceted tanzanite was placed on display by the Smithsonian Institute,[23] and several reports were published describing the gem mineral and its location.[24]

TECHNOLOGY

A colorless synthetic yttrium-aluminum garnet developed for use in microwave, laser, and ultrasonic devices was marketed as a diamond substitute. Faceted stones were sold for $50 per carat under the trade name "Diamonair".[25] A general review of diamond mining and recovery was published.[26] A study of diamonds recovered from the Witwatersrand gold mines suggested that the stones were subject to charged-particle radiation and subsequent annealing.[27] Single crystal sapphire filaments were grown to lengths of 100 feet with tensile strength of 300,000 pounds per square inch and a modulus of elasticity 65 to 75 million pounds per square inch.[28] A molten salt solution method of growing gem-grade rubies was discussed. Controlled defects can be introduced similar to those found in natural stones.[29]

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[17] Bureau of Mines. Mineral Trade Notes. Gem Stones. V. 66, No. 6. August 1969, pp. 13–14.

[18] Leiper, Hugh. A New Fossil Gem is Found in Alberta, Canada. Lapidary J. v. 23, No. 7, October 1969, pp. 932–937.

[19] The Northern Miner. B.C. Companies Join in Consortium To Exploit Mountainside Jade Find. Sept. 25, 1969, p. 20.
Western Mining News. Second Jade Discovery. Mar. 6, 1970, p. 4.

[20] Bureau of Mines. Mineral Trade Notes. Gem Stones. V. 66, No. 7, July 1969, p. 15.

[21] Bureau of Mines. Mineral Trade Notes. Gem Stones. V. 67, No. 4, April 1970, p. 12.

[22] Lapidary Journal. New Ruby, Sapphire Sources in Africa. V. 23, No. 9, December 1969, p. 1296.

[23] Trapp, Francis W. "The Midnight Blue." A New Tanzanite is Added to the Smithsonian's Collection. Lapidary J. v. 23, No. 5, August 1969, p. 680.

[24] Brayman, Harold H. "Really Beautiful Stuff" Tanzanite. Science Digest, May 1969, pp. 70–72.
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Thompson, Thomas. Tanzania to Tiffany's. Life, v. 66, No. 18, May 9, 1969, pp. 70–76.

[25] Business Week. Marketing—Why the Fake Diamoind Market Glitters. No. 2111, Feb. 14, 1970, p. 116.
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Crowingshield, Robert. Diamonair—A New Diamond Substitute. Lapidary J. v. 23, No. 12, March 1970, pp. 1614–1619.

[26] Linholm, A. A. L. Diamond Recovery is Big Business. Eng. & Min. J. v. 170, No. 11, November 1969, pp. 67–80.

[27] Raal, F. A. A Study of Some Gold Mine Diamonds. The Am. Miner., v. 54, No. 1–2, January–February, 1969, pp. 292–301.

[28] Chemistry. Hundred-Foot-Long Sapphires. V. 42, No. 1, January 1969, p. 23.

[29] Chemical Engineering. Growing Gem-Grade Rubies. V. 76, No. 5, Mar. 10, 1969, p. 64.

Gold

By Charles D. Hoyt [1]

The year 1969 marked the first complete year in which the two-tier pricing system was tested following its adoption in March 1968. Free market gold prices rose rather steadily for the first 5 months to peak at almost $44 per ounce, about 26 percent above the $35 price for monetary gold. During the balance of the year the free market price declined, and by mid-December it had dropped to the $35 monetary level. A combination of events contributed to the decline. Among these events were the successful devaluation of the French franc, the revaluation of the Deutsche mark, and the decision by the International Monetary Fund (IMF) in September 1969 to initiate the special drawing rights plan (SDR) beginning in January 1970. Additional factors contributing to the downward slide of the free market price were heavy sales by the dominant producer, South Africa, combined with heavy sales of speculative gold holdings, which had been estimated to be about 90 million ounces in March 1968. As free market gold prices dropped to the $35 mark, world concern was aroused that further drops would jeopardize monetary gold stocks and potentially create international monetary problems. This problem was resolved by agreements with the Republic of South Africa whereby it would be allowed to sell gold to IMF to meet foreign exchange need when free market prices reach or fall below $35 per ounce. An additional aspect of this agreement also allows the Republic of South Africa to dispose of gold stocks held at the time of the introduction of the two-tier system on March 17, 1968. The net result of the December agreement was to place a floor price on free market gold at $35.

Domestic mine production of gold increased considerably over that of 1968 because of the opening of a new open pit gold mine in Nevada and a strike-free year of operations for the copper industry, which produces about one-third of domestic gold output as a byproduct.

The gold reserves held by non-Communist central banks and Governments increased to about $41 billion, which represented somewhat over half of official world reserves. In 1969, the United States had net gold imports amounting to almost $225 million, contrasted with heavy net outflows of gold in the 2 previous years which totaled almost $1.6 billion.

Increased industrial use of gold continued in 1969 and reached 7.109 million ounces, which set a new record for the eighth year in a row. This compares to a domestic mine output in 1969 of 1.733 million ounces, roughly one-fourth of the consumption level.

Legislation and Government Programs.—At the end of September 1969 the members of IMF agreed to the activation of the SDR plan effective January 1, 1970. It was announced that $3.5 billion in special drawing rights would be allocated in 1970 and $3.0 billion each in 1971 and 1972. The United States had approved this plan by legislation in June 1968 (Public Law 90–349). The decision to implement the SDR plan, which took 2 years from formal introduction to approval, was a positive factor in reducing the free market gold price. The SDR plan is viewed as a natural complement to gold as the need for additional total monetary reserves arises. At the end of 1972 the proposed level of SDR reserves will total $9.5 billion, which will represent roughly one-fourth of the total official free world gold stock.

The heavy metals program of the Department of the Interior, which was started in mid-1966 to stimulate domestic gold production, achieved its first commercial result in 1969 with the startup of the Cortez gold mine in Nevada. In a report

[1] Physical scientist, Division of Nonferrous Metals.

Table 1.—Salient gold statistics

	1965	1966	1967	1968	1969
United States:					
Mine production..thousand troy ounces..	1,705	1,803	1,584	1,478	1,733
Value..................thousands..	$59,682	$63,119	$55,447	$58,038	$71,944
Ore (dry and siliceous) produced:					
Gold ore......thousand short tons..	3,113	3,447	3,076	2,780	3,393
Gold-silver ore...............do....	206	248	157	199	208
Silver ore.....................do....	752	669	617	655	555
Percentage derived from—					
Dry and siliceous ores.............	54	58	69	63	59
Base-metal ores....................	40	37	27	34	40
Placers............................	6	5	4	3	1
Refinery production [1] thousand troy ounces..	1,675	1,802	1,526	1,539	1,717
Exports [2].....................do....	36,717	13,067	28,720	23,962	338
Imports, general [2]...............do....	2,905	1,200	930	5,944	5,861
Stocks Dec. 31: Monetary [3]....millions..	$13,806	$13,235	$12,065	$10,892	$11,859
Industrial....thousand troy ounces..	2,656	2,734	3,086	3,617	4,158
Consumption in industry and the arts thousand troy ounces..	5,276	6,062	6,294	6,604	7,109
Price: [4] Average per troy ounce..........	$35	$35	$35	$39.26	$41.51
World:					
Production.......thousand troy ounces..	46,225	46,580	45,737	46,154	46,418
Official reserves [5].............millions..	$43,230	$43,185	$41,600	$40,905	$41,015

[1] From domestic ores—U.S. Bureau of the Mint.
[2] Excludes coinage.
[3] Includes gold in Exchange Stabilization Fund.
[4] U.S. Treasury price through Mar. 15, 1968, and Engelhard selling quotations Mar. 20, 1968, through 1969.
[5] Held by free-world central banks and Governments.

issued by the U.S. Geological Survey the Cortez district was described as a potentially favorable area for discovery of additional gold and mercury deposits.[2] The Bureau of Mines developed the method used commerically to treat the carbonaceous gold ores of Nevada. This process is described in the "Technology", section.

On April 26, 1969, the Treasury Department revised gold coin import regulations to permit the importing of gold coins minted prior to 1934 without license.[3] A second change in the gold regulation was made on June 11, 1969[4] which authorized "the Director of the Office of Domestic Gold and Silver Operations to license the acquisition, holding, transporation, and exportation of gold-plated coins or gold medals which are either antique or are for public display by an institution serving the public . . ."

In late November 1969 the Treasury announced that the mints, effective December 31, 1969, would no longer accept gold scrap from private citizens in exchange for gold bullion.[5]

DOMESTIC PRODUCTION

Domestic mine production of gold increased 16 percent in 1969. One major reason for this was the opening of the new Cortez gold mine near Elko, Nevada. This open pit operation went into production on January 10, 1969, and produced 166,000 ounces of gold during the year. Developed in 8 months at a cost of $8 million, the mill averaged 1,750 tons per day of throughput and processed 582,000 tons of ore averaging 0.33 ounces of gold per ton. Total ore reserves as of January 1, 1970, were almost 3 million tons at a grade of 0.275 ounce per ton.

The Nation's largest gold producer, the Homestake Mining Co., reported that its Lead. S. Dak. gold mine was the largest contributor to company earnings because of higher gold prices. Homestake is also involved in the joint operation of a lead-zinc mine and smelter complex in Missouri, an iron ore operation in Australia, a small silver mine in Colorado, uranium in New Mexico and Utah, a brick and lightweight aggregate venture in California,

[2] Erickson, R. L., G. H. Van Sickle, H. M. Nakagawa, J. H. McCarthy, Jr., and K. W. Leong. Gold Geochemical Anomaly in the Cortez District, Nevada. U.S. Geol. Survey Circ. 534, 1966, p. 9.
[3] U.S. Department of the Treasury. Imports of Gold Coins. 34 F.R. 6982, Apr. 2, 1969.
[4] U.S. Department of the Treasury. Gold Medals for Public Display and Antique Gold Medals. 34 F.R. 9211, June 11, 1969.
[5] U.S. Department of the Treasury. Termination of Gold Deposits at Mints for Exchange. 34 F.R. 19032, Nov. 29, 1969.

copper mining in Peru, and extensive uranium exploration in the Western United States.[6]

At the Homestake gold mine over 1.9 million tons of ore was processed in 1969 from which over 593,000 ounces of gold was recovered. The average selling price in 1969 for this gold was a little over $41.06 per ounce. The level of output was almost identical with 1968's. Metallurgical recovery was almost 95.4 percent, and measured ore reserves on January 1, 1970, were 10.44 million tons with a mill-head grade of 0.324 ounce per ton. Major development work was done on three of the deep levels in the Homestake mine. Indicated, potential, and possible ore reserves amounting to over 7.7 million tons are either being developed or are under planning for development. As a result of this the management expressed the opinion that "With the substantial new ore of better than average grade that has been delineated on the deepest levels, there is good reason to be optimistic about the continuing operation of this famous mine for some years." [7]

The Mayflower mine, a gold-silver operation run by Hecla Mining Co. in the Park City district of Utah, produced 52,500 ounces of gold from 117,500 tons of ore in 1969, compared with about 59,000 ounces in 1968. Estimated ore reserves declined to 257,000 tons at yearend from 309,000 tons at the beginning of 1969.[8]

The output of gold at the Carlin Gold Mining Co. operation declined to 212,000 ounces in 1969 from 280,000 ounces in 1968. The decline was due to the reduced ore grade which dropped to 0.289 ounce per ton in 1969 from 0.385 ounce in the previous year. The average price realized per ounce in 1969 was $41.04, which was $1.60 above the average 1968 price. The overall reserves at the Carlin mine, which includes 500,000 tons of carbonaceous ore, at yearend were 6.25 million tons averaging 0.253 ounce of gold per ton.

The 25 leading gold producers contributed 97.6 percent of the total domestic

[6] Homestake Mining Co. Annual Report, 1969, pp. 1–7.
[7] Work cited in footnote 6.
[8] Hecla Mining Co. Annual Report, 1969, p. 8.

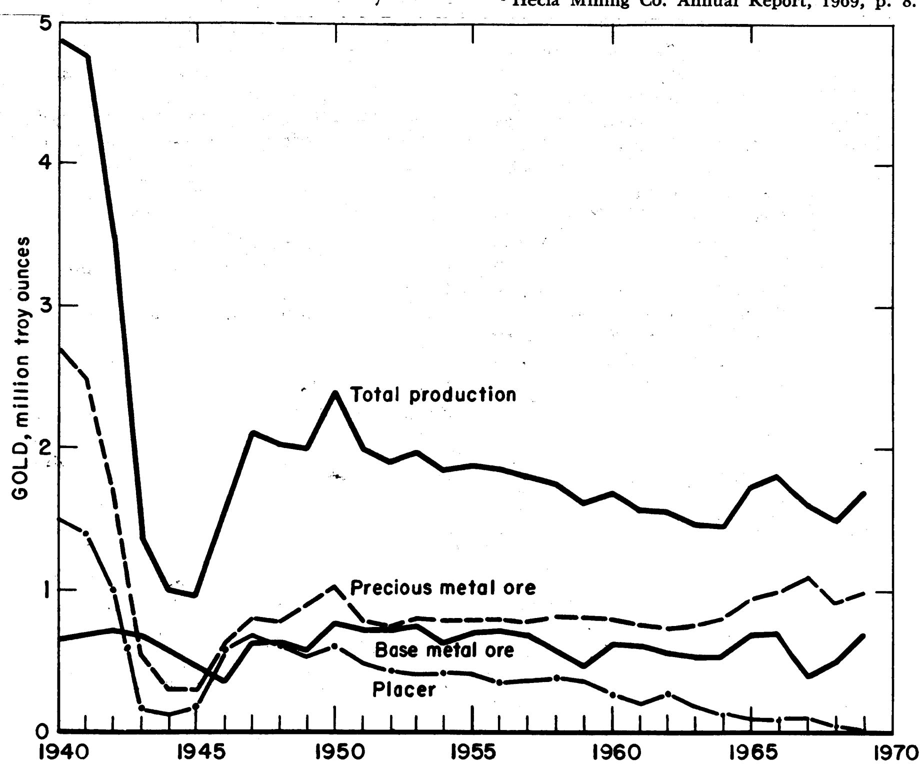

Figure 1.—Gold production in the United States.

production. These 25 producers consisted of seven lode gold mines, one placer mine, 12 copper mines, two copper-lead-zinc mines, two lead-zinc mines, and one iron mine. About 3,000 persons were employed in the gold mining industry in 1969.

CONSUMPTION AND USES

Domestic consumption of gold, as indicated by sales to fabricators of industrial and artistic products, increased in 1969 for the eighth consecutive year to a record 7.1 million ounces, or 7.5 percent above 1968 consumption. The Office of Domestic Gold and Silver Operations, U.S. Treasury Department, estimated the net industrial use of gold for jewelry, arts (decorative use), and dental purposes at 64 percent; the remainder was used for industrial products, including space and defense equipment.

The estimated industrial use of gold in the United States increased 35 percent during the 1965–69 period. Over this same period total industrial consumption of gold was roughtly 4 times domestic mine production.

A study on the trends in the use of gold, begun in early 1969 by the National Materials Advisory Board for the National Academy of Sciences and the National Academy of Engineering, was completed during the year and published in September 1969.[9] The study concludes that expansion in domestic production will not keep pace with consumption demands. Future growth is seen in expansion of existing uses, particularly those of the electrical and electronic industry, because no new technological developments are foreseen that would have any major impact on gold consumption during the next 5 years.

The jewelry industry in 1969 consumed somewhat over half of the total industrial gold used, and estimates are that the industry anticipates an annual growth of about 5 percent per year. Over 80 percent of gold used in jewelry is alloyed, usually with copper. Significant amounts of gold for jewelry are used for electroplating and also as rolled gold plate and gold fill.

The electrical and electronic industries are the second largest consumers of gold. Most of this use is in the form of gold electroplate to make semiconductors, connectors, and printed circuits. Technical advances in such areas as selective strip plating and improved plating processes have resulted in more efficient use of gold. A growth rate of 8 percent per year through 1973 is forecast for the industry.

The use of gold in dentistry is also significant, an estimated 10 percent of total gold consumption in 1969. Gold alloys are used in orthodontics and also for inlays, crowns, bridges, and partials.

Another gold application is liquid bright gold (an organogold complex with some sulfur and a fraction of a percent of rhodium) which is used for decorative purposes on glass or porcelain. Conductive gold pastes are also used in microelectronic components. In the aircraft industry gold is used as a brazing alloy; aerospace applications are also important but do not consume large amounts of gold.

The Sylvania Electric Products, Inc., reported in early 1970 a new gold-dot connector system for printed circuit boards. It was reported that the new connectors are available in 312 different configurations and will be more economic than the bellows type, now generally used. The advantage of the gold-dot system is that the gold is used only where it is needed. Each gold-dot contact has two dots per contact; the rest of the contact is a phosphor bronze which is tin or solder plated.[10]

STOCKS

Monetary.[11]—During 1969 the total U.S. gold stock, including gold in the Exchange Stabilization Fund, rose $967 million to $11,859 million at yearend. This gain compares with losses of gold in 1968 of $1,173 million. The major factor in this increase was the sale of $500 million in gold to the United States by West Germany. The U.S. balance of payments, measured on the liquidity basis, showed a deficit of $7.1 billion in 1969 compared with a surplus of

[9] National Materials Advisory Board. Trends in Usage of Gold. NMAB–254, September 1969, 17 pp. (Available from Clearinghouse for Federal Scientific and Technical Information, Springfield, Va.)

[10] American Metal Market. V. 77, No. 10, Jan. 15, 1970, pp. 1, 13.

[11] All figures in this section were taken from the Federal Reserve Bulletin, v. 56, May 1970, pp. A–75–A–93.

$158 million for 1968 and a deficit of almost $3.6 billion a year earlier. The U.S. gold tranche position in the IMF, which is the amount that the United States could draw in foreign currencies virtually automatically if needed, was $2,234 million at yearend.

The gold reserves of non-Communist central banks and Governments and international banking institutions at yearend were estimated at $41,015 million compared with $40,905 million at the end of 1968. This was the first increase in world official gold reserves after a 3-year decline from a peak of $43,230 million in 1965. Implementation of the SDR and the success of the two-tier gold arrangements combined to strengthen the international monetary system.

The U.S. gold reserves of $11,859 million at the end of 1969 represented almost 29 percent of the non-Communist gold reserves, about 2 percent more than at the end of 1968. Gold reserves of other principal non-Communist countries in millions of dollars at the end of 1969 were as follows: West Germany $4,079; France $3,547; Italy $2,956; Switzerland $2,642; Nether-

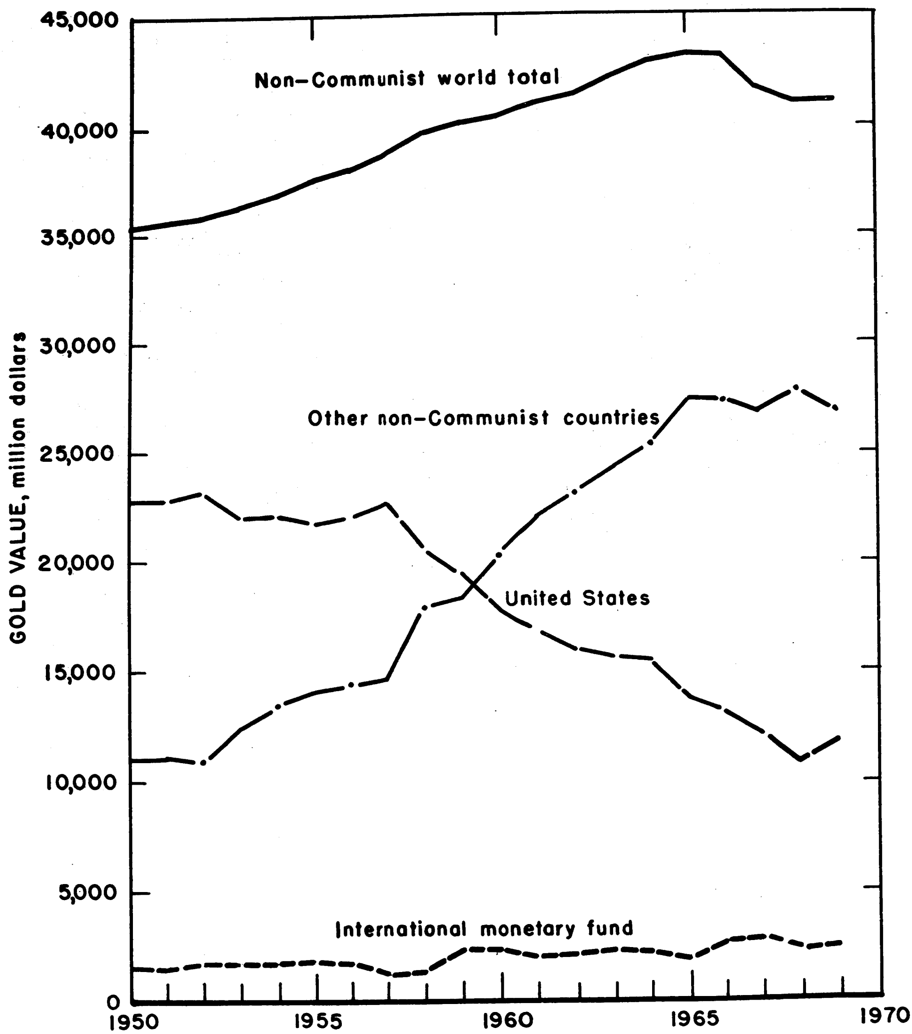

Figure 2.—Gold reserves of free world central banks and Governments.

lands $1,720; and the United Kingdom $1,471. IMF had gold reserves of $2,310 million at the end of 1969.

Industrial.—Gold held in inventories by domestic refiners and fabricators rose 15 percent over 1968 stocks to 4,158,000 ounces according to the Office of Domestic Gold and Silver Operations, U.S. Department of the Treasury. Over the past 5 years industrial inventories have increased almost 57 percent.

PRICES

On March 17, 1968, a floating open-market system was initiated for private gold sales based on supply and demand. Over the next 9 months in 1968 free market gold prices ranged from about $37.50 to $42.80 per ounce and ended 1968 at $42.30. Prices during 1969 were at a high in March, reaching $44.25 and averaged $43.56 for this month. The balance of 1969 was marked by declines until a low of $35.45 was reached on December 19. The monetary price of gold remained at $35 per ounce throughout the year.

During 1969 the final selling price for gold on the London market peaked at $43.82½ on March 10 when the U.S. selling price also reached its high of $44.25. The yearend closing price in London was $35.20, and the low was reached on December 19 when it was just at the monetary level of $35 per ounce.

Gold prices in other foreign gold markets have historically ranged considerably above the London and New York levels. During the year the highest price levels for bars were reached in the Bombay markets, where prices held at a peak $57 per ounce during March to May.

Gold coins throughout the world also commanded large premiums. Paris markets showed the highest level with prices of $75.30 per ounce in April.

High world interests rates reduced the attractiveness of holding speculative gold. The primary gold market decline took place between November 3 and 25 when U.S. prices dropped from $39.95 to $35.90 per ounce. The net result was the decline of the free market price to almost the monetary level and an IMF agreement with the Republic of South Africa on December 30, 1969. The IMF announced it would purchase gold from the Republic of South Africa when the free market price reaches or falls below the monetary level value of $35 per ounce. This action taken by the IMF and the Republic of South Africa was a key factor in stabilizing the price of gold. Due to a favorable balance of payments position, South Africa initially refrained from selling gold in March 1968. However, beginning about March 1969, this situation was reversed; the Republic of South Africa registered a large deficit in its balance of payments. Large amounts of gold were then sold during the rest of 1969 from the large South African supplies that had accumulated. There were also large gold sales from speculative gold holdings that had been acquired between late 1967 and March 1968. Estimates indicate that as much as $2.5 billion in speculative gold purchases were made in this period. Combined total sales of gold from all sources between March–December 1969 probably ranged between $1 to $2 billion; estimates indicate that the South Africans alone disposed of $800 to $850 million.

One of the complicating factors in assessing future gold pricing is the Euro-dollars situation. In 1969 the Euro-dollar pool expanded an estimated 60 percent to about $40 billion. Foreign private liquid funds into the United States in 1969 amounted to $8.8 billion and a change in the U.S. tight money situation could well reverse this flow. European bankers could then find their dollar holdings excessive and possibly purchase gold as the only alternative reserve asset available. This would result in upward pressures on free market gold prices. The yearend premiums of coins over gold bar, based on market prices in Swiss trading centers, showed the British Sovereign registering about 30 percent; the U.S. double eagle, 68 percent; French napoleon, 78 percent; and the Swiss 20-franc gold coin (vreneli), 94 percent.[12]

As mentioned earlier, one of the most significant events for 1969 was the decision by the free world countries to implement the Special drawing rights, a new reserve supplement for international monetary transactions. On October 3, 1969, the IMF announced the decision to begin using SDR's on January 1, 1970. The Under Sec-

[12] Engineering and Mining Journal. Free Gold Market. V. 171, No. 1, 1970, p. 34.

retary of the Treasury testified on November 14, 1969, before the Subcommittee on International Exchange and Payments of the Joint Economic Committee. Extracts from his statement follow:

The series of crises and near crises in international financial markets that have been characteristic of recent years have been a prod for constructive change. But we can also take some satisfaction from the fact that massive speculative flows have been absorbed and contained without rupturing the basic international financial structure or impeding the growth of trade. Our defenses have been tested, and they have stood firm.

Nowhere has this been more striking than with respect to the new gold market arrangements introduced in March of 1968—the so-called two-tier system. In essence, the decisions taken at that time separated dealings in gold among national authorities from the vagaries of industrial and speculative demands and new production in the private markets. The immediate result was to break the link between currency disturbance or speculation and a drain of gold from official stocks into private hoards—a link that, in practice, had become self-reinforcing. Instead, speculation in gold now spends itself in fluctuations in the price in private markets. The process is self-limiting, as the rising price of an asset that yields no return simply increases the risk of subsequent loss. . . .

I believe gold will continue to have an important role in the monetary system as far ahead as we can foresee. The institution of the two-tier system recognizes that, *relative* to other reserve assets, the role of gold will decline over time as the need for total reserves grows. Indeed, operation of the two-tier system must assume the creation of acceptable reserves in other forms.

In this sense, the SDR is a natural complement. Within three years, the volume of SDR's will be the equivalent of, roughly, one-fourth of the entire official stock of gold. . . .

But we must also recognize there is one area—fundamentally more important than any other I have touched on today—where the needed progress has been all too slow.

I am referring, of course, to the related problems of our balance of payments position and our internal inflation. . . .

The size and distribution of Fund quotas, the performance of the two-tier system, the effects of the German revaluation, even the major accomplishment of the SDR and the potential for some limited flexibility of exchange rates will be of limited consequence if we do not meet our own responsibilities for a reasonable degree of price stability.

In the end, world monetary stability rests on the stability of the dollar itself. . . .

FOREIGN TRADE

During 1969 the United States became a net importer of gold for the first time in 9 years. Net imports were over 5.5 million ounces. The primary import sources were Canada (55 percent), Switzerland (21 percent), and the Philippines (8 percent), with the balance (16 percent) distributed among 26 countries. Almost 80 percent of the U.S. exports of gold went to Uruguay, all in the form of refined bullion, and 15 percent went to Belgium-Luxembourg.

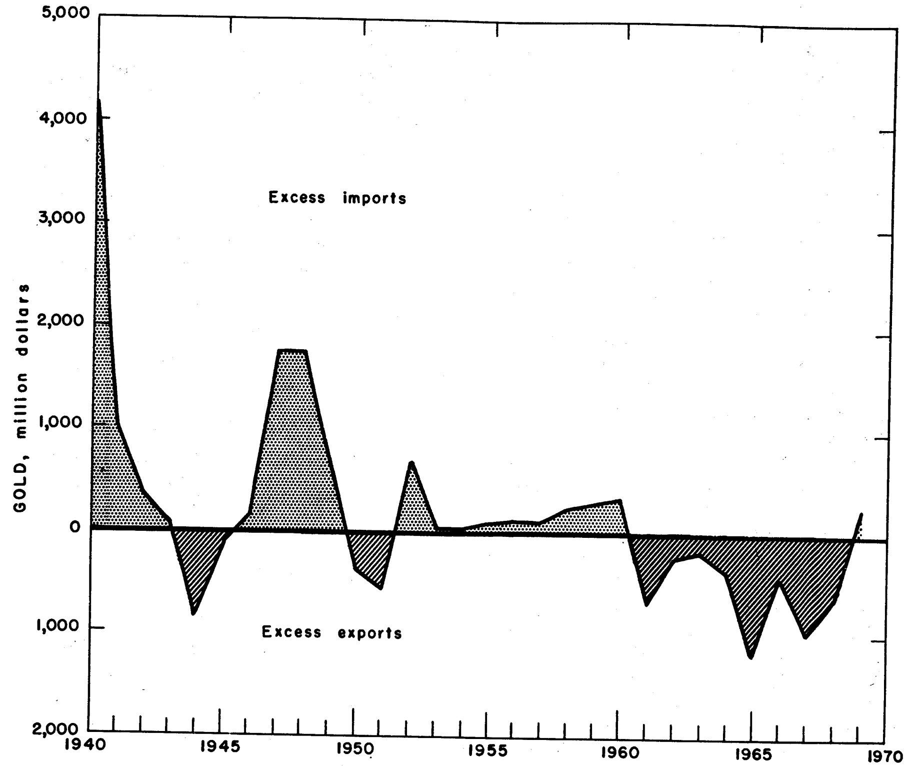

Figure 3.—Net exports or imports of gold.

WORLD REVIEW

World production of gold increased slightly in 1969 to 46.42 million ounces. Increased production in the Republic of South Africa, the U.S.S.R., the Philippines, and the United States compensated for decreased output in Canada, Australia, and Nicaragua.

The gold reserves of central banks and Governments, excluding the Communist-bloc countries, increased to slightly over $41 billion at the end of 1969, a gain of $110 million over yearend 1968 reserves.

Canada.—Gold production in Canada declined for the ninth consecutive year to 2,443,544 ounces although it still ranked as the world's third largest producer. Output declined over 9 percent, from 1968 production, and was valued at over $94.3 million. The average price paid for gold in 1969 by the Royal Canadian Mint was $37.69, almost the same as that the previous year.

Thirty-two lode mines were operating in Canada of which 29 sold their gold output to the Canadian Government and were therefore eligible for assistance under the Emergency Gold Mining Assistance Act. The other three mines sold their output on the open market. Two gold mines closed during the year.

The Province of Ontario, where 17 lode gold mines operated, produced almost half (48.2 percent) of Canada's output; the Province of Quebec, with 9 lode gold mines, (29.5 percent) was the second largest producer. Lode gold made up slightly over 80 percent of the gold output, and byproduct gold from base metal mines represented almost all of the remainder, except for a very small placer production of 0.3 percent. The average employment rate in the gold industry was about 9,000 persons.

Giant Yellowknife Mines, Ltd., increased gold output in 1969 almost 10 percent over

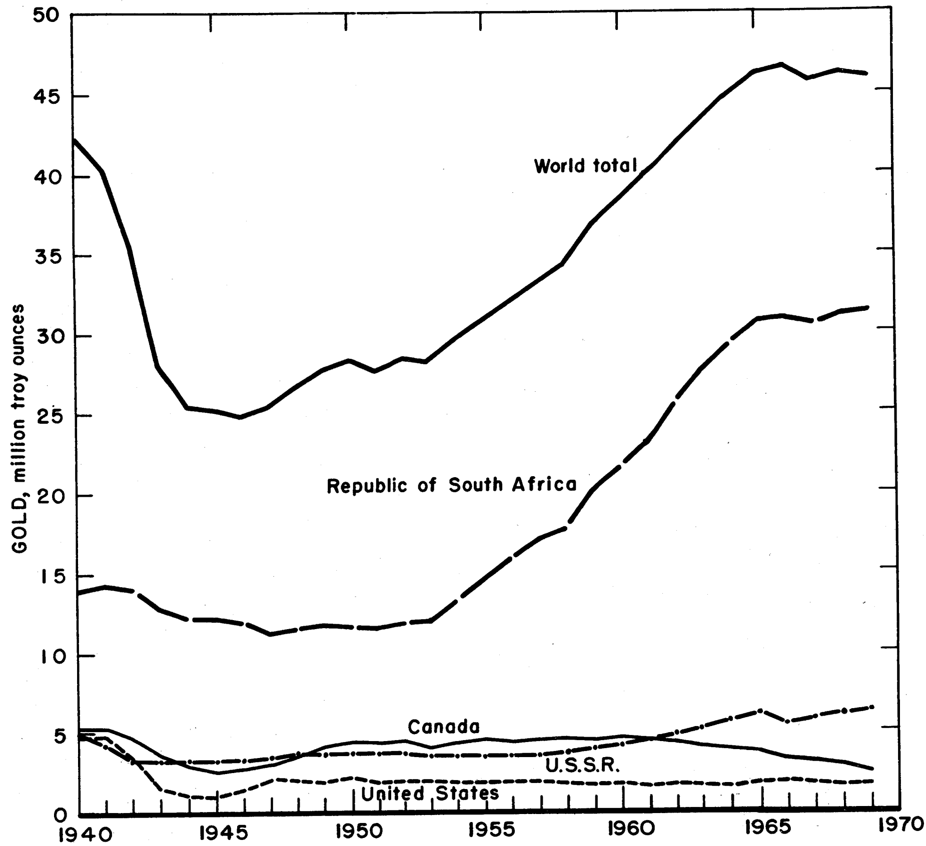

Figure 4.—World production of gold.

1968 production. Almost 400,000 tons were milled to produce over 230,000 ounces of gold. Operating costs per ton were up 13 percent to $18.24 per ton.[13]

Dome Mines Ltd. reported mixed results from its three mining operations. Total 1969 gold output was up slightly to 526,206 ounces, compared with 525,050 in 1968.[14] Of the three operations controlled by Dome Mines Ltd., Campbell Red Lake Mines Ltd., produced 176,517 ounces in 1969, Dome Mines Ltd. produced 179,661 ounces, and Sigma Mines (Quebec) Ltd., produced 84,936 ounces of gold.

Kerr-Addison Mines Ltd. reported gold output of 151,500 ounces for 1969, down from 179,900 ounces in 1968. Ore reserves at yearend were estimated at almost 2.5 million tons averaging 0.50 ounces of gold compared to reserves of almost 3.3 million tons of 0.46 ounce of gold per tons at the end of 1968.[15]

Colombia.—The International Mining Corp., an American firm, produced 96,132 ounces from the operation of four dredges in the Department of Choco and from one underground mine, which produced two-thirds of the total output. The dredges processed over 17 million cubic yards in 1969. At yearend proven dredging reserves were 180.64 million cubic yards averaging 17.8 cents per cubic yard in gold values.[16]

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[13] Giant Yellowknife Mines, Ltd. Annual Report, 1969, p. 3.

[14] Dome Mines Ltd. Report to Shareholders for 1969, p. 50.

[15] Kerr-Addison Mines Ltd., Annual Report, 1969, p. 7.

[16] International Mining Corp. Annual Report. 1969, p. 6.

Underground reserves were 111,000 tons averaging 0.79 ounce of gold per ton.

The 1969 output of Pato Consolidated Gold Dredging Ltd., which is controlled by International Mining Corp. decreased 6 percent to 72,312 ounces. At yearend the workable total reserves were 271 million cubic yards with an average value of 15.7 cents per cubic yard.[17]

Philippines.—Gold output rose for the sixth consecutive year in 1969 to over 571,000 ounces. The two largest producers were Benguet Consolidated, Inc. 250,932 ounces [18] and Lepanto Consolidated Mining Co. Ltd. 131,379 ounces. Lepanto's output was up almost 50 percent over that of 1968.[19] Lepanto began operation of a 150-ton-per-day mill in October 1969.

South Africa, Republic of.—Output from South African mines reached a new high of 31.28 million ounces valued at $1.1 billion, which represented about 78 percent of the free world gold production. Gold production from the 48 mines that are members of the Chamber of Mines of South Africa was slightly over 30.89 million ounces, produced by mining and processing 80.69 million tons of ore. Ore reserves of the group at yearend increased to almost 175 million tons compared with 159.1 million tons at the end of 1968.

The Anglo-American Corporation of South Africa Ltd. (Anglo-American) reported that gold output from its group of 12 mines was up 2 percent over 1968 production to almost 12.8 million ounces, or almost 41 percent of total South African output. Total working profit of the gold mines was up 14 percent. One of the Anglo American mines, Western Deep Levels, increased its working profit by 23 percent in 1969.[20] Western Deep Levels was the largest gold mine in the Republic of South Africa in terms of milling capacity and processed over 3.4 million tons of ore from which over 2 million ounces of gold was recovered. This single mine's output exceeded the entire U.S. production in 1969.

Other large mines operated by Anglo American, with 1969 gold output in ounces, were as follows: Western Holdings Ltd. 1.8 million; Vaal Reefs Exploration and Mining Company Ltd. 1.12 million; Free State Geduld Mines Ltd. 1.95 million; and President Brand Gold Mining Company Ltd. 1.6 million.[21]

Union Corp. Ltd. (Union Group) operates 8 gold mines in the Republic of South Africa along with many other diversified investments including platinum, nickel, copper, and chrome operations in South Africa and lead, zinc, silver, copper, and fluorspar in Mexico. The total gold produced by the Union Group in 1969 was 4.08 million ounces from mining and milling 12.9 million tons of ore. The St. Helena mine is the largest mine in the group and produced almost 1.1 million ounces in 1969. The average gold price obtained for sales of Union gold during 1969 was 5 percent above the average 1968 price.[22]

Consolidated Gold Fields Ltd. through Gold Fields of South Africa Ltd. operated nine producing gold mines and one developing gold mine, East Driefontein, where shaft sinking and surface construction are underway. Gold production of the group was 5 million ounces in 1969, a half-million ounces below the previous year's output. This decline in output was due to serious flooding of the West Driefontein mine, the world's largest gold mine, in October 1968. In addition, a severe rock burst in the mine killed eight miners early in 1969; subsequently there was a severe underground fire in the mine. However, by September 1969 the mine was almost back to normal operating levels. In spite of these setbacks the mine produced 1.9 million ounces of gold in 1969.

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[17] Pato Consolidated Gold Dredging Ltd. 36th Annual Report. 1969, pp. 3, 9.

[18] Benguet Consolidated, Inc. Annual Report. 1969, p. 9

[19] Lepanto Consolidated Mining Co. Ltd. Annual Report. p. 7.

[20] Mining Journal. Statement by Mr. H. F. Oppenheimer, Chairman, Anglo American Corporation of South Africa Ltd. V. 279, No. 7033, June 5, 1970, p. 530.

[21] Chamber of Mines of South Africa. Analysis of Working Results of Gold and Gold and Uranium Mining Members; Results for year January to December, 1969, pp. 4–5.

[22] Union Corp. Ltd. Report and Accounts for the year ended 31st December 1969, pp. 1, 11.

TECHNOLOGY

During the year and in the first half of 1970, the Bureau of Mines issued a series of reports on the results of investigations that were conducted under the Department of the Interior's heavy metals program, which began in mid-1966. The most significant results were obtained in the Bureau's attempts to develop a process to treat the carbonaceous gold ores of northeastern Nevada that were described in earlier reports.[23]

Preliminary successful results in solving this problem were presented in a 1969 report.[24] The technical feasibility of recovering gold from carbonaceous ore by chemical and electrolytic oxidation treatment prior to cyanidation was demonstrated. The gold that occurs in the ore in the form of organic compounds is liberated by oxidation, and the adsorptive properties of the ore are passivated by the oxidation treatment. Gold recovery of over 90 percent was obtained on ores containing 0.3 ounce of gold per ton as compared with only 6- to 32-percent extraction obtained by direct cyanidation without oxidation pretreatment. The commercial importance of this work was clearly demonstrated by the development of economic methods, based on the Bureau process, that can be used on a half-million tons of formerly valueless refractory carbonaceous material in the Nevada open pit mine operated by the Nation's number two gold producer, the Carlin Gold Mining Company. The company announced construction of a 500-ton-per-day mill with completion scheduled for September 1970.[25]

Other areas of investigation in the heavy metals program were the recovery of gold from scrap electronic solders[26] and the experimental leaching of gold from mine waste by percolation cyanide leaching.[27] An additional report was made on secondary gold in the United States.[28]

The therochemistry of gold and its compounds has been thoroughly investigated and reported on by two Canadian researchers.[29]

[23] Merwin, Roland W. Gold Resources in the Oxidized Ores and Carbonaceous Material in the Sedimentary Beds of Northeastern Nevada. BuMines Tech. Prog. Rept. 1, 1968, 16 pp.
Scheiner, B. J., R. E. Lindstrom, and T. A. Henrie. Investigation of Oxidation Systems for Improving Gold Recovery from Carbonaceous Materials. BuMines Tech. Prog. Rept. 2, 1968, 8 pp.

[24] Scheiner, B. J., R. E. Lindstrom, and T. A. Henrie. Electrolytic Oxidation of Carbonaceous Ores for Improving Gold Recovery. BuMines Tech. Prog. Rept. 8, 1969, 12 pp.

[25] Wall Street Journal. Nevada Mine to Extract Gold From Carbon Deposit. Apr. 20, 1970, p. 12.

[26] Kleespies, E. K., J. P. Bennetts, and T. A. Henrie. Gold Recovery From Scrap Electronic Solders by Fused Salt Electrolysis. BuMines Tech. Prog. Rept. 9, 1969, 8 pp.

[27] Heinen, H. F., and Bernard Porter. Experimental Leaching of Gold From Mine Waste. BuMines Rept. of Inv. 7250, 1969, 5 pp.
Potter, George M. Recovering Gold From Stripping Waste and Ore by Percolation Cyanide Leaching. BuMines Tech. Prog. Rept. 20, 1969, 5 pp.

[28] Staff, Bureau of Mines. Secondary Gold in the United States. Inf. Circ. 8447, 1970, 30 pp.

[29] Gedansky, L. M., and L. G. Hepler. Thermochemistry of Gold and Its Compounds. Englehard Industries Tech. Bull., v. 10, No. 1, June 1969, pp. 5–9.

Table 2.—Mine production of recoverable gold in the United States, by States

(Troy ounces)

State	1965	1966	1967	1968	1969
Alaska	42,249	27,325	22,948	21,262	21,227
Arizona	150,566	142,528	80,844	95,999	110,878
California	62,885	64,764	40,570	15,682	7,904
Colorado	37,228	31,915	21,181	22,638	25,777
Idaho	5,078	5,056	4,838	3,227	3,403
Montana	22,772	25,009	9,786	13,385	24,189
Nevada	229,050	366,903	434,993	317,382	456,294
New Mexico	9,506	9,295	5,188	6,630	8,952
Oregon	499	281	186	23	875
Pennsylvania	[1] 90,674	[1] 85,000	[1] 73,337	[1] 54,453	[1] 47,020
South Dakota	628,259	606,467	601,785	593,052	593,146
Tennessee	122	141	181	140	126
Utah	426,299	438,736	288,350	334,419	433,385
Washington	(1)	(1)	(1)	(1)	(1)
Wyoming	3	--------	--------	--------	(1)
Total	1,705,190	1,803,420	1,584,187	1,478,292	1,733,176

[1] Production of Pennsylvania, Washington, and Wyoming (1969) combined to avoid disclosing individual company confidential data.

Table 3.—Mine production of recoverable gold in the United States, by months

(Troy ounces)

Month	1968	1969	Month	1968	1969
January	90,524	128,918	August	145,578	151,655
February	82,615	129,443	September	134,628	147,700
March	85,054	147,158	October	138,534	162,577
April	131,259	143,237	November	121,615	153,476
May	137,704	144,811	December	122,992	143,726
June	133,158	133,257			
July	154,631	147,218	Total	1,478,292	1,733,176

Table 4.—Twenty-five leading gold-producing mines in the United States in 1969, in order of output

Rank	Mine	County and State	Operator	Source of gold
1	Homestake	Lawrence, S. Dak	Homestake Mining Co	Gold ore.
2	Utah Copper	Salt Lake, Utah	Kennecott Copper Corp	Copper, gold-silver ores.
3	Carlin	Eureka, Nev	Carlin Gold Mining Co	Gold ore.
4	Cortez	Lander, Nev	Cortez Gold Mines	Do.
5	Veteran-Tripp	White Pine, Nev	Kennecott Copper Corp	Copper ore.
6	Mayflower	Wasatch, Utah	Hecla Mining Co	Copper-lead-zinc ore.
7	Knob Hill	Ferry, Wash	Knob Hill Mines, Inc	Gold ore.
8	Copper Queen-Lavender Pit	Cochise, Ariz	Phelps Dodge Corp	Copper ore.
9	New Cornelia	Pima, Ariz	do	Copper, gold-silver ores.
10	San Manuel	Pinal, Ariz	Magma Copper Co	Copper ore.
11	Idarado	Ouray and San Miguel, Colo	Idarado Mining Co	Copper-lead-zinc ore.
12	Copper Canyon	Lander, Nev	Duval Corp	Copper ore.
13	Berkeley Pit	Silver Bow, Mont	The Anaconda Company	Do.
14	Morenci	Greenlee, Ariz	Phelps Dodge Corp	Copper, gold-silver ores.
15	Hogatza River	Yukon River Region, Alaska	United States Smelting Refining and Mining Co	Placer.
16	Magma	Pinal, Ariz	Magma Copper Co	Copper ore.
17	U.S. and Lark	Salt Lake, Utah	United States Smelting Refining and Mining Co	Lead, lead-zinc ores.
18	Sunnyside	San Juan, Colo	Standard Metals Corp	Lead-zinc ore.
19	Eureka	Madison, Mont	Pacific Mines, Inc	Gold-silver ore.
20	Oriental	Sierra, Calif	Dickey Exploration Co	Gold ore.
21	Continental	Grant, N. Mex	United States Smelting Refining and Mining Co	Copper ore.
22	Christmas	Gila, Ariz	Inspiration Consolidated Copper Co	Do.
23	Pacific	Madison, Mont	Pacific Mines, Inc	Gold-silver ore.
24	Chino	Grant, N. Mex	Kennecott Copper Corp	Copper ore.
25	Ray Pit	Pinal, Ariz	do	Do.

Table 5.—Production of gold in the United States in 1969, by States, types of mines, and classes of ore yielding gold, in terms of recoverable metal

State	Placer (troy ounces of gold)	Lode					
		Gold ore		Gold-silver ore		Silver ore	
		Short tons	Troy ounces of gold	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold
Alaska	21,146	(1)	75	-------	-----	-------	-----
Arizona	5	512	500	63,565	139	75,487	153
California	2,650	[2] 6,263	[2] 4,739	(2)	(2)	126	3
Colorado	1,056	100	70	515	86	3,583	63
Idaho	3	[2] 58	[2] 75	(2)	(2)	531,313	887
Montana	4	[2] 7,086	[2] 7,479	(2)	(2)	36,242	986
Nevada	2	1,380,771	378,934	-------	-----	5,081	264
New Mexico	1	---------	---------	1,287	502	-------	-----
Oregon	W	[3] 854	[3] 875	(3)	(3)	-------	-----
South Dakota	W	1,934,622	[4] 593,146	-------	-----	-------	-----
Utah	------	---------	---------	142,738	1,156	2,842	544
Other States	------	62,237	45,708	-------	-----	-------	-----
Total	25,418	3,392,503	[5] 1,031,050	208,105	1,883	654,674	2,900
Percent of total gold	1	---------	59	-------	(1)	-------	(1)

State	Lode					
	Copper ore		Lead ore		Zinc ore	
	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold
Alaska	----------	-------	50	6	-------	-----
Arizona	107,774,696	108,718	218	106	-------	-----
California	----------	-------	[6] 104,388	[6] 391	-------	-----
Colorado	----------	-------	982	97	277,350	873
Idaho	542	5	[7] 255,785	[7] 1,555	(7)	(7)
Montana	16,016,901	15,420	[7] 2,879	[7] 267	(7)	(7)
Nevada	14,345,225	76,212	4,519	615	-------	-----
New Mexico	12,491,450	8,163	-------	-----	221,563	182
Oregon	----------	-------	-------	-----	-------	-----
Utah	38,650,300	370,632	534	32	-------	-----
Other States	389	21	-------	-----	261,144	2
Total	189,279,503	579,171	369,355	3,069	760,057	1,057
Percent of total gold	----------	33	-------	(1)	-------	(1)

State	Lode						Refinery production [12] (troy ounces of gold)
	Copper-lead, lead-zinc copper-zinc, and copper-lead-zinc ores		Old tailings, etc.		Total		
	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold	
Alaska	---------	------	-------	-----	50	21,227	18,900
Arizona	106,783	30	91,744	[8] 1,227	108,113,005	110,878	114,900
California	(6)	(6)	417	[9] 121	111,194	7,904	7,250
Colorado	741,484	[10] 23,532	-------	-----	1,024,014	25,777	26,200
Idaho	677,039	875	600	3	1,465,337	3,403	3,400
Montana	1,068	9	5,435	24	16,069,611	24,189	20,000
Nevada	2,749	28	14,844	239	15,753,189	456,294	452,500
New Mexico	54,413	102	76	2	12,768,789	8,952	10,000
Oregon	---------	------	-------	-----	854	875	350
South Dakota	---------	------	-------	-----	1,934,622	593,146	593,200
Tennessee	1,574,140	126	-------	-----	1,574,140	126	110
Utah	567,514	60,040	36,786	981	39,400,714	433,385	425,000
Other States	---------	------	33	[11] 1,289	323,803	47,020	[13] 45,040
Total	3,725,190	84,742	149,935	3,886	198,539,322	1,733,176	1,716,850
Percent of total gold	---------	5	-------	(1)	-----------	100	---------

W Withheld to avoid disclosing individual company confidential data; included in placer total and in lode ores as noted.

[1] Less than ½ unit.
[2] Gold and gold-silver ores combined to avoid disclosing individual company confidential data.
[3] Placer combined with gold and gold-silver ores to avoid disclosing individual company confidential data.
[4] Placer combined with gold ore to avoid disclosing individual company confidential data.
[5] Excludes Oregon and South Dakota placer production; included in placer total.
[6] Lead and lead-zinc ores combined to avoid disclosing individual company confidential data.
[7] Lead and zinc ores combined to avoid disclosing individual company confidential data.
[8] Includes byproduct gold recovered from uranium ore.
[9] Includes byproduct gold recovered from tungsten ore.
[10] Includes byproduct gold recovered from fluorspar ore.
[11] Includes byproduct gold recovered from magnetite-pyrite ore.
[12] Source: U.S. Bureau of the Mint.
[13] Washington only.

Table 6.—Gold produced in the United States from ore, old tailings, etc., in 1969, by States and methods of recovery, in terms of recoverable metal

State	Total ore, old tailings, etc., treated[1][2] (thousand short tons)	Ore and old tailings to mills					Crude ore, old tailings, etc., to smelters[1]	
		Thousand short tons[1][2]	Recoverable in bullion		Concentrates smelted and recoverable metal			
			Amalgamation (troy ounces)	Cyanidation (troy ounces)	Concentrates (short tons)	Troy ounces	Thousand short tons	Troy ounces
Alaska	(3)	(3)	75	-------	6	6	-----	------
Arizona	118,575	117,907	400	18	3,062,631	104,613	668	5,842
California	111	107	1,869	-------	12,198	1,860	4	1,525
Colorado	1,090	1,087	4,014	-------	156,777	20,639	3	68
Idaho	1,802	1,748	52	-------	196,208	3,223	54	125
Montana	16,131	16,032	22	-------	393,882	15,524	99	8,639
Nevada	20,215	20,122	374	378,493	372,443	75,377	93	2,048
New Mexico	12,876	12,769	-------	-------	484,867	8,421	107	530
Oregon	1	1	145	-------	49	178	(3)	46
South Dakota	1,935	1,935	390,918	202,183	---------	-------	(3)	------
Tennessee	5,863	5,863	-------	-------	309,678	126	-----	------
Utah	39,492	39,211	-------	-------	1,023,839	430,486	281	2,899
Other States	1,741	1,741	-------	-------	106,248	47,018	(3)	2
Total	219,832	218,523	397,869	580,694	6,118,826	707,471	1,309	21,724

1 Includes some nongold-bearing ores not separable.
2 Excludes tonnages of fluorspar, magnetite-pyrite, tungsten, and uranium ores from which gold was recovered as a byproduct.
3 Less than ½ unit.

Table 7.—Gold produced at amalgamation and cyanidation mills in the United States and percentage of gold recoverable from all sources

Year	Bullion and precipitates recoverable (troy ounces)		Gold recoverable from all sources (percent)			
	Amalgamation	Cyanidation	Amalgamation	Cyanidation	Smelting[1]	Placers
1965	460,271	392,171	27.0	23.0	44.2	5.8
1966	432,130	519,631	24.0	28.8	42.1	5.1
1967	400,836	609,714	25.3	38.5	32.1	4.1
1968	394,051	482,616	26.7	32.6	38.2	2.5
1969	397,869	580,694	23.0	33.5	42.0	1.5

1 Crude ores and concentrates.

Table 8.—Gold production at placer mines in the United States, by methods of recovery

Method and year	Mines producing	Washing plants	Material treated (thousand cubic yards)	Gold recoverable: Thousand troy ounces	Value (thousands)	Average value per cubic yard
Bucketline dredging:						
1965	9	11	13,685	83	$2,889	$0.211
1966	9	11	13,384	75	2,631	.197
1967	10	10	5,448	48	1,690	.310
1968	4	4	3,770	20	778	.206
1969	4	4	814	13	547	.672
Dragline dredging:						
1965	10	11	[1] 632	[2] 2	57	.090
1966	9	9	[1] 227	[2] 2	70	.308
1967	4	4	[1] 55	[2] 1	21	[3] .981
1968	3	3	[1] 81	[2] 1	54	[3] .499
1969	2	2	[1] 2	[2] ([4])	17	[3] .934
Hydraulicking:						
1965	6	6	4	([4])	3	.750
1966	4	4	41	([4])	9	.211
1967	4	5	7	1	27	[3] .478
1968	--	--	------	--	------	------
1969	4	--	3	([4])	3	1.245
Nonfloating washing plants:						
1965	48	64	[1] 501	[2] 11	391	.779
1966	41	59	[1] 548	[2] 13	456	.834
1967	41	57	[1] 797	[2] 13	472	[3] .449
1968	26	37	[1] 384	[2] 8	325	[3] .498
1969	30	42	[1] 347	[2] 9	365	[3] .727
Underground placer, small-scale mechanical and hand methods, and suction dredge:						
1965	70	48	68	4	140	2.059
1966	57	23	26	2	56	2.159
1967	53	19	63	2	59	.925
1968	50	22	[1] 241	[2] 8	296	[3] 1.227
1969	26	4	112	3	123	1.100
Total placers:						
1965	143	140	[1] 14,890	[2] 100	3,480	.234
1966	120	106	[1] 14,226	[2] 92	3,222	.227
1967	112	95	[1] 6,370	[2] 65	2,269	[3] .332
1968	83	66	[1] 4,476	[2] 37	1,457	[3] .292
1969	66	52	[1] 1,278	[2] 25	1,055	[3] .726

[1] Excludes tonnage of material treated at commercial sand and gravel operations recovering byproduct gold.
[2] Includes gold recovered at commercial sand and gravel operations recovering byproduct gold.
[3] Gold recovered as a byproduct at sand and gravel operations not used in calculating average value per cubic yard.
[4] Less than ½ unit.

Table 9.—U.S. gold consumption in industry and the arts [e]

(Thousand troy ounces)

Industry group	1965	1966	1967	1968	1969
Jewelry and arts	[r] 3,429	[5] 3,758	[r] 3,840	3,908	3,839
Dental	[r] 369	[r] 424	[r] 566	771	710
Industrial, including space and defense	[r] 1,478	[r] 1,880	[r] 1,888	1,925	2,560
Total	5,276	6,062	6,294	6,604	7,109

[e] Estimated by Office of Domestic Gold and Silver Operations. [r] Revised.

Table 10.—U.S. exports of gold in 1969, by countries

Destination	Ore, base bullion, and scrap: Troy ounces	Ore, base bullion, and scrap: Value (thousands)	Refined bullion: Troy ounces	Refined bullion: Value (thousands)
Belgium-Luxembourg	48,527	$2,023	2,895	$125
Canada	------	------	632	23
Colombia	------	------	147	6
Mexico	------	------	6,747	284
Sweden	2,300	88	-------	-----
United Kingdom	8,040	323	-------	-----
Uruguay	------	------	269,013	9,415
Total	58,867	2,434	279,434	9,853

Table 11.—U.S. imports of gold in 1969, by countries

Country	Ore and base bullion: Troy ounces	Ore and base bullion: Value (thousands)	Refined bullion: Troy ounces	Refined bullion: Value (thousands)
Australia	24,340	$796	---------	-------
Austria	-------	-----	35	$1
Belgium-Luxembourg	5,242	215	70,840	2,592
Bolivia	179	8	34,456	1,323
Canada	66,945	2,567	3,157,233	131,102
Chile	8,858	310	---------	-------
Colombia	334	7	---------	-------
Ecuador	22	(1)	---------	-------
El Salvador	-------	-----	1,109	40
France	-------	-----	41,800	1,797
Germany, West	681	27	8,702	333
Honduras	5,640	177	1,691	69
Hong Kong	1,304	47	6,020	248
Italy	-------	-----	666	29
Japan	-------	-----	94,750	3,352
Mexico	4,013	169	---------	-------
Netherlands	-------	-----	207,758	8,398
Nicaragua	46,662	1,936	---------	-------
Norway	123	5	---------	-------
Panama	2,039	84	---------	-------
Peru	21,633	719	---------	-------
Philippines	47,110	1,937	412,158	14,459
Singapore	140	5	---------	-------
South Africa, Republic of	1,442	54	24,896	952
Sweden	31	1	3,601	152
Switzerland	-------	-----	1,215,473	49,267
U.S.S.R	-------	-----	25,062	1,090
United Kingdom	-------	-----	318,131	12,626
Venezuela	-------	-----	268	12
Total	236,738	9,064	5,624,649	227,842

[1] Less than ½ unit.

Table 12.—Value of gold imported into and exported from the United States

(Thousand dollars)

Year	Imports	Exports
1967	$32,547	$1,005,199
1968	226,263	839,159
1969	236,906	12,287

Table 13.—World production of gold by countries

(Troy ounces)

Country[1]	1967	1968	1969 p
North America:			
Canada	2,961,999	2,688,018	2,433,544
Costa Rica e	500	500	500
Haiti e	r 5,000	3,000	3,000
Honduras	5,924	6,150	6,223
Mexico	165,287	176,952	180,599
Nicaragua	177,702	193,008	120,011
United States[2]	1,584,187	1,478,292	1,733,176
South America:			
Bolivia	55,069	68,266	e 51,000
Brazil	r 185,735	176,628	176,938
Chile	58,135	57,743	59,102
Colombia	257,668	239,555	218,872
Ecuador	6,738	8,659	7,287
French Guiana	7,584	5,099	3,590
Guyana	2,379	4,088	2,102
Peru	82,006	105,118	127,722
Surinam	4,514	4,702	2,389
Venezuela	20,000	20,600	19,385
Europe:			
Finland	20,281	21,380	18,872
France	62,703	55,000	48,000
Germany, West	916	e 1,000	e 1,000
Portugal (mine output)	27,103	17,394	e 17,758
Sweden (mine output)	r 60,668	49,737	e 42,310
U.S.S.R. e [3]	5,700,000	5,900,000	6,250,000
Yugoslavia	68,064	70,314	76,068
Africa:			
Cameroon	991	465	177
Congo (Brazzaville)	r 5,048	4,790	5,000
Congo (Kinshasa)	153,520	169,975	175,804
Ethiopia	r 22,943	38,828	42,400
Gabon	29,250	16,724	14,243
Ghana	762,609	727,122	706,621
Kenya	33,366	31,974	17,903
Liberia [4]	5,111	3,216	1,136
Malagasy Republic	752	543	646
Nigeria	39	215	298
Rhodesia, Southern	519,877	499,943	e 480,000
South Africa, Republic of	30,534,695	31,168,831	31,275,882
Sudan	200	29	NA
Tanzania	r 18,523	17,473	16,016
Zambia e	5,000	5,000	5,000
Asia:			
Burma e	150	150	150
Cambodia e	4,000	4,000	4,000
China, mainland e	50,000	50,000	50,000
India	101,628	115,357	109,473
Indonesia	7,752	5,968	7,597
Japan [5]	252,993	238,511	252,705
Korea:			
North e	160,000	160,000	160,000
South [2]	63,337	62,405	50,734
Malaysia:			
Malaya	1,290	1,454	3,153
Sarawak	2,521	2,718	2,271
Philippines	490,557	527,355	571,145
Taiwan	35,563	20,994	21,486
Oceania:			
Australia	r 805,336	787,358	716,089
Fiji	111,028	106,784	91,572
New Zealand	10,703	8,626	10,717
Papua and New Guinea	27,671	26,144	25,857
Total [6]	r 45,736,615	46,154,155	46,417,523

e Estimate. p Preliminary. r Revised. NA Not available.

[1] Gold is also produced in Bulgaria, Czechoslovakia, Rumania, Spain, and small quantities probably in East Germany, Hungary, Thailand, and several other countries. Data for these are not available. Data are also lacking on clandestine activities.

[2] Mine production.

[3] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.

[4] Purchases by Bank of Monrovia.

[5] Refinery production for Japan was as follows: 1967—678,133 ounces; 1968—614,348 ounces; and 1969—677,480 ounces.

[6] Totals are of listed figures only.

Graphite

By Lewis K. Weaver [1]

Domestic production of manufactured graphite increased to 225,500 short [2] tons in 1969 from 208,200 tons in 1968 (revised from 213,300). Imports of natural graphite decreased from 67,800 tons to 58,500 tons, and the domestic output increased slightly.

Legislation and Government Programs.—Defense material inventories showed that the 1969 yearend stockpile of various natural graphites totaled 42,828 tons, compared with 43,653 tons at yearend 1968. The change was due to a decrease of 405 tons of Malagasy crystalline and 420 tons of other crystalline.

As of December 31, 1969, 14,331 tons of Malagasy crystalline flake was authorized for commercial disposal by negotiated offers over a period of years.[3] A bill (S. 3451) to authorize the disposal of approximately 386 tons of natural Ceylon amorphous lump graphite now held in the national stockpile has been introduced in the Senate. This quantity is the excess over the objective of Ceylon amorphous lump shown in table 2.

[1] Petroleum engineer. Bureau of Mines, Dallas, Tex.

[2] The quantites used throughout this chapter are short tons unless otherwise specified.

[3] Disposal plans approved by the affected Federal agencies and Government-industry consultation limit the quantities to be sold in a given period. GSA solicitations and invitations-for-bid should be consulted for actual quantities being offered for sale.

DOMESTIC PRODUCTION

For the eighth consecutive year the only domestic producer of natural graphite was the Southwestern Graphite Co., Burnet, Tex. Data on their output are company confidential; 1969 output was slightly more than in 1968.

Table 1.—Salient natural graphite statistics [1]

	1965	1966	1967	1968	1969
United States:					
Consumption [2] ______ short tons__	[3] 47,100	[3] 48,400	38,300	38,500	37,200
Value [2] ______ thousands__	[3] $6,390	[3] $6,629	$5,700	$5,904	$6,354
Exports ______ short tons__	3,200	3,200	3,600	4,200	5,700
Value ______ thousands__	$419	$428	$460	$509	$682
Imports for consumption ______ short tons__	58,100	56,700	56,700	67,900	58,500
Value ______ thousands__	$2,387	$2,545	$2,348	$2,495	$2,419
World: Production ______ short tons__	669,400	533,816	394,817	481,493	NA

NA Not available.
[1] All short tons rounded to nearest 100.
[2] Includes some artificial graphite.
[3] Includes some estimates.

Synthetic graphite production was 225,526 tons in 1969, an 8.3-percent increase over the revised 1968 tonnage (208,197 tons). Total value increased from $114.6 million in 1968 (revised from $117.7 million) to $138.2 million in 1969. Most synthetic graphite is manufactured from petroleum coke. The eight companies producing

Table 2.—Government yearend stocks of natural graphite

(Short tons)

Type of graphite	National stockpile	Supplemental stockpile	Total all stockpiles
Malagasy crystalline flake:			
Objective	10,800	-----	10,800
Excess: Stockpile grade	14,690	-----	14,690
Total	25,490	-----	25,490
Malagasy crystalline fines:			
Objective	5,230	1,909	7,139
Excess: Non-stockpile grade	-----	1	1
Total	5,230	1,910	7,140
Ceylon amorphous lump:			
Objective	[1] 4,296	1,204	5,500
Excess: Stockpile grade	162	224	386
Total	4,458	1,428	5,886
Other than Ceylon and Malagasy, crystalline:			
Objective	[2] 2,800	-----	2,800
Excess: Stockpile grade	1,512	-----	1,512
Total	4,312	-----	4,312

[1] Includes 56 short tons non-stockpile-grade material.
[2] Includes 867 short tons non-stockpile-grade material.

Source: Office of Emergency Preparedness. Summary of Raw Material Inventories on Hand as of Dec. 31, 1969. DM-77.

synthetic graphite and the plant locations are as follows:

Company	*Location*
Air Reduction Co., Inc.:	
Airco Speer Electrode and Anode	Niagara Falls, N.Y.
Airco Speer Carbon Products	St. Marys, Pa.
Becker Brothers Carbon Co	Cicero, Ill.
Chas. Pfizer & Co., Inc.:	
Space Age Material Corp	Woodside, N.Y.
Minerals, Pigments, & Metals	Easton, Pa.
The Carborundum Co	Hickman, Ky.
Do	Sanborn, N.Y.
Great Lakes Carbon Corp	Rosamond, Calif.
Do	Morganton, N.C.
Do	Niagara Falls, N.Y.
The Ohio Carbon Co	Cleveland, Ohio
Stackpole Carbon Co	St. Marys, Pa.
Union Carbide Corp	Columbia, Tenn.
Do	Niagara Falls, N.Y.

New producers of manufactured graphite in 1969 include two divisions of Chas. Pfizer & Co., Inc.: The Space Age Material Corp., Pyrogenics Division, and the Minerals, Pigment & Metals Division. Another division of Air Reduction Co., Inc., the Airco Speer Carbon Products, was added to the list. Deleted from the list was The Dow Chemical Co. plant, which was closed in 1969.

CONSUMPTION AND USES

Manufactured and natural graphite are being used to make many of the same products, including lubricants, steel, foundry facings, batteries, and brushes for electric motors. Manufactured graphite is an excellent electrode material because of its purity, chemical inertness, resistance to thermal shock, and high conductivity.

Caution is suggested in determining consumption patterns of natural graphite from the data in table 3. Only about 67 percent of the apparent consumption was reported in 1969 and 58 percent in 1968.

Table 3.—Consumption[1] of natural graphite in the United States in 1969, by uses

Use	Crystalline		Amorphous [2]		Total [3]	
	Short tons	Value	Short tons	Value	Short tons	Value
Batteries	W	W	W	W	W	W
Bearings	104	$51,307	(4)	(4)	104	$51,307
Brake linings	452	155,428	614	$213,570	1,066	368,998
Carbon brushes	67	38,485	521	247,384	588	285,869
Crucibles, retorts, stoppers, sleeves, and nozzles	4,639	780,793	(4)	(4)	4,639	780,793
Foundry facings	1,762	353,978	6,266	663,243	8,028	1,017,221
Lubricants	302	107,821	2,400	384,495	2,702	492,316
Packings	195	102,681	214	80,302	409	182,983
Paints and polishes	23	7,514	159	20,483	182	27,997
Pencils	1,492	528,414	698	137,681	2,190	666,095
Refractories	(5)	(5)	5,554	735,419	5,554	735,419
Rubber	(5)	(5)	225	73,054	225	73,054
Steelmaking	960	156,158	5,664	422,228	6,624	578,386
Other [6]	1,827	531,990	3,026	561,369	4,853	1,093,359
Total	11,823	2,814,569	25,341	3,539,228	37,164	6,353,797

W Withheld to avoid disclosing individual company confidential data; included in "Other."
[1] Consumption data incomplete. Excludes numerous small consuming firms.
[2] Includes mixtures of natural and manufactured graphite.
[3] Data may not add to totals shown because of independent rounding.
[4] Included with crystalline to avoid disclosing individual company confidential data.
[5] Included with amorphous to avoid disclosing individual company confidential data.
[6] Includes adhesives, chemical equipment and processes, electronic products, gray iron castings, powdered metal parts, small packages, specialties, and items indicated by symbol W.

PRICES

Quoted prices for natural graphite show the range of prices negotiated between buyer and seller for different specifications of several kinds of graphite.

The Oil, Paint and Drug Reporter reports on a different basis. All prices are ex warehouse; December 1969 quotations follow:

	Per pound
Nos. 1 and 2 flake graphite, 90 to 95 percent carbon	$0.29 to $0.32
Powdered crystalline graphite:	
88 to 90 percent carbon	.20 to .245
90 to 92 percent carbon	.225 to .255
95 to 96 percent carbon	.29 to .32
Powdered amorphous graphite	.065 to .12
Powdered amorphous graphite, minimum of 97 percent carbon	.305 to .33

Yearend prices, f.o.b. source quoted in the Engineering and Mining Journal, for two major classifications of graphite imported by the United States were as follows:

	Per short ton	
	1968	1969
Flake and crystalline graphite, bags:		
Ceylon	$74 to $214	$80 to $179
Germany, West	112 to 610	118 to 635
Malagasy Republic	86 to 204	82 to 281
Norway	90 to 155	68 to 109
Amorphous, nonflake, cryptocrystalline graphite (80 to 85 percent carbon):		
Mexico (bulk)	$19 to $22	$19 to $21
South Korea (bulk)	18	24
Hong Kong (bags)	23	24

FOREIGN TRADE

Exports of natural graphite increased about 36 percent over the 1968 level to an alltime high of 5,655 tons. Imports for consumption decreased about 14 percent to 58,479 tons, but stayed above the average for the past 5 years (57,320 tons). Although Ceylon increased the export duty on graphite, U.S. imports for consumption increased 1,295 tons.

Table 4.—U.S. exports of natural graphite, by countries

Destination	Amorphous, crystalline flake, lump, or chip, and natural n.e.c. [1]			
	1968		1969	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Argentina	3	$1	18	$2
Australia	69	8	42	4
Bolivia	---	---	11	1
Brazil	19	2	55	5
Canada	1,959	223	2,087	235
Chile	44	6	41	4
Colombia	45	7	38	6
Denmark	6	1	41	5
Dominican Republic	21	3	55	4
Finland	22	2	---	---
France	185	23	376	42
Germany, West	137	14	92	8
Ireland	30	3	5	1
Israel	---	---	20	1
Italy	111	12	95	13
Japan	246	30	408	54
Libya	---	---	35	6
Mexico	450	51	362	46
Netherlands	90	12	343	40
New Zealand	---	---	25	2
Panama	---	---	23	3
Peru	22	3	17	2
Philippines	74	10	168	17
Spain	---	---	10	2
Switzerland	9	1	9	1
Taiwan	---	---	38	4
United Kingdom	409	60	1,020	138
Venezuela	170	32	159	27
Other countries	48	5	62	9
Total	4,169	509	5,655	682

[1] Not elsewhere classified.

WORLD REVIEW

Italy.—A joint venture of Union Carbide and Insud Italiana started manufacturing graphite in June 1969 at a plant near Caserta, Italy. The initial plant investment was about $9.6 million and production will be about 12,125 tons annually.

Table 5.—U.S. imports for consumption of natural artificial graphite, by countries

Year and country	Natural						Artificial		Total	
	Crystalline flake		Crystalline lump, chip, or dust		Other natural, crude and refined					
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1967	4,763	$511	14	$4	51,585	$1,796	313	$37	56,675	$2,348
1968:										
Austria	---	---	---	---	28	2	---	---	28	2
Canada	---	---	---	---	57	4	[r](1)	[r](1)	57	4
Ceylon	---	---	---	---	2,222	261	---	---	2,222	261
Germany, West	829	170	161	50	1,516	194	---	---	2,506	414
Hong Kong	---	---	---	---	225	5	---	---	225	5
Italy	---	---	30	10	33	4	7	2	70	16
Korea, South	---	---	---	---	460	12	---	---	460	12
Malagasy Republic	[r,2]3,924	[r,2]413	25	2	104	16	---	---	[r]4,053	[r]431
Mexico	---	---	---	---	55,160	1,035	---	---	55,160	1,035
Mozambique	5	4	---	---	---	---	---	---	5	4
Netherlands	2	4	---	---	---	---	---	---	2	4
Norway	---	---	---	---	2,999	269	---	---	2,999	269
South Africa, Republic of	---	---	30	2	---	---	---	---	30	2
Switzerland	---	---	---	---	---	---	10	4	10	4
United Kingdom	---	---	---	---	---	---	95	31	95	31
Total	4,760	591	246	64	62,804	1,802	112	37	67,922	2,494
1969:										
Austria	---	---	---	---	20	2	---	---	20	2
Ceylon	---	---	102	9	3,415	393	---	---	3,517	402
France	2	1	---	---	14	8	---	---	16	9
Germany West	317	59	92	30	1,114	148	12	9	1,535	246
Hong Kong	---	---	---	---	337	8	---	---	337	8
Italy	---	---	16	6	---	---	2	2	18	8
Korea, South	22	2	---	---	596	15	---	---	618	17
Malagasy Republic	4,531	457	---	---	511	50	---	---	5,042	507
Mexico	---	---	---	---	43,269	876	---	---	43,269	876
Norway	---	---	---	---	4,037	334	---	---	4,037	334
Sweden	---	---	---	---	44	4	---	---	44	4
Switzerland	---	---	---	---	---	---	6	2	6	2
United Kingdom	20	4	---	---	---	---	(1)	(1)	20	4
Total	4,892	523	210	45	53,357	1,838	20	13	58,479	2,419

[r] Revised.
[1] Less than ½ unit.
[2] Includes 28 short tons ($2,277) reported from Turkey, believed to be Malagasy Republic, by the Bureau of Mines.

Table 6.—World production of natural graphite by countries

(Short tons)

Country [1]	1967	1968	1969p
North America:			
Mexico	44,853	58,085	NA
United States	W	W	W
South America:			
Argentina	236	121	NA
Brazil	3,192	2,491	NA
Europe:			
Austria	34,768	28,074	e 28,660
Germany, West	13,066	e 13,228	e 13,228
Italy	2,069	1,556	e 1,543
Norway	r 8,331	9,017	e 8,818
U.S.S.R. e	71,650	77,162	77,162
Africa:			
Malagasy Republic	16,414	18,111	NA
South Africa, Republic of	740	797	441
Asia:			
Ceylon (exports)	11,428	11,907	12,586
China, mainland e	33,069	33,069	33,069
Hong Kong	21	558	219
Japan	1,890	1,641	1,903
Korea:			
North e	82,673	82,673	82,673
South	r 70,417	143,003	e 81,461
Total [2]	r 394,817	481,493	341,763

e Estimate. p Preliminary. r Revised. NA Not available. W Withheld to avoid disclosing individual company confidential data.

[1] Graphite is produced in Czechoslovakia, India, Southern Rhodesia, and Southwest Africa, but production data are not available.

[2] Total is of listed figures only.

Table 7.—Malagasy Republic: Exports of graphite, by countries

(Short tons)

Destination	1967	1968
Australia	55	191
Canada	56	86
France	4,321	2,063
Germany, West	1,784	2,625
India	207	91
Italy	944	752
Japan	2,230	2,272
Netherlands	104	66
Poland	243	165
Spain	255	215
United Kingdom	2,818	4,629
United States	4,817	4,286
Other countries	22	70
Total	17,856	17,511

TECHNOLOGY

Research and development of graphite composites was continued bv several companies that were testing fiber composites for use as aircraft and aerospace structural components.[4] These components would effect substantial weight savings, especially valuable for aircraft and aerospace uses. One application now being tested on an aircraft is 27 percent lighter than the usual aluminum section.

A new method for treating graphite raises its threshold of oxidation from 750° F to 1,000° F.[5] Graphite semipermanent molds made from treated material should last longer, and field tests of fluxing tubes made of the treated material last from 2.5 to 6 times longer than untreated tubes.

NASA research has produced a new solid lubricant, graphite fluoride, which is effective in both moist and dry air and in dry argon up to about 400° C.[6]

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[4] Vaccani, John A. Graphite Composites Take Aim at the Sky. Materials Eng., v. 69, No. 2, February 1969, pp. 36–38.

[5] Steel. Treatment Ups Graphite Durability. V. 164, No. 5, Feb. 3, 1969, p. 21.

[6] Iron Age. Graphite Fluoride: A Solid Lubricant. V. 204, No. 24, Dec. 11, 1969, p. 26.

Gypsum

By Roy Y. Ashizawa [1]

Despite a scarcity of mortgage money and increased interest rates which discouraged residential building, greater demand for drywall plaster components in construction of hotels, office buildings, and high-rise apartment structures resulted in a record output of 9.1 billion square feet of gypsum wallboard in 1969. Increased imports of crude gypsum countered the slightly lower production of gypsum at domestic mines and provided a supply of crude exceeding that of 1968. Sales of uncalcined gypsum for use as a retarder in portland cement reached an alltime high. Production of calcined gypsum was the highest in 5 years. The unit values of crude and calcined gypsum increased significantly in consonance with rising labor and transportation costs.

Table 1.–Salient gypsum statistics

(Thousand short tons and thousand dollars)

	1965	1966	1967	1968	1969
United States:					
Active mines and plants [1]	113	121	113	r 115	113
Crude: [2]					
Mined	10,033	9,647	9,393	10,018	9,881
Value	$37,375	$35,681	$34,383	$36,775	$38,315
Imports for consumption	5,911	5,479	r 4,563	r 5,474	5,858
Calcined:					
Produced	9,320	8,434	7,879	8,844	9,324
Value	$133,028	$119,747	$115,467	$133,239	$143,466
Products sold (value)	$419,620	$376,871	$362,268	$404,739	$414,880
Exports (value)	$2,032	$2,674	$2,918	$3,556	$3,446
Imports for consumption (value)	$13,328	$17,281	$11,353	$13,058	$14,522
World: Production	52,894	53,676	50,879	53,443	55,194

r Revised.

[1] Each mine, calcining plant, or combination mine and plant is counted as 1 establishment.

[2] Excludes byproduct gypsum.

DOMESTIC PRODUCTION

Nearly 9.9 million tons of crude gypsum was produced in 21 States at 74 mines, of which 60 were open pit, 13 were underground, and one was a combination open pit and underground mine. The leading gypsum-producing States were Michigan, Texas, California, and Iowa.

Domestic and imported gypsum was calcined at 77 plants in 30 States. The plants utilized 235 kettles and 77 other pieces of calcining equipment to produce over 9.3 million tons of calcined gypsum. Compared with 1968, the volume of calcined gypsum produced increased 4 percent in the Eastern States, 6 percent in the Central States, 2 percent in the Mountain States, and 13 percent in the Pacific States. A record total of 10.3 billion square feet of gypsum board products with a value of $355.4 million was fabricated on 85 board machines.

Georgia-Pacific Corp., the third largest manufacturer of gypsum products, added a new plant in Westchester County, N.Y., bringing the company's gypsum production facilities to 10, with a total capacity to produce over 1.8 billion square feet of gypsum board per year. Georgia-Pacific entered the Pacific Northwest with acquisi-

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tion of a plant near Lovell, Wyo. Dierks Forest, Inc., Briar, Ark., doubled its gypsum wallboard production capacity. Republic Gypsum Co. reported that its subsidiary, La Porte Minerals Corp., had outlined reserves of 20 million tons of recoverable gypsum on a 4,000-acre lease in La Porte County, Ind. Texas Gypsum Co. planned to construct a $5 million gypsum wallboard plant in West Memphis, Tenn., which would be larger than the company's existing plant at Irving, Tex. The company also had a large gypsum deposit in Owen County, Ind.

Table 2.—Crude gypsum mined in the United States, by States

(Thousand short tons and thousand dollars)

State	1968			1969		
	Active mines	Quantity	Value	Active mines	Quantity	Value
Arizona	4	W	W	4	83	$424
California	9	1,360	$3,603	9	1,210	3,339
Colorado	6	98	354	5	94	339
Idaho	1	3	13	--	-----	-----
Iowa	5	1,351	5,838	5	1,169	5,274
Michigan	5	1,405	5,196	5	1,327	5,384
Nevada	3	552	1,534	3	521	1,550
New Mexico	5	146	549	5	141	526
New York	5	570	2,925	4	492	2,945
Oklahoma	8	931	2,565	7	956	3,873
South Dakota	1	16	65	1	11	46
Texas	7	1,039	3,616	8	1,314	4,398
Other States [1]	17	2,547	10,517	18	2,563	10,217
Total	76	10,018	36,775	74	9,881	38,315

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes the following States to avoid disclosing individual company confidential data: Louisiana, Montana, Virginia, and Washington, 1 mine each; Arkansas, Indiana, Kansas, Ohio, and Utah, 2 mines each; and Wyoming, 3 mines (1968), 4 mines (1969).

Table 3.—Calcined gypsum produced in the United States, by States

(Thousand short tons and thousand dollars)

State	1968					1969				
	Active plants	Quantity	Value	Calcining equipment		Active plants	Quantity	Value	Calcining equipment	
				Kettles	Other [1]				Kettles	Other [1]
California	7	742	$10,675	17	9	7	874	$10,922	16	11
Florida	3	433	W	9	2	3	W	W	9	2
Georgia	3	519	9,910	15	--	3	551	10,577	15	--
Iowa	5	848	13,100	22	4	5	823	12,837	22	4
Michigan	4	369	6,396	10	1	4	373	6,840	10	1
Nevada	3	303	3,251	11	7	3	325	3,506	12	6
New Jersey	4	356	4,308	9	3	4	383	5,022	9	3
New York	7	907	13,803	26	3	8	921	13,891	25	6
Ohio	3	359	5,158	9	1	3	356	5,506	9	1
Texas	7	826	12,081	28	3	7	961	15,102	28	3
Other States [2]	30	3,182	54,557	75	39	30	3,757	59,263	80	40
Total	76	8,844	133,239	231	72	77	9,324	143,466	235	77

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes rotary and beehive kilns, grinding-calcining units, Holo-Flites, and Hydrocal cylinders.
[2] Comprises States and number of plants as follows: Arizona, Arkansas, Colorado, Connecticut, Delaware, Illinois, Massachusetts, Montana, New Hampshire, Pennsylvania, and Washington, 1 plant each; Kansas, Louisiana, Maryland, New Mexico, Oklahoma, Utah, Virginia, and Wyoming, 2 plants each; and Indiana, 3 plants.

CONSUMPTION AND USES

The domestic supply of newly mined crude gypsum totaled 15.7 million tons, 9.9 million tons from domestic mines and 5.8 million tons imported primarily from U.S.-company-affiliated mines in Canada, Mexico, and Jamaica. Nearly 4.7 million tons of the crude was sold uncalcined, of which 3.5 million tons was for use as portland cement retarder, 1.1 million tons for agricultural use, and the remainder for filler and other uses. The decrease in sales of agricultural gypsum to 1.1 million tons from 1.4 million tons in 1968 was attributed to lower use by California potato and cotton growers, among the principal consumers of agricultural gypsum in the United States.

Consumption of calcined gypsum for prefabricated building products was about 600,000 tons more than in 1968, with virtually all of the gain realized from the manufacture of drywall components used in hotel, office building, and apartment construction. Total output of wallboard, alone, was a record 9.1 billion square feet. Sales of building plasters and lath declined. Output of industrial plasters gained appreciably, with pottery and filler uses accounting for much of the increase. Demands for molding and plate glass plasters were lower than in 1968.

Table 4.—Gypsum products (made from domestic, imported and byproduct gypsum) sold or used in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1968		1969	
	Quantity	Value	Quantity	Value
Uncalcined:				
Portland-cement retarder	3,439	$16,037	3,464	$15,850
Agricultural gypsum	1,388	6,222	1,100	5,333
Other uses [1]	108	886	117	865
Total	4,935	23,145	4,681	22,048
Calcined:				
Industrial:				
Plate glass and terra cotta plasters	30	464	21	350
Pottery plasters	54	1,400	61	1,631
Dental and orthopedic plasters	15	624	15	661
Industrial molding, art, and casting plasters	119	3,078	115	2,761
Other industrial uses [2]	83	3,348	104	3,366
Total	301	8,914	316	8,769
Building:				
Plasters:				
Basecoat	536	10,522	473	9,745
Veneer plaster (basecoat and finishes)	46	2,315	51	2,767
Mill-mixed basecoats (sanded and perlited)	301	7,977	253	7,138
To mixing plants	W	W	W	W
Gaging and molding	76	1,974	74	1,986
Prepared finishes	8	694	8	632
Roof deck	319	5,432	290	5,234
Keene's cement	17	517	17	586
Other [3]	11	576	10	547
Total	1,314	30,007	1,176	28,635
Prefabricated products [4]	[5] 8,776	342,673	[5] 9,369	355,428
Total	-----	372,680	-----	384,063
Grand total, value	-----	404,739	-----	414,880

W Withheld to avoid disclosing individual company confidential data; included with "Other."

[1] Includes uncalcined gypsum for use in filler and rock dust, in brewer's fixe, in color manufacture, and for unspecified uses.

[2] Includes dead-burned filler, granite polishing, and miscellaneous uses.

[3] Includes joint filler, patching, painter's, insulating, and unclassified building plasters; and quantity and value indicated by symbol W.

[4] Excludes tile.

[5] Includes weight of paper, metal, or other materials.

Table 5.—Prefabricated products sold or used in the United States, by products

Product	1968 Thousand square feet	1968 Thousand short tons [1]	1968 Value (thousands)	1969 Thousand square feet	1969 Thousand short tons [1]	1969 Value (thousands)
Lath:						
3/8 inch	827,223	607	$21,698	685,672	496	$17,886
1/2 inch	162,399	158	6,010	217,695	208	7,807
Other [2]	9,283	11	433	13,728	17	606
Total	998,905	776	28,141	917,095	721	26,299
Wallboard:						
1/4 inch	108,605	62	2,574	110,242	62	2,746
3/8 inch	1,430,485	1,056	47,351	1,310,027	940	41,477
1/2 inch	5,880,978	5,588	212,995	6,369,691	5,839	215,067
5/8 inch	854,679	1,005	41,997	1,244,750	1,451	57,833
1 inch [3]	7,759	16	688	55,299	79	2,194
Total	8,282,506	7,727	305,605	9,090,009	8,371	319,317
Sheathing	221,569	222	6,754	228,917	227	7,495
Laminated board	[4] 6,608	8	402	[4] 9,256	12	687
Formboard	41,131	43	1,771	37,106	38	1,630
Grand total [5]	9,550,719	8,776	342,673	10,282,383	9,369	355,428

[1] Includes weight of paper, metal, or other materials.
[2] Includes a small amount of 1/4-inch, 5/8-inch, and 1-inch lath.
[3] Includes a small amount of 5/16-inch, 3/4-inch, 1 5/8-inch, and 3 3/4-inch wallboard.
[4] Area of component board and not of finished products.
[5] Excludes tile, for which figures are withheld to avoid disclosing individual company confidential data.

PRICES

Rising costs of labor, transportation, and raw materials were reflected in the price increases for gypsum products in 20 U.S. cities published monthly in Engineering News-Record. Neat plaster averaged $34.51 per ton in January and rose to $37.83 by December; gaging plaster averaged $40.47 per ton in January and $42.92 by yearend. During the same period the quotations for 3/8-inch gypsum board, increased from an average of $53.98 to $54.93 per thousand square feet; for 1/2-inch board, from $62.09 to $63.49; and for 3/8-inch gypsum lath from $44.71 to $46.05. The marketing of these and other gypsum products was highly competitive, and during the latter part of 1969 they reportedly were being sold at substantial discounts from posted prices in most cities.

FOREIGN TRADE

Exports of gypsum and gypsum products were valued at $3.4 million and consisted of 40,000 tons of crude, crushed, or calcined material valued at $2 million and manufactured gypsum products valued at $1.4 million.

Table 6.—U.S. exports of gypsum and gypsum products
(Thousand short tons and thousand dollars)

Year	Crude, crushed, or calcined: Quantity	Crude, crushed, or calcined: Value	Other manufactures n.e.c., value	Total value
1967	39	$1,707	$1,211	$2,918
1968	39	1,688	1,868	3,556
1969	40	2,003	1,443	3,446

Imports of crude gypsum from foreign U.S.-company-affiliated mines increased from 5.5 million tons in 1968 to 5.8 million tons. Receipts of crude gypsum from Canada through east coast and Pacific Northwest customs districts comprised 81 percent of the total imports; from Mexico through the California, Washington, and Texas districts, 13 percent; from Jamaica through the Florida, Louisiana, and Texas districts, 5 percent; and from the Dominican Republic, Australia, and Italy through the Puerto Rico, Florida, and New York districts, respectively, 1 percent.

Table 7.—U.S. imports for consumption of gypsum and gypsum products

(Thousand short tons and thousand dollars)

Year	Crude (including anhydrite)		Ground or calcined		Alabaster manufactures,[1] value	Other manufactures n.e.c., value	Total value
	Quantity	Value	Quantity	Value			
1967	4,563	$9,723	2	$86	$855	$689	$11,353
1968	5,474	11,384	2	89	932	653	13,058
1969	5,858	12,394	2	87	1,242	799	14,522

[1] Includes imports of jet manufactures, which are believed to be negligible.

Table 8.—U.S. imports for consumption of crude gypsum (including anhydrite), by countries

(Thousand short tons and thousand dollars)

Country	1968		1969	
	Quantity	Value	Quantity	Value
Canada	4,254	$8,976	4,722	$10,277
Dominican Republic	90	290	43	136
Italy	(1)	4	(1)	2
Jamaica	226	734	304	830
Mexico	904	1,380	789	1,144
Other countries	---	---	(1)	5
Total	5,474	11,384	5,858	12,394

[1] Less than ½ unit.

WORLD REVIEW

Australia.—Australia lacks native sulfur deposits, but has extensive gypsum deposits. Delhi Australian Petroleum, Ltd., was considering the possibility of extracting elemental sulfur from gypsum occurring in the Lake Torrens area of South Australia.[2]

Canada.—About 70 percent of Canada's total output of gypsum was mined in Nova Scotia, and almost all of this was shipped to the United States. Gypsum also was mined in Newfoundland, New Brunswick, Ontario, Manitoba, and British Columbia for use at 14 wallboard and plaster plants and one plaster plant established across Canada. A gypsum deposit averaging 30 feet in thickness was found to underlie the Clearwater River Valley for a strike distance of 18 miles at depths from near-surface to 300 feet.[3] Strong Wall Gypsum Industries, Ltd., planned completion of a plant with a capacity of 50 million square feet of gypsum wallboard a year at Redwater, Alberta, in early 1970. Canadian Gypsum Co., Ltd., planned to construct a gypsum wallboard plant at St. Jerome, Quebec, scheduled for completion by 1971.

Mexico.—Companía Industrial Kaiser S.A., an affiliate of Kaiser Gypsum Co., began to produce gypsum wallboard in April 1969 at its new plant in the City of Puebla. Gypsum was brought by rail to the plant from a mine at Matamoros de Azucar, about 40 miles away.[4]

South Africa, Republic of.—The possibility of recovering sulfur from gypsum obtained as a byproduct of phosphoric acid manufacture was being investigated by the firm of Bosveld Kunsmis of South Africa.[5]

[2] Industrial Minerals (London). Gypsum as Sulphur Source. No. 22, July 1969, p. 23.

[3] Hamilton, W. N. Subsurface Gypsum Deposits Near Fort McMurray, Alberta. Canadian Min., and Met. Bull., v. 62, No. 691, November 1969, pp. 1193–1202.

[4] Pit and Quarry. Mexico's 1st Gypsum Board Plant Serves Area East of Mexico City. v. 62, No. 4, October 1969, pp. 108–111.

[5] Chemical Age. South African Studies on Sulphur Recovery From Gypsum Show Promise. V. 99, No. 2608, July 11, 1969, p. 9.

Table 9.—World production of gypsum, by countries

(Short tons)

Country [1]	1967	1968	1969 p
North America:			
Canada [2]	5,175,380	5,926,935	6,871,965
United States	9,392,784	10,017,793	9,881,107
Central America:			
Dominican Republic	130,855	e 110,231	e 110,231
Guatemala	12,566	8,488	e 8,818
Honduras	15,347	7,188	8,443
Jamaica	184,086	230,000	e 220,462
Mexico	1,076,297	1,361,620	1,343,818
Nicaragua [2]	11,023	15,432	33,069
Trinidad and Tobago	4,020	4,760	e 4,409
South America:			
Argentina	291,730	408,991	NA
Brazil	78,760	238,979	NA
Chile	r 146,108	113,607	NA
Colombia	r e 128,970	133,380	166,449
Paraguay	1,984	2,535	3,858
Peru	71,650	NA	NA
Venezuela e	100,310	109,129	90,389
Europe:			
Austria [2]	813,555	r 769,648	e 771,617
Bulgaria	r 169,756	r 211,644	e 220,462
Czechoslovakia	408,957	448,640	e 457,459
France [2]	r 5,811,635	e 5,621,781	e 5,621,781
Germany:			
East [3]	r 252,429	249,122	e 249,122
West (marketable)	r 1,409,163	1,629,077	e 1,653,465
Greece	231,485	242,508	259,043
Ireland	r 277,782	288,805	e 286,601
Italy e	3,637,623	3,637,623	3,637,623
Luxembourg	12,125	e 11,023	e 11,023
Poland	r 832,244	r 870,825	e 892,871
Portugal	114,896	117,171	e 115,743
Spain e	r 3,968,316	4,299,009	e 4,409,240
U.S.S.R.	5,170,936	5,177,550	e 5,180,857
United Kingdom [2]	5,062,910	5,278,963	e 5,291,088
Yugoslavia	188,412	r 216,747	e 220,462
Africa:			
Ethiopia	6,727	396	5,722
Kenya [2]	44,584	45,293	e 46,297
Libya [4]	e 11,023	15,873	e 16,535
Morocco e	99,208	------	------
Niger	1,750	2,157	NA
South Africa, Republic of	339,062	348,385	396,192
Sudan [2]	r 4,114	11,272	NA
Tanzania	r 17,063	4,917	12,161
United Arab Republic	601	448	NA
Asia:			
Burma	e 2,205	3,968	3,857
China (Mainland) e	551,155	551,155	606,271
Cyprus	50,376	22,399	17,953
India	r 1,133,175	1,456,152	1,587,326
Iran e [4]	r 1,204,825	1,082,468	2,204,620
Israel e [5]	99,208	77,162	88,185
Japan	644,004	619,690	617,251
Lebanon	33,069	44,092	44,092
Mongolia e	27,558	27,558	27,558
Pakistan	112,832	50,706	149,914
Philippines	r 22,358	22,764	40,800
Saudi Arabia	30,591	44,425	e 38,581
Syrian Arab Republic e	16,535	16,535	16,535
Taiwan	18,141	6,214	5,647
Thailand	68,008	141,199	101,449
Turkey e	242,508	242,509	242,508
Oceania: Australia	r 914,083	845,845	903,894
Total [6]	r 50,878,857	r 53,442,786	55,194,823

e Estimate. p Preliminary. r Revised. NA Not available.

[1] Gypsum is also produced in Rumania, Switzerland, and Cuba, but production data are not available. Production in Bolivia and Ecuador is negligible.

[2] Includes anhydrite.

[3] Crude production estimates based on calcined figures.

[4] Year ended March 20 of year following that stated.

[5] Year ended March 31 of year following that stated.

[6] Total is of listed figures only.

TECHNOLOGY

Interest in the United States in recovering sulfur values from crude and byproduct gypsum and anhydrite remained high. Results of studies conducted at two Bureau of Mines research laboratories were being assembled for publication. The Salt Lake City (Utah) Metallurgy Research Center was investigating alternative processes for sulfur recovery from gypsum. A reducing roast was used to convert gypsum to calcium sulfide, and the calcium sulfide was converted to hydrogen sulfide by reacting it with carbon dioxide in a water slurry. The hydrogen sulfide was then converted to elemental sulfur. The College Park (Md.) Metallurgy Research Center developed techniques and defined parameters for microbial conversion of hydrous calcium sulfate to hydrogen sulfide, employing two strains of sulfate-reducing bacteria.

Numerous publications continued to carry articles describing the processes for recovery of sulfur from gypsum materials and of simultaneous production of portland cement.[6]

The interest in obtaining sulfur and portland cement from gypsum prompted publication of abstracts of basic patents dating back to 1886.[7]

Full-scale plant operations for recovery of sulfur from gypsum ore were initiated by two companies. Agricultural Chemical Div., Reserve Oil and Gas Co., added a unit to its ammonia fertilizer facility at Hanford, Calif., to react gypsum with ammonia and carbon dioxide to produce ammonium sulfate and a calcium carbonate residue. Elcor Chemical Corp. began test runs in a plant at its gypsum deposit 42 miles northeast of Van Horn, Tex., to recover elemental sulfur from gypsum at a reported rate of 1,000 tons per day.

The gypsum building products industry concentrated its research efforts on developing new fire-resistant and sound-control assemblies and on updating design data.[8] A fire-block gypsum board was designed for use between the roofing and the rafters in frame construction to eliminate fire penetration problems.[9] Systems were refined for better control of sound transmission between partition walls in apartment houses, motels, hotels, and high-rise buildings.[10]

In the production of plaster-faced gypsum board, one side of the board was covered with a mixture of unset gypsum plaster, bentonite, and an aggregate. When the board was positioned on the wall, the plaster face was wetted, troweled, and allowed to set.[11] Colemanite or other boron oxide material was incorporated in core mix to improve neutron shielding properties in gypsum board.[12] Calcined gypsum, unexpanded vermiculite, boric acid, and chopped glass fibers were combined as a core composition for fire-resistant gypsum board.[13]

In the production of lightweight gypsum block and panels which required no drying, a slurry of the plaster was treated with sulfuric acid and calcium carbonate to generate gas in situ and foam the slurry.[14] Glass fibers were dispersed through the edge portions of gypsum board for rigidity.[15] Prussian blue was included in the gypsum core composition to prevent sagging of gypsum board upon exposure to moisture.[16]

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[6] Briber, Frank E., Jr. Industrial Minerals Processing—A Look at the Future. Min. Eng., v. 21, No. 6, June 1969, pp. 76–78.
Canadian Mining and Metallurgical Bulletin. Recovery of Sulphur Values From Gypsum and Anhydrite. V. 62, No. 689, September 1969, pp. 967–971.
Chemical Engineering. Turning Byproduct Gypsum into a Valuable Asset. V. 76, No. 6, Mar. 24, 1969, pp. 106–108.
Engineering and Mining Journal. Sulphuric Acid and Cement from By-Product Gypsum Process Catching On. V. 170, No. 1, January 1969, p. 88.
Pit and Quarry. Sulfuric Acid and Portland Cement From Anhydrite. V. 61, No. 10, April 1969, pp. 130–133, 140.

[7] North, Oliver S. Processes for Making Portland Cement From Gypsum. . .a Review of the Patents. Min. Proc., March 1969, pp. 12–14, 28–29.

[8] Gypsum Association (Chicago). Design Data. September 1969, pp. 1–77.

[9] Gypsum Drywall Industry Newsmagazine. Gypsum Fire Block. V. 12, No. 4, August–September 1969, pp. 6–7.

[10] Southern Building. Better Sound Control. Publication of Southern Bldg. Code Cong. April 1969, pp. 1–11.

[11] Murray, M. G. Plasterboard With a Remoistenable Plaster Facing. U.S. Pat. 3,422,587, Jan. 21, 1969.

[12] Darling, A. H., and H. L. Weightman (assigned to Kaiser Gypsum Co., Oakland, Calif.). Process for Making Structural Gypsum Board for Neutron Shielding. U.S. Pat. 3,453,160, July 1, 1969.

[13] Wiley, G. S. (assigned to U.S. Gypsum Co., Chicago, Ill.). Fire Resistant Plaster Product. U.S. Pat. 3,454,456, July 8, 1969.

[14] Foster, E. G., and M. S. Bloom (assigned to Imperial Chemical Industries, Ltd., London). Process for the Production of Foamed Gypsum Castings. U.S. Pat. 3,454,688, July 8, 1969.

[15] Littin, R. J. (assigned to Owens-Corning Fiberglas Corp.). Gypsum Wallboard. U.S. Pat. 3,462,341, Aug. 19, 1969.

[16] Janninck, D. R. (assigned to U.S. Gypsum Co., Chicago, Ill.). Sag-Resistant Gypsum Board and Method Therefor. U.S. Pat. 3,486,965, Dec. 30, 1969.

Helium

By Edwin M. Thomasson [1]

Sales of grade A helium in the United States in 1969 were 759.5 million cubic feet, a decline of about 106.6 million cubic feet from 1968 sales. Of the total, 360.7 million cubic feet was sold by the Bureau of Mines compared with 478.4 million cubic feet in 1968. Private plants had a total sales volume of 398.8 million cubic feet in 1969, compared with 388.7 million cubic feet in 1968. Helium purchases by the Bureau of Mines under the conservation program were 3,645.3 million cubic feet in 1969.

The price of helium, f.o.b. Bureau of Mines' plants, remained at $35 per thousand cubic feet, a price established in 1961. Helium was sold by private producers at various rates somewhat lower than the Bureau of Mines' price.

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PRODUCTION

On January 1, 1969, there were 16 helium extraction plants operating in the United States. By December 31, 1969, only 12 of these plants remained in operation. Table 1 shows the plants operating at the beginning of the year and their status at yearend. These plants may be classified in three categories: (1) Plants owned by the Federal Government and operated by the Bureau of Mines; (2) "conservation" plants, privately owned and operated, producing only crude helium (50- to 85-percent purity), almost all of which is purchased by the Bureau of Mines under the national helium conservation program; and (3) privately owned and operated plants producing helium for independent sale to commercial (non-Federal) customers.

Table 1.—Ownership and location of helium extraction plants in the United States

Owner or operator and category [1]	Location	Type of production	Status Dec. 31, 1969
Bureau of Mines (1)	Amarillo, Tex.	Grade A helium	Operating.
Do. (1)	Exell, Tex.	do	Do.
Do. (1)	Keyes, Okla.	do	Do.
Cities Service Helex, Inc. (2)	Ulysses, Kans.	Crude helium only	Do.
National Helium Corp. (2)	Liberal, Kans.	do	Do.
Northern Helex Co. (2)	Bushton, Kans.	do	Do.
Phillips Petroleum Co. (2)	Dumas, Tex.	do	Do.
Do. (2)	Hansford Co., Tex.	do	Do.
Kerr-McGee Corp. (3)	Navajo, Ariz.	Grade A helium [2]	Do.
Arizona Helium Corp. (3)	do	do	Not operating.
Air Reduction Corp. (3)	Teec Nos Pos, Ariz.	Crude helium	Abandoned.
Alamo Chemical Co. (3)	Elkhart, Kans.	Grade A helium [2]	Operating.
Kansas Refined Helium Co. (3)	Otis, Kans.	do	Do.
Cities Service Cryogenics, Inc. (3)	Scott City, Kans.	Crude helium [3]	Do.
Air Reduction Corp. (3) [4]	Shiprock, N. Mex.	Grade A helium	Abandoned.
Linde Co. (3)	Amarillo, Tex.	Grade A helium [2 5]	Not operated during year.

[1] See text for description of plant category.
[2] Plant equipped to produce liquid helium.
[3] Crude helium is shipped by pipeline to Cities Service Helex plant for purification.
[4] Former Bureau of Mines plant, now owned by Navajo Tribe of Indians and operated under lease.
[5] Purification and liquefaction facilities only. Plant cannot extract helium from natural gas.

Table 2.—Helium production in the United States

(Million cubic feet)

Year	Quantity
1966	4,606.1
1967	4,712.3
1968	4,854.8
1969	4,752.4

Total production of helium (of all grades) from all plants during 1969 was 4,752.4 million cubic feet. This is a decrease of 2.2 percent from the 1968 production of 4,854.8 million cubic feet.

Bureau of Mines Plants.—The three Bureau of Mines plants, at Amarillo and Exell, Tex., and Keyes, Okla., operated normally throughout the year. Production from the three plants was 666.9 million cubic feet of grade A (purity 99.995+ percent) helium or about 1.6 percent less than the 677.7 million cubic feet produced by Bureau plants in 1968. Helium produced by the Bureau of Mines and not sold was stored in the Cliffside gasfield near Amarillo, Texas. The Bureau of Mines plants at Exell, Tex., and Keyes, Okla., processed essentially all helium-bearing natural gas tendered by the natural-gas pipeline company serving the plants.

Table 3.—Production of grade A helium by Bureau of Mines plants

(Million cubic feet)

Plant location	Quantity	
	1968	1969
Amarillo, Tex.	62.0	57.1
Exell, Tex.	270.2	256.4
Keyes, Okla.	308.6	353.4
Shiprock, N. Mex. [1]	36.9	-----
Total	677.7	666.9

[1] Ownership of plant transferred to Navajo Tribe of Indians, July, 1968.

Extensive modernization of the Exell plant and the installation of additional processing facilities was commenced during the year. Completion of this work is expected about mid-1970.

Conservation Plants.—Five privately owned and operated helium extraction plants produced helium for sale to the Bureau of Mines under long-term contract for the Government's helium conservation program. These plants produced only crude helium, principally for storage at Cliffside Field, but two of the plants sold small quantities of crude helium produced in excess of conservation contract requirements to private helium plants for purification. Some of this excess helium was stored at Cliffside Field under contract with the private producers. During 1969, the five conservation plants produced a total of 3,837.0 million cubic feet of helium. The Bureau of Mines purchased 3,645.3 million cubic feet of this total, compared with 3,639.8 million cubic feet purchased in 1968.

Table 4.—Helium purchased by the Bureau of Mines for conservation

(Million cubic feet)

Company and location of plant	Helium delivered				
	1965	1966	1967	1968	1969
Northern Helex Co., Bushton, Kans.	585.1	565.5	654.9	618.1	662.4
Cities Service Helex Inc., Ulysses, Kans.	638.6	717.4	740.6	771.4	718.3
National Helium Corp., Liberal, Kans.	1,310.2	1,303.7	1,245.6	1,211.6	1,247.4
Phillips Petroleum Co., Dumas, Tex.	513.6	539.8	551.2	569.9	429.3
Phillips Petroleum Co., Hansford Co., Tex.	502.1	490.7	426.4	468.8	587.9
Total	3,549.6	3,617.1	3,618.7	3,639.8	3,645.3

Table 5.—Helium in conservation storage

(Million cubic feet)

Year	Quantity in storage on Dec. 31
1965	9,072.8
1966	[1] 12,720.2
1967	[1] 16,527.0
1968	[1] 20,328.5
1969	[1] 24,224.0

[1] Includes helium stored for private companies under storage contracts and not owned by Bureau of Mines: 1966, 50.2 million cubic feet (MMcf); 1967, 57.4 MMcf; 1968, 69.8 MMcf; 1969, 21.0 MMcf.

Private Plants.—As seen in table 1, several private plants were either abandoned or not operated during 1969, and only four plants were in operation at yearend. All of the private plants operate independently of the Federal helium program, and sales are made for the most part directly, or through industrial gas distributors, to commercial (non-Federal) customers.

Production from all private helium plants in 1969, was 398.8 million cubic feet of grade A helium. This compared with the 388.7 million cubic feet produced by these plants during 1968.

CONSUMPTION

Bureau of Mines sales of grade A helium continued to decline during the year. Bureau sales were 360.7 million cubic feet in 1969, compared with 478.4 million cubic feet in 1968. Total sales of grade A helium from both Bureau and private sources also decreased, falling from a total of 867.1 million cubic feet in 1968 to 759.8 million cubic feet in 1969. Of the total Bureau of Mines sales of grade A helium, 284.0 million cubic feet was delivered to Federal agencies and 76.7 million cubic feet to commercial customers. However, much of the helium delivered to commercial firms was redistributed to Federal agencies, and thus is not indicative of actual helium use by non-Federal customers.

All Bureau of Mines shipments of grade A helium were made in gaseous form in cylinders, highway semitrailers, or railway tank cars. Private plants ship helium in both the gaseous and liquid states.

Helium redistribution continued satisfactorily under contracts with the General Services Administration. The private companies purchase helium from the Bureau of Mines in bulk, repackage it in smaller containers, and distribute it to the helium using Federal agencies. These contracts make relatively small quantities of helium readily available to the agencies and reduce freight charges for small purchases.

The largest user of helium in 1969 was again the Nation's space and missile program. Private industry and research organizations continue to use large quantities of helium each year.

Table 6.—Shipments of grade A helium from Bureau of Mines plants to various customers

(Million cubic feet)

Recipient	1968 Quantity	1968 Percent[1]	1969 Quantity	1969 Percent[1]
Federal agencies:				
Department of Defense	279.9	58.5	191.6	53.1
Atomic Energy Commission	28.5	6.0	23.3	6.5
National Aeronautics and Space Administration	86.6	18.1	63.8	17.7
Weather Bureau (ESSA)	4.5	.9	4.5	1.2
Other	.9	.2	.8	.2
Subtotal	400.4	83.7	284.0	78.7
Non-Federal customers[2]	78.0	16.3	76.7	21.3
Grand total	478.4	100.0	360.7	100.0

[1] Percentage of all shipments.
[2] A large part of this helium is redistributed by the Bureau's non-Federal customers to Federal agencies and their contractors; hence, the data herein are not indicative of actual helium use by non-Federal customers.

Table 7.—Grade A helium used in the United States

(Million cubic feet)

Year	Quantity[1]
1965	757
1966	948
1967	907
1968	867
1969	760

[1] Includes helium produced and sold by privately owned helium extraction plants.

RESOURCES

In 1969, the survey to locate the helium resources of the United States was continued. A total of 443 natural gas samples from fields and wells in 23 States and eight foreign countries were collected and analyzed for helium.

Judging from the information now available, no significant discoveries of helium were made in 1969; however, the future development of some new fields could increase estimates of reserves.

As of December 31, 1969, helium reserves of the United States were estimated to be 157 billion cubic feet, exclusive of the 24 billion cubic feet of helium in storage at Cliffside Field, Potter County, Tex., near Amarillo. Five major helium-bearing gasfields located in the Texas Panhandle, Oklahoma Panhandle, and southwestern Kansas contain over 80 percent of the helium reserves of the United States. These fields are (1) the Hugoton field in Kansas, Oklahoma, and Texas; (2) the Panhandle field of Texas; (3) the Keyes field in Oklahoma; (4) the Greenwood field in Kansas and Colorado; and (5) the Cliffside field in Texas. All of these fields are withn 200 miles of Amarillo, Texas. The remaining helium reserves are contained in 83 gasfields located in Airzona, Colorado, Kansas, Montana, New Mexico, Oklahoma, Texas, Utah, West Virginia, and Wyoming.

FOREIGN TRADE

Export licenses for helium are issued by the Office of Munitions Control, U.S. Department of State. Exports of helium in 1969 are estimated to be about 50 million cubic feet. Most exported helium was used in fundamental and applied research, in chromatography, and in various atomic energy applications.

WORLD REVIEW

The only helium extraction plant in operation in the free world besides those in the United States is located near Swift Current in Saskatchewan Province, Canada. The plant began production in December 1963. It processes nonflammable helium-bearing gas from a small reserve. In 1967 the annual plant capacity was increased from 12 million cubic feet of helium to 36 million cubic feet. While exact production data are unknown, it is believed that the plant operates at near capacity. Most of the helium produced is said to be exported to Japan and other Asian countries, although some is used domestically.

Iron Ore

By F. E. Brantley [1]

Continued growth in 1969 of world steel production resulted in a corresponding increase in iron ore mined to meet the market demand. The major activity was in Australia, where the results of multimillion dollar investments in iron ore projects, based largely on long-term Japanese contracts, were beginning to become apparent in the form of exports.

Iron ore was still plentiful in international markets, and intense competition remained, preventing iron ore prices from following the upward trend of steel prices during the year. This was compounded as larger combination carriers further effectively widened the ocean distances over which iron ore could be transported economically.

Opposing forces, including continued closing of the less profitable ore operations and increased labor costs in most producing countries, signaled a decline in the buyer's bargaining advantage. This was beginning to be obvious by year end in negotiations announced for both annual and longer term contracts. It was thought that the next few years would see a leveling and upward price trend.

Japanese steelmakers continued to add to their long term contracts for iron ore, which will average over 80 million tons annually through 1975, and to negotiate in most of the producing free-world countries for additional supplies.

Investments made by U.S. firms during 1969 to increase domestic ore production were limited largely to expansion of existing mines and pelletizing facilities. A number of foreign ore developments in Africa, South America, and Australia were being studied by U.S. iron and steel interests from a standpoint of future large-scale investments.

[1] Physical scientist, Division of Ferrous Metals.

Table 1. Salient iron ore statistics

(Thousand long tons and thousand dollars)

	1965	1966	1967	1968	1969
United States:					
Iron ore (usable; [1] less than 5 percent Mn):					
Production [2]	87,439	90,147	84,179	85,865	88,260
Shipments [3]	84,073	90,041	82,415	81,934	89,854
Value [3]	$801,350	$854,134	$817,511	$836,433	$929,293
Average value at mines per ton	$9.53	$9.49	$9.92	$10.21	$10.34
Exports	7,085	7,779	5,906	5,884	5,160
Value	$80,418	$92,157	$71,585	$70,835	$62,310
Imports for consumption	45,103	46,259	44,611	43,941	40,758
Value	$443,788	$462,354	$443,918	$453,753	$402,529
Consumption	131,888	134,047	127,424	131,753	140,235
Stocks Dec. 31:					
At mines [3]	12,667	12,160	12,959	r 16,041	13,790
At consuming plants	53,799	54,658	55,121	53,232	51,003
At U.S. docks	2,494	2,707	2,987	2,797	2,648
Manganiferous iron ore (5 to 35 percent Mn):					
Shipments	333	246	289	245	385
World: Production	611,187	625,799	612,820	674,440	712,406

r Revised.
[1] Direct shipping ore, washed ore, concentrates, agglomerates, and byproduct pyrites cinder and agglomerates.
[2] Includes byproduct ore.
[3] Excludes byproduct ore.

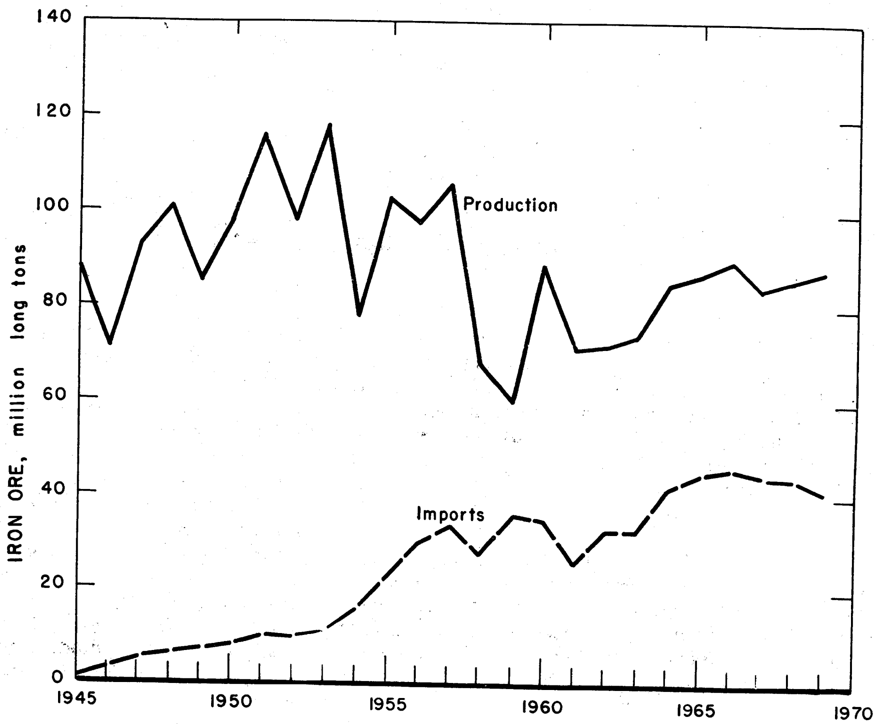

Figure 1.—United States iron ore production and imports for consumption.

EMPLOYMENT

There was a 4 percent decrease in total man hours worked at mines and beneficiating plants of the Lake Superior district for 1969, and a slight drop (1 percent) for the rest of the country. Crude ore production increased during the year by 5 and 6 percent, respectively for the two areas; the major increase from increased taconite output in Minnesota. While the practice of mining companies to maintain a stable labor force by keeping men employed all year, even if not producing iron ore continued to prevent a true measure of productivity, and affected averages to some extent, the trend toward reduction of high-cost smaller mines, more efficient operation of the larger open pit mines and beneficiating plants, and improved technology has contributed to a continued overall higher average hourly output. Production of domestic usable iron ore per man hour for example, has increased by 7 percent in the past 5 years to 2.04 tons in 1969.

Revised data for 1968 showed a total of 44,459,000 man hours worked during 5,544,000 man shifts, and the indicated average number of men employed to be 18,469.

DOMESTIC PRODUCTION

Crude ore production from domestic mines increased in 1969 by 5.7 percent over that of 1968, although the number of producing mines declined from 111 to 92, or 17 percent. Most of the change occurred in Minnesota where ore output increased by 8.1 million tons while the number of operating mines was reduced by 13, owing to the consolidation of taconite operations and the closing of smaller mines. Underground crude production in the United States increased by 580,000 tons over the 1968 output, owing to increased production from large mine operations.

Production of domestic usable ore increased 2.8 percent over that of 1968. Hematite ore represented 40 percent of all usable ore produced in 1968 and 45 percent in 1969. Magnetite ore in 1968 and 1969 was 57 percent and 53 percent, respectively. Limonite, or brown ore, and byproduct ore represented the remainder each year. The Lake Superior district produced 78 percent of the total domestic ore; for the first time since 1966, the district included Wisconsin, as the Black River Falls pellet plant of Inland Steel Co.'s subsidiary, Jackson County Iron Co., began operation and made its first shipment in December. Capacity of the plant was reported as 750,000 tons per year; the output will help meet the steelmaking demands of Inland's Indiana Harbor Works near Chicago.

In Minnesota, the National Steel Plant at Keewatin, owned by National Steel Corp. and the Hanna Mining Co., resumed operations in March after an 8-month period of plant alterations involving the furnace section. At the end of the year the plant was producing at a rate of 2.8 million tons per year, 20 percent over the original projected capacity. The Eveleth Taconite Co.'s pellet plant produced about 16 percent over design capacity in 1969, and modifications were under consideration to increase production by about 10 percent. Published shipments for 1969 totaled 1.98 million tons. Announcement was made late in 1969, by the United States Steel Corp. that its Minntac pellet plant at Mountain Iron would be expanded from 6 million tons to 12 million tons annual capacity, with the construction to be completed in 1972. The Pilot Knob Pellet plant near Ironton, Mo., operated by Hanna Mining, was reported as having solved start-up problems and in December was operating at the rated capacity of 1 million tons per year.

Mines closed during the year included the Schley group at Gilbert, Minn., owing to exhaustion of ore reserves, and the Homer and Wauseca underground mines at Iron River, Mich., where the ore was reported as no longer being competitive. Also closed was the Bristol mine at Crystal Falls, Mich., because of lack of demand for this ore.

Development of an iron mining complex on the Snettisham Penisula in Alaska was planned by the Marcona Corp. at a project cost of $130 million. The ore body, previously drilled by the Bureau of Mines on a preliminary basis, was to be fully explored by Marcona as the first phase of operations.

CONSUMPTION AND USES

The method of reporting iron ore consumption adopted in 1963 was continued in 1969. Concentrate used for agglomerate produced at mine sites was not reported as reported when the agglomerate produced iron ore consumption. Its consumption was was shipped to the furnace site and used. However, concentrate and fines used for agglomerate production (mainly sinter) at blast furnaces and steel mills was reported as iron ore consumed. This method of reporting gives a valid balance between reported consumption and iron ore supply (production plus imports less exports including adjustments for losses due to processing and transporting).

Iron ore consumed in making agglomerate at steel mills includes foreign and domestic direct-shipping ores, fines generated in shipping, and foreign and domestic iron ore concentrate. Other materials such as limestone, flue dust, mill scale, and coke breeze used in making agglomerates were excluded.

The record high consumption of iron ore, 140.2 million tons, exceeded the 1968 total by 6.4 percent. Miscellaneous use was unchanged, and steel furnace consumption dropped 15 percent to 3.4 million tons, owing to additional open hearth furnace shut downs. Ore consumed by the blast furnace increased 9 million tons; the weight ratio of ore consumed to hot metal produced remained approximately the same, 1.6 to 1.

STOCKS

Iron ore stocks at mines, U.S. docks, and consuming plants, excluding byproduct ore, totaled 67.4 million tons on December 31, 1969, down 4.6 million from the previous yearend inventory of 72.0 million tons. The American Iron Ore Association reported stocks at U.S. docks of 2.6 million tons; mine stocks were 13.8 million tons. At the average monthly rate of consumption in 1969, the total stocks represented approximately a 5-month supply. The decrease in stocks was attributed to Canadian labor strikes, which affected about 80 percent of the Canadian production, and resulted in decreased shipments to the United States.

PRICES

Base prices for Lake Superior iron ores, 51.5 percent iron, natural, remained unchanged during 1969, and some of the published prices, rail of vessel, lower lake ports, per long ton, were as follows: Mesabi non-Bessemer, $10.55; Mesabi Bessemer, $10.70, Old Range non-Bessemer, $10.80; and Old Range Bessemer, $10.95. Lake Superior pellets were quoted at $0.252 per long ton unit. The Cleveland-Cliffs Iron Co.. and The Hanna Mining Co. announced price increases for 1970 amounting to $0.25 per ton for natural iron ores, which reflected increased transporation and handling costs. Lake Superior pellets also were increased the equivalent of 1.4 cents per long ton iron unit. Revised base prices for 1970 were as follows: Mesabi non-Bessemer, $10.80; Mesabi Bessemer, $10.95; Old Range non-Bessemer, $11.05; Old Range Bessemer, $11.20; and Lake Superior pellets, $0.266 per long ton unit. The changes were the first for the natural ores since 1964, when they were reduced 10 cents per ton owing to transportation adjustments, and the first for pellets since 1962, when they were first quoted. Hanna Mining reported also that the increases would apply to both natural ores and pellets produced by Iron Ore Co. of Canada, which Hanna Mining managed.

The average value of domestic usable ore per long ton f.o.b. mines, excluding byproduct ore, was $10.34, compared with $10.21 in 1968 and $9.92 in 1967. These data were taken from producers' statements and approximated the commerical selling price less the cost of mine-to-market transportation.

Published prices of selected foreign ores were as follows: Venezuela, Orinoco No. 1, 58 percent iron, f.o.b., Puerto Ordaz, $7.88 per long ton; Brazil, lump ore, 68.5 percent iron, f.o.b. mine or mill, $9.10-$9.60 per long ton; and Australia, lump, 64 percent iron, $9.37 per long ton (contract), f.o.b. port.

TRANSPORTATION

Three developments in materials transporation have brought into sharper focus future possibilities in iron ore movements around the world. Multipurpose supercarriers, pipeline systems, and slurry ships. The supercarriers of about 100,000-ton size see regular service for ore transport, and are expected to be commonplace in the future as docks are enlarged and harbors deepened to accomodate them. Japanese steelmakers have plans for using 200,000-ton combination carriers by 1972, according to the Japan Steel Information Center. These carriers, to reduce transportation costs to a minimum, would load oil in the Persian Gulf, unload in European or American Ports, load coal up to 80,000 tons, or to depths allowed by the port at Hampton Roads, then complete loading with iron ore at a Canadian, African, or Brazilian port for return to Japan. Under this system, where port facilities limit coal loading, and iron ore can be loaded to full ship capacity, the iron ore can be considered more or less as ballast, and transportation cost is reduced to a point where Canadian ores can compete with Australian ores. A 10-year charter contract was reportedly concluded by Kawasaki Steel Corp. with a Norwegian firm for commissioning of a 220,000-ton oil/ore carrier in 1971 that would transport ore to Japan on a combination haul. Freight cost of iron ore by this method from Brazil to Japan was to be approximately $3.15 per ton.

The Grängesberg Co., (Sweden), took delivery on a combination oil/ore carrier of 106,400 tons d.w. in March, and contracted with a Yugoslav shipbuilder for two 265,000-ton carriers to be delivered in 1972–73.

The movement of iron ore by pipeline as a slurried concentrate has proved to be a successful method of transportation, with over 2 years operation of a 53-mile facility completed in Tasmania. Plans are under study to move ore greater distances in other locations from land-locked mines to ports.

A third system involves both large carriers and pipe-lines and may have a rapid growth, as it also has proven successful in commerical movement of ore to both the United States and Japan from South America. Slurried ore is pumped from shore to carrier by pipeline much in the same manner that oil is loaded. However, at the ships, the ore slurry is dewatered and shipped as a high moisture content concentrate, which at its destination is reslurried and pumped to a second dewatering system for either immediate use or storage. The operation of this system would allow concentrate made at a mine in the interior to be pumped direct to an ore carrier, and because the pipeline could be extended off shore beyond dock distance, the system would not have to depend on a deep harbor for high-capacity loading or unloading. The result could be that future carriers may be limited in size only by design and the point of diminishing monetary return. The Marcona Corp. had one of its carriers, the 50,000-ton San Juan Merchant, under conversion to carry oil, ore, or slurry, the first to be designed for all three possibilities. Marcona also commissioned two 130,000-ton combination ore/oil carriers.

A 400,000-ton oil tanker has been ordered from Ishikawajima-Harima Heavy Industries (Japan), and the Mitsubishi Heavy Industries had anticipated even larger vessels by applying to the Government for permission to construct a dock that would allow a 1-million-ton carrier to be built.

The American Ship Building Co. at Lorain, Ohio, began the second phase of construction on the first of the larger carriers to be constructed on the Great Lakes when keel-laying ceremonies were held for the United States Steel Corp.'s 45,000-ton-capacity carrier. The completed vessel, which will be built in two sections, is expected to be in service possibly by the end of the 1970 shipping season.

As a result of the completion of the new Poe lock at Sault Ste. Marie, a vice president of Litton Industries' Design Division, discussed the design and construction of the maximum-size carrier possible for use on the Great Lakes.[2] The carrier could haul a maximum of 60,000 tons of iron ore at the locks mid-summer draft limit of 28½ feet.

FOREIGN TRADE

Labor strikes in the Canadian iron ore and steel industries affected both imports and exports in the United States, since approximately one-half of the domestic iron ore moved in and out of the country involves Canada. Imports from Canada in 1969 were down 28 percent from 1968, and exports to Canada declined 8 percent.

Total U.S. exports decreased from 1968 by 0.7 million tons, and imports by 3.2 million tons. Increased shipments from Venezuela, Chile, Peru, Liberia, and Australia made up part of the domestic import deficit. The value per ton of exported ore remained approximately the same as for 1968, value of imported ore decreased by about 5 percent.

WORLD REVIEW

Angola.—The Companhia Mineria do Lobito contracted to supply 14 million tons of ore to six Japanese steel companies over the next 8 years from its Cassinga deposits. In addition to Japan, ore was shipped during 1969 to West Germany, England, France, and the United States. A contract was concluded with West German interests to supply ore for a 5-year period.

[2] Yu, A. T. and R. K. Quinn. A New Dimension in Great Lakes Iron Ore Transportation. Skillings' Min. Rev., v. 58, No. 7, Feb. 15, 1969, pp. 1–10.

Argentina.—Governmental plans to develop the Sierra Grande iron ore deposits were announced after efforts to secure bids from international sources met with failure. By Decree 4045, Fabricaciones Militares, in charge of governmental mineral resources, was authorized to proceed with the project. Proposed facilities included a pelletizing plant to handle 2.6 million tons of pellets per year. Punta Colorado on the Gulf of San Matías would be the shipping terminal, with a target date of 1974 scheduled for startup and shipment. The Sierra Grande deposits are estimated to range from 52 to 57 percent iron and total about 145 million tons. About 50 percent of the proposed output would be used to replace iron ore imports required to supplement domestic ore production for future scheduled steel production.

Australia.—The rise of Australia, primarily Western Australia, as a top-ranking supplier of iron ore to the world has been meteoric. In addition to commitments for supplying Japanese steelmills during the next two decades, the success of the combination supercarriers has opened the European markets on a competetive basis with South American ores, and the possibility of another round of long-term contracts; these would be with European steelmakers.

The Savage River Mines, a joint venture of Australian, Japanese and U.S. companies, in which Pickands Mather & Co. held interest and managed through an Australian subsidiary, had contracts for shipment of about 45 million tons of pellets over a 20-year period. The company transported concentrate to Port Latta, Tasmania, from its mine site 53 miles away by pipeline to a pelletizing plant. The plant, operating with a capacity of 2.25 million tons per year, marked its first full year of operation in 1969.

Hamersley Iron Pty, Ltd., moved ahead to lead the Australian producers of iron ore in exports for 1969 with a total of 13 million tons. This represented a 40-percent increase over 1968 and included 1.7 million tons of pellets. Hamersley Iron is a wholly owned subsidiary of Hamersley Holdings Ltd., which in turn is controlled 54 percent by Conzinc Riotinto of Australia Ltd., 36 percent by Kaiser Steel Corp., and 10 percent by the Australian public. Contracts held by Hamersley exceeded 265 million tons to be delivered over periods varying from 1 to 15 years. U.S. contracts for 1970 amounted to 0.6 million tons, and term contracts with European steelmakers, 11 million tons. Most of the remainder was scheduled for Japan. Plans for expansion included development of a new mine at Paraburdoo to give a total output capacity of 37.5 million tons annually by 1974. This combined with planned expansions at Mt. Tom Price would make Hamersley the world's largest iron ore producer.

The Mt. Newman project, in which the Amax Iron Ore Corp., a subsidiary of American Metal Climax (AMAX) of the United States has 25 percent interest, began production mining in January on Mt. Whaleback, the principal ore body. From 5 million tons in 1969, output was scheduled to increase to 19 million tons in 1974, to fullfill long-term contracts totaling over 200 million tons with Japanese steelmakers and 70 million tons with one of the joint owners, Broken Hill Pty. Co. Ltd. (BHP) of Australia.

The Robe River venture, financed by Australian, Japanese, and United States interests, including the Cleveland-Cliffs Iron Co., of the United States as manager, continued negotiations to finalize agreements with prospective partners and begin development of reserves near Mt. Enid, south of Dampier. Contracts negotiated with Japanese steel companies exceeded 150 million tons of pellets and sinter fines over a 21-year period.

Goldsworthy Mining Ltd., owned by Consolidated Gold Fields Australia Ltd., Utah Development Co., of the United States, and Cyprus Mines Corp., of the United States, each of which hold one-third interest, increased shipments in 1969 to slightly over 5 million tons. A recent contract for the shipment of 52 million tons to Japan brought to 83 million tons the total committed for Japanese mills by Goldsworthy.

The Koolanooka development, northeast of Geraldton, in which Western Mining Corp. Ltd., of Australia, has one-half interest and the other half is divided between Homestake Mining Co., and Hanna Mining Co., of the United States, shipped 575,000 tons of ore to Japan on contracts amounting to about 5 million tons through 1973.

Brazil.—A new pelletizing plant at Tubarão with a capacity of 2 million tons per year started operating near the end of the year as part of the expansion program of Cia. Vale do Rio Doce (CVRD). CVRD, a government-controlled company combined with Cia, Meridional de Mineração (CMM), United States Steel Corp.'s mining subsidary in Brazil, to form a new company for joint development of the iron ore deposits in the state of Pará. In 1969, CMM obtained prospecting permits for the Pará iron districts, where company geologists had previously located outcroppings of high-grade ore exceeding 65 percent iron. These districts were thought to be some of the largest potential sources of quality ore in Brazil.

Purchase contracts obtained by CVRD from Japanese steelmakers call for delivery of 8.7 million tons in 1971 and 1972, then increasing to 9.7 million per year through 1977.

Canada.—A significant reduction in production and shipments of iron ore from Quebec and Newfoundland occurred in 1969, attributable to labor strikes lasting several weeks, and which also affected steel production by The Steel Company of Canada, Ltd. and the Algoma Steel Corp. Overall Canadian iron ore output in 1969 decreased from the 1968 record of 47.4 million tons to 40.0 million tons.

During the year, Iron Ore Co. of Canada, (IOC) and Quebec Cartier Mining Co., announced agreements to ship iron ore to Japanese steelmakers. IOC will begin shipments in 1970 and supply about 1 million tons over a 2-year period; and Quebec Cartier will ship 1.2 million tons per year for a 5-year period beginning in 1971. Ocean movement by supercarriers exceeding 100,000 tons was planned. These plans involve triangular oil-coal-ore shipments, and may result in the Quebec-Labrador region furnishing Japan with larger quantities of ore in the future. Studies were started by Quebec Cartier of its Mt. Wright iron ore property with the intention of opening a new mine in the 1970's. The Mt. Wright Range is estimated to contain about three times the reserves that are available at Lac Jeannine, both of which are part of the South Labrador Geosyncline.

Pellet capacity was expected to be increased by about 700,000 tons in 1970 when two projects would be completed; Inco's Copper Cliff plant to add 400,000 tons annual capacity, and Falconbridge Nickel Mines 300,000 tons of a prereduced pellet that is 90-percent iron and 1.5-percent nickel. The latter project, located near Sudbury, was to produce the first combination pellet that included nickel for the world market.

The Zeballos Iron Mines Ltd. closed production facilities at its mine in British Columbia. Output previously had gone to Japan.

Chile.—Development of the Chañar Boqueron iron ore deposit was scheduled to start by Corporación de Fomento de La Productión (CORFO), the State-controlled majority stockholder of Compañia de Acero de Pacífico, S.A. (CAP), which would operate the mine. Investment in the open pit operation would be about $3.5 million. The reserves were estimated at 180 to 350 million tons, varying from 35 to over 60 percent iron content, and present in large magnetite bodies over an area of about 800 square miles.

CAP was expanding facilities at the El Algarrobo mine to increase its production by 700,000 tons per year; production was estimated at 3.1 million tons in 1969.

Gabon.—Studies were still under discussion between the Gabonese Government and Société des Mines de Fer de Mekombo (SOMIFER) concerning development of the Belinga ore deposits. Construction of a railroad to a saltwater port would be necessary in order to move the ore to market, and was planned as the first development step. The Belinga deposits contain an estimated 500 million tons of high-grade ore averaging 64 percent iron.

Guinea.—An international consortium of six firms from five nations, including the United States, was reported to have secured an agreement leading to possible development of the Mt. Nimba iron deposits, near the Liberian border. An output of 15 million tons per year has been proposed as a joint venture with the Guinean Government; about one-half of the output would go to Japan. Iron ore deposits in this area have been reported as approximately 200 million tons of potential ores, containing about 24 percent silica and 47 percent iron.

India.—Production of iron ore in 1969 increased only 900,000 tons over the 27.4 million tons recorded for 1968. However, several projects and planned expansions were expected to raise the capacity and increase India's share of the world market. Negotiations were continuing with Japanese steelmaking interests to supply approximately 200 million tons of ore over a 15-year period, largely from the Bailadila project in Madhya Pradesh, south central India, and the Barajamda and Daitari mines in Orissa. This would require improved facilities to dock and load the larger ore carriers.

Under the revised fourth 5-year plan ending March 31, 1974, $319 million had been recommended by the Government Planning Group on Iron Ore for investment to raise exports to 31 million tons annually. About half of this amount would be for the Bailadila, Barajamda, and Daitari mines, with associated transporation and port facilities.

Kaiser Engineers were reported to be studying the possibility of developing iron deposits in Mysore State for export. The Marcona Corp., together with the Japanese Okura Co., was to prepare a preliminary report early in 1970 on the economic feasibility of developing the Kudermukh mines near Mangalore.

Ivory Coast.—Pickands-Mather International, a subsidiary of Pickands Mather & Co., on the basis of a concession granted in December 1968, began exploration and evaluation of a 4,100 square mile area located in the western part of the country. The first phase of a U.N. Development Program for minerals research in the southwest was completed during the year. A second project was started to concentrate on specific minerals including iron. The U.N. evaluation of potential iron ore in the Ivory Coast totals 2.4 billion tons, ranging in grade from 40 to 46 percent iron.

Japan.—Japan's output of iron ore is insignificant in comparison with the amount needed to keep up with the country's rapid steel expansion, and Japanese ore contract missions have tied up a large part of the world's merchant ore that would be available in the next few years. As the world's largest importer of iron ore, the purchase contracts for 1969 totaled 81 million metric tons,[3] distributed as follows in millions of metric tons: Africa, 8.27; Australia, 27.05; U.S.S.R., 1.00; India including Goa, 15.84; South America, 18.68; Malaysia, 3.78; Phillipines and Hong Kong, 1.38; United States, 3.20; and Canada, 2.016. Pellets amounted to an estimated 11 million tons of the 1969 ore imports, with another 3 million tons produced in Japan. Quality standards for four categories of Japanese pellet contracts were discussed by development personnel of one supplier.[4]

Liberia.—The Bong Mining Co. had an expansion program underway to recover high-grade concentrate at a rate of 5 million tons per year. By the end of 1970 a pelletizing plant was expected to be finished that would pelletize part of the material at a rate of 2 million tons per year, with the other 3 million tons to be shipped as 60 percent iron concentrate. Total cost of the pelletizing plant was estimated at $45 million. Output from the operation has been going to steelmakers in West Germany and Italy.

LAMCO Joint Venture through its Liberian Iron Ore, Ltd. (LIO), operated the Buchanan pelletizing plant for the first full year, producing 1.6 million tons of pellets, about 80 percent of capacity. The washing plant operated at full capacity to produce 8.6 million tons of washed fines and lump ore. Total production from the Nimba mine amounted to 10.8 million tons, with 11.7 million scheduled for 1970.

Exploration and limited diamond drilling continued in areas west of the Nimba range, the mountain ridges of Gangra and Yuelliton, and Mount Tokedah where an estimated 150 million tons of ore averaging 50 percent iron content was indicated.

Mexico.—Cerro de Mercado, S.A., affiliated mining company of Cia Fundidora de Fierro y Acero de Monterrey, S.A. completed the first full year's operation of its heavy-media plant designed to upgrade low-grade conglomerate at the Cerro de Mercado mine site near the city of Durango. The beneficiation plant was to produce 40 tons per hour of sink product analyzing 60 to 65 percent iron, supplementing the regular sized-ore production. The company also was given government concessions to develop iron ore in national reserves to include Santas Ritas, adjacent to Cerro de Mercado, and in Sierra Majada, Coahuila, near the Hercules deposit.

Las Encinas S.A., mining subsidiary of Hojalata y Lamina, S.A. (HyL), had a pelletizing installation near completion in

[3] World Mining. Iron Ore Sales Contracts Make Many Mining Booms. V. 5, No. 11, October 1969, pp. 37–41.

[4] Fraser, M. J. and R. R. Beebe. Quality Control for the Japanese Iron Ore Pellet Market. Skillings' Min. Rev., v. 58, No. 13, Mar. 29, 1969 pp. 1, 4, 5, 21.

the state of Colima near Pihuamo; production capacity to be about 1 million tons per year. Stockpiled fines and ore from the mining operations at the El Encino deposits would furnish high-grade material for producing pellets to be shipped to HyL's steelmaking operations at Monterrey or Puebla, near Mexico City.

New Zeland.—Break-in tests were started on the production of sponge iron from New Zealand iron sands, using the Stelco-Lurgi process. A 246-foot kiln was operated to reduce pellets prepared from the sand concentrate at a rate of about 10 tons per hour. The metallized product would supply the electric-arc steel furnaces of New Zealand Steel's plant near Glenbrook, which was expected to be producing over 200,000 tons of steel annually by 1971.

New Zealand Steel Ltd., owned 45 percent by the government and 55 percent by private shareholders, had an agreement with The Steel Co. of Canada to advise on the project and provide technical and training assistance.

Norway.—The state-owned A/S Sydvaranger, Norway's largest iron ore producer, began production in a new pelletizing plant at Sydvaranger at a rate of 1.2 million tons of pellets per year. The facility, located near the port of Kirkenes, will be supplied with concentrate prepared from the Sydvaranger open pit mines. Concentrate has been produced at a rate of approximately 2.5 million tons per year, which averaged about 65 percent iron.

Sierra Leone.—The Sierra Leone Development Co. Ltd. (DELCO) improved port facilities at Pepel to allow the docking of 100,000-ton-ore carriers, and raised the loading capacity from 2,750 tons per hour to 4,000 tons per hour. A 250,000-ton additional stocking capacity also was added at the port during 1969. Beneficiation improvements at the concentrating plant of the Marampa mine were being made in the sizing and concentrating sections to give a minimum 3.1-million-ton total capacity in 1970. Reserves at Marampa were estimated at 100 million tons varying from 40 to 60 percent iron.

South Africa, Republic of.—The South African Iron and Steel Industrial Corp. Ltd. (ISCOR) was to bring a new open pit mine into production at its Thabazimbi operations in the northwestern region of the Transvaal. Costing in excess of $3 million, the mine's output would help supply iron ore for the company's expanding steel operations.

Negotiations were reported as entering the final stages between ISCOR, a Government-controlled company, and a group of Japanese steelmakers to ship between 5 and 10 million tons of ore annually to Japan from the Sishen deposits in Cape Province. A technical report submitted to the Government by ISCOR and the South African Railways called for a 400-mile rail link to a port site on Saldanha Bay. Reserves of 1,000 million tons were estimated in the Sishen-Postmanburg area.

Sweden.—In June, the state-owned Luossavaara-Kiirunavaara Aktiebolag (LKAB) started pellet production at its $19.3 million Svappavaara plant. The start up was to increase the company's pellet capacity by 1.8 million to a total of 5 million tons of pellets per year. A major project at Kiruna involved an underground transporation system to include computer control and a crusher plant costing $29 million, completion of which was set for 1971. Kiruna, the world's largest underground mine produces over 20 million tons per year, mostly for European consumption.

The Grängesberg Co's. 1.6 million ton-per-year plant to produce low-phosphorus cold-bonded pellets at Grängesberg was scheduled for production starting in 1970. AB Dannemora Gruvor was to increase the mine capacity at Dannemora from 1 to 2 million tons per year.

Sweden's iron ore industry has felt the competition of new developments in Canada, Africa, and Australia in recent years, and the prospects for mines producing less than 1 million tons of reasonable grade ore to remain open were not considered good without a rise in prices.[5]

Sweden's mines produced 33.3 million tons in 1969, and exports were 32 million tons. A strike at LKAB mines during December reduced output and resulted in stock reductions of 3.3 million tons to meet export demands.

Venezuela.—A study for development of the San Isidro iron ore deposit was being prepared for the Government by an inter-

[5] Huggins, C. B. Swedish Iron Ore Mining Operations: A Summary of Present and Future Prospects. Inst. Min. and Met. Trans. (Sec. A), v. 78, No. 755, October 1969, pp. 112–116.

national consortium of experts. If favorable, tenders would be requested from private interests for producing and marketing both regular and pelletized ore on the world market. Yearly production of 4.5 million tons was previously proposed from the deposit, which contains an estimated 300 million tons of 62-percent iron ore.

Orinoco Mining Co.'s briquetting plant to produce 1 million tons of an 86.5 percent-iron product annually was in the second year of construction.

TECHNOLOGY

Pelletizing and prereduction received a major share of attention in 1969. Interest in the prereduced pellet increased because of the high prices quoted for scrap during the year and because of indicated future shortages in high-quality coking coal. Pellet demand continued to increase at the expense of standard ores. Iron content of agglomerates shipped from domestic mines increased from 29.9 million tons in 1968 to 34.7 million in 1969; the iron content of direct shipping ores decreased from 5.3 million tons to 5.0 million tons in 1968 and 1969, respectively. Inland Steel Co. expected pellets to account for about 75 percent of its iron ore consumption in 1970, and Youngstown Sheet and Tube Co. reported that pellets supplied slightly more of its total ore needs for steelmaking. Republic Steel Corp. and Armco Steel Corp. were two steel producers evaluating the use of prereduced iron pellets for electric furnace feed.

Two prereduced pellet plants were operating in the United States, both using imported fine ore. One, the Portland, Oregon, metallized pellet plant of Midland-Ross Corp., was declared successful in the first year of its operation, and the product was said to increase productive capacity of an electric furnace by at least 35 percent.[6] Construction starts on three additional plants by Midland-Ross in 1970 were announced, one of which would be at Georgetown, South Carolina, and another at Hamburg, West Germany. The third was expected to be in Japan.

The other metallized pellet plant was being operated by the McWane Cast Iron Pipe Co., near Mobile, Alabama, where use of the D–LM process was said to be successfully producing a prereduced product for making electric furnace pig iron.

Other possible developments for producing a prereduced iron product in the United States included the fluidized hydro carbons process of Standard Oil Co. of New Jersey, reported to be moving ahead with a program to produce and sell briquets with a 92-percent-iron content.[7]

Outside the United States, the SL/RN process appeared to be gaining a foothold in several countries. SL/RN reduction plants were in operation or nearing the operational stage in South Korea, South Africa, New Zealand, and at the Falconbridge plant in Ontario, Canada, where a combination iron-nickel pellet was to be produced. The process which makes use of sized ore or pellets, was described and advantages presented.[8] The largest installations of the SL/RN plants are scheduled for Australia, where Hamersley Iron Pty. Ltd. has announced that it will produce a 92-percent-iron product known as HImet, in pellet, briquet, or lump form. Initial production was set at 1 million tons per year, with exports to start in 1973.

A new plant was started in Puebla, Mexico, by the Hylsa Steel Group, owners of the HyL process of reducing lump ore. This process, using natural gas for reduction, is the oldest successful commerical process in terms of continuous production. Several other countries were reported to be considering use of the HyL process.[9] In Sweden, The Grängeberg Co. was to complete their new pellet plant early in 1970. The plant, with a capacity of 1.6 million tons annually, would produce a phosphorous-free, cold-bonded product to be sold under the name of Grangcold pellets (GP).

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[6] Mining Engineering. World's First Metallized Pellet Plant Acclaimed as Steelmaking Breakthrough. V. 21, No. 12, December 1969, pp. 45–46. Skillings' Mining Review. World's First Metallized Pellet Plant Commences Production at Portland, Ore. V. 58, No. 48, Nov. 29, 1969, pp. 1, 8–11.

[7] McManus, G. J. Pellets Reach the Payoff Point. Iron Age, v. 204, No. 20, Nov. 13, 1969, pp. 71–75.

[8] Janke, Dr. Wolfgang, Sponge Iron—Production by the SL/RN Process and Further Treatment to Obtain Steel, Metallges, A.G., Rev. Activ. N.S. No. 12, 1969, pp. 16–32.

[9] Engineering and Mining Journal. Mexico's 4th Mini-Steel Plant Starts With Direct Reduction of Iron Ore. V. 170, No. 11, October 1969, pp. 67–69.

Another process, developed by the Freeman Corp. of Quebec, Canada, was being testd in West Germany by Gutehoffnungshutte Sterkrade AG of Oberhausen, who was reported to have bought patent rights. Similar to the SL/RN process, it would be marketed as the GHH-Freeman process, depending on successful pilot operations in Europe.

The Cleveland-Cliffs Iron Co. (CCI) had research and development groups working to perfect a flotation concentration process that would allow commercial utilization of a large hematitic taconite reserve on the Marquette range in Michigan. The studies were considered successful, and details were to be completed in 1970. A paper summarizing cooperative research by the Bureau of Mines and CCI on the use of flotation methods to concentrate nonmagnetic Marquette range ores was published.[10] Results were discussed of metallurgical tests using a goethitic type ore and one containing chiefly hematite and martite as the iron minerals. Another article contained data concerning the capital and production costs of producing pellets from a Michigan jasper, a Minnesota magnetic taconite, and a Minnesota semitaconite.[11] The study was made on the basis of Bureau and University of Minnesota test work.

Bureau research groups also worked on the problems of lowering the silica content of both concentrates and pellets, and the separation of iron and manganese from Cuyuna range manganiferous iron ores. Results of a study to convert nonmagnetic iron ore from Steep Rock Lakes, Canada, were published.[12]

Metallization of 12 Minnesota ores was accomplished using hydrogen reduction and magnetic separation methods to obtain products with 85- to 92-percent-iron content.[13] Tests to upgrade Knob Lake (Canada) ores using lignite resulted in a highly metallized product, but results indicated that large-scale processing would require several steps to obtain a product suitable for steelmaking.[14]

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[10] Frommer, D. W. USBM–CCI Cooperative Research On Flotation of Nonmagnetic Taconites of Marquette Range. Blast Furnace and Steel Plant, v. 57, No. 8, August 1969, pp. 652–659.

[11] Hays, Ronald M. Economic Evaluation of Processing Low-Grade Oxidized Iron Ores. Blast Furnace and Steel Plant, v. 57, No. 8, August 1969, p. 652.

[12] Prasky, Charles, and Willard S. Swanson. Reduction Roasting of Steep Rock Iron-Bearing Materials. BuMines Rept. of Inv. 7242. March 1969, 21 pp.

[13] Jacobs, H. D. and R. B. Schluter. Production of Metallic Concentrates From High-Silica Iron Ores. BuMines Rep. of Inv. 7314, November 1969, 17 pp.

[14] Fine, M. M. and R. B. Schluter. Metallization of Iron Ores With Solid Reductants. BuMines Rept. of Inv. 7290, September 1969, 19 pp.

Table 2.—Employment at iron ore mines and beneficiating plants, quantity and tenor of ore produced and average output per man, by districts and States, in 1969

District and State	Employment [p]: Average number of men employed (thousands)	Employment [p]: Time employed: Average number of days	Employment [p]: Time employed: Total man shifts (thousands)	Employment [p]: Time employed: Man hours: Average per shift	Employment [p]: Time employed: Man hours: Total (thousands)	Production: Crude ore (thousand long tons)	Production: Usable ore: (Thousand long tons)	Production: Usable ore: Iron contained [1]: (Thousand tons)	Production: Usable ore: Iron contained [1]: Percent (natural)	Production: Average per man: Crude ore: Per shift	Production: Average per man: Crude ore: Per hour	Production: Average per man: Usable ore: Per shift	Production: Average per man: Usable ore: Per hour	Production: Average per man: Usable ore: Iron contained: Per shift	Production: Average per man: Usable ore: Iron contained: Per hour
Lake Superior:															
Minnesota	9	317	2,762	8.0	22,098	135,483	55,275	33,773	61.1	49.05	6.13	20.01	2.50	12.22	1.53
Michigan	4	243	923	8.0	7,386	29,584	13,417	7,862	58.6	32.05	4.00	14.54	1.82	8.52	1.06
Total	13	294	3,685	8.0	29,484	165,067	68,692	41,635	60.6	44.79	5.60	18.64	3.06	11.30	1.41
Southeastern States:															
Alabama and Georgia [2]	1	242	116	8.6	998	3,127	1,437	602	41.9	26.96	3.13	12.39	1.44	5.19	.60
Northeastern States:															
New York and Pennsylvania [3]	2	269	538	8.0	4,308	9,575	3,800	2,443	64.3	17.80	2.22	7.06	.88	4.54	.57
Western States:															
Arizona, Montana, Utah, and Wyoming	1	254	264	8.0	2,123	10,084	4,067	2,212	54.4	38.19	4.75	15.41	1.92	8.38	1.04
Undistributed [4]	3	261	757	8.0	6,061	18,818	9,565	5,882	61.5	24.86	3.10	12.64	1.58	7.77	.97
Grand total [5]	19	285	5,361	8.0	42,974	206,671	87,561	52,774	60.3	38.55	4.81	16.33	2.04	9.84	1.23

[p] Preliminary.
[1] Average content of all types of ore shipped.
[2] Includes small quantity of ore produced in North Carolina.
[3] Includes small quantity of ore produced in Virginia.
[4] Includes California, Colorado, Idaho, Missouri, Nevada, New Mexico, and Texas.
[5] Data may not add to totals shown because of independent rounding.

Table 3.—Crude iron ore mined in the United States, by districts, States, and varieties

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

District and State	1968					1969				
	Number of mines	Hematite	Limonite	Magnetite	Total [1]	Number of mines	Hematite	Limonite	Magnetite	Total [1]
Lake Superior:										
Michigan	11	W	------	W	29,218	10	W	------	W	29,584
Minnesota	50	37,012	60	90,308	127,380	37	37,856	------	97,626	135,483
Wisconsin	--	------	------	------	------	1	------	------	472	472
Total	61	37,012	60	90,308	156,598	48	37,856	------	98,098	165,539
Southeastern States:										
Alabama	7	1,078	1,251	------	2,329	5	W	1,115	------	W
Georgia	3	------	730	------	730	3	------	950	------	950
North Carolina	--	------	------	------	------	1	------	------	W	W
Total	10	1,078	1,981	------	3,059	9	W	2,065	W	950
Northeastern States:										
New York, Pennsylvania	5	------	------	10,075	10,075	5	------	------	9,575	9,575
Western States:										
Arizona	3	W	------	W	17	1	18	------	------	18
California	3	W	------	W	W	3	W	------	W	W
Colorado	3	------	W	W	197	3	------	W	W	W
Idaho	2	------	------	W	W	2	------	------	W	W
Missouri	2	------	------	W	W	2	------	------	W	W
Montana	2	------	------	12	12	1	------	------	13	13
Nevada	4	W	------	W	W	4	W	------	W	W
New Mexico	3	------	------	W	W	1	------	------	W	W
Texas	3	------	[2] W	------	W	4	------	[2] W	------	W
Utah	6	W	------	W	4,016	6	W	------	W	5,722
Wyoming	4	W	------	W	4,182	3	W	------	W	4,331
Total	35	W	W	12	8,424	30	18	W	13	10,084
Undistributed	---	20,060	[2] 2,093	33,251	17,776	--	32,718	[2] 2,734	24,063	20,995
Grand total [1]	111	58,150	[2] 4,134	133,646	195,932	92	70,592	[2] 4,799	131,749	207,143

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Data may not add to totals shown due to independent rounding.
[2] Includes a small quantity of siderite.

Table 4.—Crude iron ore mined in the United States, by districts, States, and mining methods

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

District and State	1968			1969		
	Open pit	Underground	Total [1]	Open pit	Underground	Total [1]
Lake Superior:						
Michigan	24,574	4,644	29,218	25,577	4,006	29,584
Minnesota	127,380	------	127,380	135,483	------	135,483
Wisconsin	------	------	------	472	------	472
Total	151,954	4,644	156,598	161,532	4,006	165,539
Southeastern States:						
Alabama	1,251	1,078	2,329	1,115	W	W
Georgia	730	------	730	950	------	950
North Carolina	------	------	------	------	W	W
Total	1,981	1,078	3,059	2,065	W	950
Northeastern States:						
New York, Pennsylvania	W	W	10,075	W	W	9,575
Western States:						
Arizona	17	------	17	18	------	18
California	W	------	W	W	------	W
Colorado	197	------	197	W	W	W
Idaho	W	------	W	W	------	W
Missouri	------	W	W	------	W	W
Montana	12	------	12	13	------	13
Nevada	W	------	W	W	------	W
New Mexico	W	------	W	W	------	W
Texas	W	------	W	W	------	W
Utah	4,016	------	4,016	5,722	------	5,722
Wyoming	W	W	4,182	W	W	4,331
Total	4,242	W	8,424	5,753	W	10,084
Undistributed	25,052	6,981	17,776	24,510	9,277	20,995
Grand total [1]	183,229	12,703	195,932	193,860	13,283	207,143

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Data may not add to totals shown because of independent rounding.

Table 5.—Crude iron ore shipped from mines in the United States, by districts, States, and disposition

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

District and State	1968			1969		
	Direct to consumers	To beneficiation plants	Total [1]	Direct to consumers	To beneficiation plants	Total [1]
Lake Superior:						
Michigan	2,353	26,650	29,003	1,972	27,592	29,565
Minnesota	5,044	121,904	126,947	5,461	130,695	136,157
Wisconsin	------	------	------	------	332	332
Total	7,397	148,553	155,950	7,433	158,619	166,054
Southeastern States:						
Alabama	148	2,006	2,154	W	1,893	W
Georgia	------	730	730	------	950	950
North Carolina	------	------	------	------	W	W
Total	148	2,736	2,884	W	2,843	950
Northeastern States:						
New York, Pennsylvania	------	10,014	10,014	------	9,629	9,629
Western States:						
Arizona	W	------	W	18	------	18
California	W	W	W	W	W	W
Colorado	W	------	W	W	------	W
Idaho	W	------	W	W	------	W
Missouri	------	W	W	------	W	W
Montana	12	------	12	13	------	13
Nevada	W	W	W	W	W	W
New Mexico	------	W	W	W	------	W
Texas	------	W	W	W	W	W
Utah	W	W	2,044	W	W	2,460
Wyoming	W	W	4,146	W	W	4,413
Total	12	W	6,202	31	W	6,904
Undistributed	1,768	22,331	17,909	2,233	23,726	20,978
Grand Total [1]	9,325	183,634	192,959	9,697	194,817	204,515

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Data may not add to totals shown because of independent rounding.

Table 6.—Usable iron ore produced in the United States, by districts, States, and varieties

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

District and State	1968				1969			
	Hematite	Limonite	Magnetite	Total [1]	Hematite	Limonite	Magnetite	Total [1]
Lake Superior:								
Michigan	W	------	W	13,770	W	------	W	13,417
Minnesota	22,116	83	30,255	52,454	21,894	------	33,381	55,275
Wisconsin	------	------	------	------	------	------	38	38
Total	22,116	83	30,255	66,224	21,894	------	33,419	68,730
Southeastern States:								
Alabama	914	411	------	1,326	W	389	------	W
Georgia	------	183	------	183	------	237	------	237
North Carolina	------	------	------	------	------	------	W	W
Total	914	594	------	1,509	W	626	W	237
Northeastern States:								
New York, Pennsylvania, Virginia	------	------	3,963	3,963	------	------	3,800	3,800
Western States:								
Arizona	W	------	W	W	18	------	------	18
California	W	------	W	W	W	------	W	W
Colorado	------	W	W	W	------	W	------	W
Idaho	------	------	W	W	------	------	W	W
Missouri	------	------	W	W	------	------	W	W
Montana	------	------	12	12	------	------	13	13
Nevada	W	------	W	W	W	------	W	W
New Mexico	------	------	W	W	------	------	W	W
Texas	------	[2] W	------	[2] W	------	[2] W	------	[2] W
Utah	W	------	W	1,813	W	------	W	2,071
Wyoming	W	------	W	2,002	W	------	W	1,965
Total	W	W	12	3,827	18	W	13	4,067
Undistributed	11,597	[2] 501	15,101	9,614	17,587	[2] 942	9,301	10,765
Total all States [1]	34,627	[2] 1,177	49,331	85,137	39,499	[2] 1,568	46,533	87,599
Byproduct ore [3]	------	------	------	728	------	------	------	661
Grand Total [1]	34,627	[2] 1,177	49,331	85,865	39,499	[2] 1,568	46,533	88,260

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Data may not add to totals shown because of independent rounding.
[2] Includes a small quantity of siderite.
[3] Cinder and sinter obtained from treating pyrites. Ore was treated in Arizona, Colorado, Delaware, Pennsylvania, Tennessee, and Virginia (1968).

Table 7.—Usable iron ore produced in the United States, by districts, States, and types of products

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

District and State	1968				1969			
	Direct shipping ore	Agglomerates	Concentrates	Iron content (natural percent)	Direct shipping ore	Agglomerates	Concentrates	Iron content (natural percent)
Lake Superior:								
Michigan	2,440	10,772	557	60	2,014	10,879	523	61
Minnesota	5,002	30,255	17,197	58	5,461	33,381	16,433	59
Wisconsin	------	------	------	--	------	38	------	62
Total	7,442	41,027	17,754	59	7,475	44,298	16,965	59
Southeastern States:								
Alabama	323	------	1,003	39	W	------	934	39
Georgia	------	------	183	48	------	------	237	50
North Carolina	------	------	------	--	------	------	W	W
Total	323	------	1,186	40	W	------	1,171	41
Northeastern States:								
New York, Pennsylvania, Virginia	------	W	W	W	------	W	W	W
Western States:								
Arizona	W	------	------	W	18	------	------	59
California	W	W	W	W	W	W	W	W
Colorado	W	------	------	W	W	------	------	W
Idaho	W	------	------	W	W	------	------	W
Missouri	------	W	W	W	------	W	W	W
Montana	12	------	------	45	13	------	------	45
Nevada	W	------	W	W	W	------	W	W
New Mexico	------	------	17	58	W	------	------	W
Texas	------	W	W	W	W	W	W	W
Utah	1,258	------	555	53	1,361	------	710	53
Wyoming	W	W	W	W	W	W	W	W
Total	1,270	W	572	45	1,392	W	710	53
Undistributed	530	9,350	5,682	58	923	10,018	4,655	61
Total all States [1]	9,565	50,377	25,194	58	9,790	54,316	23,501	59
Byproduct ore [2]	------	728	------	67	------	661	------	67
Grand Total [1]	9,565	51,105	25,194	59	9,790	54,977	23,501	59

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Data may not add to totals shown because of independent rounding.
[2] Cinder and sinter obtained from treating pyrites.

Table 8.—Shipments of usable iron ore from mines in the United States in 1969

(Thousand long tons and thousand dollars; exclusive of ore containing 5 percent or more manganese)

District and State	Gross weight of ore shipped				Iron content of ore shipped				
	Direct shipping ore	Agglomerates	Concentrates	Total quantity[1]	Direct shipping ore	Agglomerates	Concentrates	Total quantity[1]	Total value[1]
Lake Superior:									
Michigan	1,972	11,657	429	14,058	1,023	7,340	233	8,596	169,756
Minnesota	5,461	33,693	17,802	56,957	2,812	20,962	9,654	33,428	570,446
Wisconsin	------	36	------	36	------	23	------	23	W
Total	7,433	45,386	18,231	71,051	3,835	28,325	9,887	42,047	740,202
Southeastern States:									
Alabama	W	------	1,016	W	W	------	406	W	6,435
Georgia	------	------	241	241	------	------	127	127	1,338
North Carolina	------	------	W	W	------	------	W	W	W
Total	W	------	1,257	241	W	------	533	127	7,773
Northeastern States:									
New York, Pennsylvania, Virginia	------	W	W	3,404	------	W	W	2,192	48,080
Western States:									
Arizona	18	------	------	18	11	------	------	11	136
California	W	W	W	W	W	W	W	W	W
Colorado	W	------	------	W	W	------	------	W	W
Idaho	W	------	------	W	W	------	------	W	W
Missouri	------	W	W	W	------	W	W	W	W
Montana	13	------	------	13	6	------	------	6	W
Nevada	W	------	W	W	W	------	W	W	W
New Mexico	W	------	------	W	W	------	------	W	W
Texas	W	W	W	W	W	W	W	W	W
Utah	1,399	------	522	1,921	721	------	246	967	12,552
Wyoming	W	W	W	2,048	W	W	W	1,194	20,751
Total	1,430	W	522	4,000	738	W	246	2,178	33,439
Undistributed	834	10,202	4,558	11,158	454	6,398	2,751	6,622	99,797
Total all States[1]	9,697	55,588	24,568	89,854	5,027	34,723	13,417	53,166	929,291
Byproduct ore[2]	------	727	------	727	------	486	------	486	8,066
Grand total[1]	9,697	56,315	24,568	90,581	5,027	35,209	13,417	53,652	937,357

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] Data may not add to totals shown because of independent rounding.

[2] Cinder and sinter obtained from treating pyrites. Ore treated in Arizona, Colorado, Delaware, Pennsylvania, Tennessee, and Virginia.

Table 9.—Iron ore produced in the Lake Superior district, by ranges

(Thousand long tons and exclusive after 1905 of ore containing 5 percent or more manganese)

Year	Marquette	Menominee	Gogebic	Vermilion	Mesabi	Cuyuna	Spring Valley	Black River Falls	Total[1]
1854–1964	330,808	283,584	319,362	101,840	2,463,124	66,668	6,611	--	3,571,997
1965	8,973	4,595	810	782	50,280	367	625	--	66,432
1966	9,589	4,620	113	704	51,506	1,299	772	--	68,603
1967	10,231	3,792	49	202	48,857	1,041	58	--	64,229
1968	10,086	3,684	-------	-------	51,411	961	83	--	66,224
1969	10,048	3,369	-------	-------	55,275	------	-----	38	68,730
Total[1]	379,735	303,644	320,334	103,528	2,720,453	70,336	8,149	38	3,906,215

[1] Data may not add to totals shown because of independent rounding.

Table 10.—Average analyses of total tonnage (bill-of-lading weights) of all grades of iron ore from all ranges of Lake Superior district

Year	Thousand long tons	Content, percent[1]					
		Iron	Phosphorus	Silica	Manganese	Alumina	Moisture
1965	64,689	56.85	0.068	8.16	0.48	1.00	6.10
1966	69,724	56.83	.068	7.99	.55	1.02	6.21
1967	63,845	57.81	.059	7.62	.47	.93	5.70
1968	64,065	58.70	.051	7.35	.40	.80	5.16
1969	71,389	59.04	.045	7.32	.45	.69	4.82

[1] Iron on natural basis; phosphorus, silica, manganese, and alumina on dried basis.

Source: American Iron Ore Association.

Table 11.—Consumption of iron ore and agglomerates in the United States in 1969

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

State	Iron ore[1]		Agglomerates[2]		Miscellaneous[3]	Total
	Blast furnaces	Steel furnaces	Blast furnaces	Steel furnaces		
Alabama, Kentucky, Tennessee, and Texas	7,641	155	4,817	---	117	12,730
California, Colorado, Utah	5,286	366	2,776	---	79	8,507
Ohio and West Virginia	19,841	488	6,642	W	W	26,971
Illinois and Indiana	19,143	432	11,467	W	W	31,042
Michigan and Minnesota	7,897	78	2,753	W	50	10,778
Maryland, New York, and Pennsylvania	23,366	1,195	24,728	W	51	49,340
Undistributed	------	-----	------	704	163	867
Total[4]	83,174	2,715	53,182	704	460	140,235

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Includes 48,323,000 tons of pellets and nodules produced at mines.
[2] Does not include agglomerate produced at mine site.
[3] Includes iron ore used in making paint and cement, also ore consumed in ferroalloy furnaces.
[4] Data may not add to totals shown because of independent rounding.

Table 12.—Beneficiated iron ore shipped from mines in the United States[1]

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

Year	Beneficiated	Total	Proportion of beneficiated to total (percent)
1965	64,667	84,073	76.9
1966	70,451	90,041	78.2
1967	66,243	82,415	80.3
1968	72,781	81,934	88.8
1969	80,157	89,854	89.2

[1] Excludes byproduct ore.

Table 13.—Usable iron ore[1] consumed in agglomerating plants and agglomerate produced from this ore in 1969, by states

(Thousand long tons)

State	Iron ore consumed[1]	Agglomerate produced
Alabama, Kentucky, Texas	3,171	3,734
California, Colorado, Utah	2,249	2,781
Ohio and West Virginia	4,770	6,121
Illinois, Indiana, Michigan	9,387	11,963
New York, Maryland, Pennsylvania	14,524	17,704
Total	34,101	42,303

[1] Does not include material used in agglomerate produced at mine site.

Table 14.—Production of agglomerates [1] in the United States, by types

(Thousand long tons)

Type	Agglomerate produced	
	1968	1969
Sinter, nodules, and cinder	[2] 43,605	[3] 46,585
Pellets	48,526	53,458
Total	92,131	100,043

[1] Production at mines and consuming plants.
[2] Includes 18,710 thousand tons of self-fluxing sinter.
[3] Includes 21,036 thousand tons of self-fluxing sinter.

Table 15.—Stocks of usable iron ore at mines [1] Dec. 31, by districts

(Thousand long tons)

District	1968 [r]	1969
Lake Superior	10,330	8,009
Southeastern States	612	678
Northeastern States	3,768	4,164
Western States	1,331	939
Total	16,041	13,790

[r] Revised.
[1] Excluding byproduct ore.

Table 16.—Average value of usable iron ore shipped from mines or beneficiating plants in the United States in 1969

(Per long ton)

District	Direct-shipping ore			Concentrates			Agglomerates
	Hematite	Limonite	Magnetite	Hematite	Limonite	Magnetite	
Lake Superior	$7.01	----	----	$7.47	W	----	$12.17
Southeastern	W	----	----	W	$5.53	W	------
Northeastern	----	----	----	----	----	W	14.23
Western	6.19	W	$6.83	W	W	W	11.89
Total	6.90	W	6.83	7.42	7.49	$6.08	12.26

W Withheld to avoid disclosing individual company confidential data.

Table 17.—U.S. exports of iron ore, by countries

(Thousand long tons and thousand dollars)

Destination	1967		1968		1969	
	Quantity	Value	Quantity	Value	Quantity	Value
Canada	2,258	$29,069	2,278	$28,113	2,085	$26,255
Germany, West	43	270	53	349	62	409
Japan	3,602	42,179	3,550	42,314	3,009	35,529
Other countries	3	67	3	59	4	117
Total	5,906	71,585	5,884	70,835	5,160	62,310

Table 18.—U.S. imports for consumption of iron ore, by countries

(Thousand long tons and thousand dollars)

Country	1967		1968		1969	
	Quantity	Value	Quantity	Value	Quantity	Value
Angola	------	-------	------	-------	50	$701
Australia	1	$18	131	$1,884	315	3,556
Brazil	1,624	14,744	1,257	11,622	1,233	11,300
Canada	24,214	276,597	26,339	308,014	19,004	219,698
Chile	1,365	11,286	1,441	11,515	1,783	14,371
Liberia	3,099	23,737	2,942	23,389	3,144	27,227
Norway	436	2,217	360	2,646	269	1,937
Peru	879	9,404	925	9,375	1,003	10,738
Sweden	148	1,840	232	2,610	155	1,659
Venezuela	12,820	103,718	10,313	83,153	13,751	110,745
Other	25	357	1	45	51	597
Total	44,611	443,918	43,941	453,753	40,758	402,529

Table 19.—U.S. imports for consumption of iron ore, by customs districts

(Thousand long tons and thousand dollars)

Customs district	1968		1969	
	Quantity	Value	Quantity	Value
Baltimore	9,261	$90,389	9,500	$91,586
Bridgeport	4	45	------	-------
Buffalo	2,546	32,735	2,505	33,795
Chicago	6,724	78,919	4,399	47,542
Cleveland	8,796	94,873	6,620	69,126
Detroit	1,381	20,071	1,095	16,126
Houston	775	8,981	687	7,809
Los Angeles	33	231	------	-------
Mobile	3,943	34,309	4,171	36,805
New Orleans	647	5,670	458	4,204
Norfolk	306	2,887	96	941
Ogdensburg	52	859	18	415
Pembina	24	347	------	-------
Philadelphia	9,445	83,371	11,070	92,470
Portland, Ore	------	-------	126	1,632
Other	4	66	13	78
Total	43,941	453,753	40,758	402,529

Table 20.—World production of iron ore, iron ore concentrates, and iron ore agglomerates, by countries [1]

(Thousand long tons)

Country	1967	1968	1969 p
North America:			
Canada	r 37,783	47,443	40,001
Mexico (60 percent Fe equivalent)	2,653	3,151	3,440
United States	84,179	85,869	89,241
South America:			
Argentina	r 222	273	e 295
Brazil	r 21,946	24,726	e 32,500
Chile	r 10,613	11,729	11,453
Colombia	795	569	346
Peru	r 8,450	8,873	8,936
Venezuela	r 16,736	15,934	19,412
Europe:			
Albania [2]	r 403	e 400	e 400
Austria	3,418	3,427	3,919
Belgium	87	e 90	92
Bulgaria	2,459	2,603	2,657
Czechoslovakia	1,884	1,547	1,547
Denmark	56	e 55	e 40
Finland [3]	r 926	e 850	870
France	48,443	54,365	54,525
Germany:			
East	1,653	1,392	e 1,380
West	r 6,679	6,345	5,965
Greece	17	12	------
Hungary	r 704	628	669
Italy [3]	1,068	1,041	661
Luxembourg	6,204	6,292	6,211
Norway	r 3,184	3,645	3,735
Poland	3,026	3,002	2,777
Portugal	194	201	161
Rumania	2,752	2,704	e 2,660
Spain	r 4,987	6,087	6,154
Sweden	r 27,889	31,908	32,661
U.S.S.R	r 165,588	173,825	183,061
United Kingdom	12,740	13,715	12,104
Yugoslavia	2,539	2,677	2,678
Africa:			
Algeria	r 2,498	3,030	e 3,450
Angola	1,136	3,167	5,391
Liberia	17,936	19,262	22,505
Mauritania	7,334	7,581	8,440
Morocco	870	794	737
Rhodesia, Southern	689	1,279	e 1,280
Sierra Leone	r 2,862	2,953	2,323
South Africa, Republic of	7,615	8,103	8,649
Swaziland	1,715	2,018	2,267
Tunisia	904	1,000	e 980
United Arab Republic	416	440	453
Asia:			
China, mainland e [4]	27,500	37,400	39,400
Hong Kong	142	159	163
India [5]	25,744	27,000	27,857
Japan [6]	2,184	2,137	1,826
Korea:			
North e	6,400	6,900	7,400
South	687	817	699
Malaysia	5,350	5,085	5,150
Philippines	1,455	1,332	1,536
Taiwan	13	6	8
Thailand	540	492	469
Turkey	1,462	1,958	2,391
Oceania:			
Australia	r 16,887	25,977	38,478
New Caledonia	201	169	------
New Zealand	3	3	e 3
Total [7]	612,820	674,440	712,406

e Estimate. p Preliminary. r Revised.

[1] Table does not include Guatemala, Uruguay, and a few additional countries where iron-bearing materials are produced for manufacture of cement and other materials, or in countries where production is for exploration or metallurgical testing only.

[2] Iron-nickel ore.

[3] Includes pelletized iron oxide derived from pyrite.

[4] Roughly containing 50 percent iron.

[5] Including production from Goa, as follows: 1967, 7,086; 1968, 6,748; and 1969, 6,899.

[6] Including production from iron sands, as follows: 1967, 1,108; 1968, 1,096; and 1969, 885.

[7] Totals are of listed figures only.

Iron and Steel

By F. E. Brantley [1]

The year 1969 was marked by a record high for domestic raw steel [2] production of 141.3 million tons, a downturn in iron and steel imports, and a decided upturn in exports.

The industry as a whole, departing from the pattern of 1968 when imports reached a record high of 18 million tons, was less concerned with passing restrictive import legislation and more interested in taking advantage of the increased market opportunities both at home and overseas. As a world boom developed for iron and steel mill products, the inability of Western European steelmakers and Japan to meet the full needs of the market demands became apparent, resulting in increased export sales by U.S. mills, particularly to European countries.

Price trends were upward, reflecting both labor and raw material cost advances as well as shortages in certain categories, such as flat rolled products and nickel-bearing steels. Coking coal became a major concern for some U.S. as well as European and Japanese steelmakers.

A rising need for increased capital expenditures for equipment to meet pollution regulations added to the problem of reducing production costs. Total plant and equipment expenditures by the steel industry for 1969 amounted to $2.1 billion, slightly less than expenditures for 1968 which reached $2.4 billion.

In spite of the record steel output, the industry's profits failed to match those of most other industrial sectors, and diversification was turned to more and more by the larger steelmakers in order to raise the desirability and profitability of steel stocks. Real estate development, manufacture of mobile homes, and leasing of major items of industrial and transporation equipment were some of the new ventures appearing under the financial structure of the individual steel companies during the year. At least one company established a subsidiary to serve as a vehicle for entering new fields of diversification.

For the first time some of steel industry's larger companies were either taken over or merged with outside interests. Two were the Jones & Laughlin Steel Corp., which became a part of Ling-Temco-Vought, Inc. (LTV), and The Youngstown Sheet and Tube Co., which merged with the Lykes Corp., to form the Lykes-Youngstown Corp.

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[1] Physical scientist, Division of Ferrous Metals.

[2] The term raw steel, as used by the American Iron and Steel Institute, includes ingots, steel castings, and continuously cast steel. It corresponds to the term crude steel as used by the United Nations.

Table 1.—Salient iron and steel statistics

(Thousand short tons)

	1965	1966	1967	1968	1969
United States:					
Pig iron:					
Production	88,207	91,287	86,799	88,767	95,003
Shipments	88,391	90,884	86,819	89,085	95,472
Exports	28	12	7	9	44
Imports for consumption	882	1,187	605	786	407
Steel: [1]					
Production of raw steel:					
Carbon	116,651	118,732	113,190	116,269	124,832
Stainless	1,493	1,651	1,451	1,432	1,569
All other alloy	13,318	13,718	12,572	13,761	14,861
Total	131,462	134,101	127,213	131,462	141,262
Index (1957–59) =100	135.3	138.1	131.0	135.0	145.4
Total shipments of steel mill products	92,666	89,995	83,897	91,856	93,877
Exports of major iron and steel products	2,888	2,144	1,898	2,460	5,512
Imports of major iron and steel products [2]	10,640	11,043	11,446	17,893	14,019
World production:					
Pig iron [3]	369,000	382,000	393,000	425,000	460,000
Raw steel (ingots and castings)	506,000	524,000	544,000	584,000	633,000

[1] American Iron and Steel Institute. Includes ingots, continuous cast steel and all other cast forms.
[2] Data not comparable for all years.
[3] Includes ferroalloys.

PRODUCTION AND SHIPMENTS OF PIG IRON

Production of pig iron in the United States increased by 7 percent over that of 1968 and exceeded the previous record set in 1966, 91 million tons, by 4 million tons. The 95 million tons produced required a total of 59,054 blast furnace days, with an average production of 1,609 tons per blast furnace day, according to the American Iron and Steel Institute (AISI). There were 228 blast furnaces, including 5 ferroalloy furnaces, reported on the last day of 1969, a net loss of 2 during the year. Of these, 169, including 2 ferroalloy furnaces, were in blast at yearend compared with 154, including 4 ferroalloy furnaces, in blast at the beginning of the year. Over half of those operating were located in three States —Pennsylvania, Ohio, and Indiana.

The United States Steel Corp. reported that it would have a new blast furnace with a capacity of about 1.5 million tons per year in operation near Chicago in the summer of 1970. Several other companies during the year also were modifying or had planned changes to install furnace facilities to increase efficiency.

Metalliferous Materials Consumed in Blast Furnaces.—Total net iron ore including agglomerates consumed in the blast furnaces was 150 million tons. The total tonnage of materials used to produce agglomerates in 1969 contained 81.5 percent ore, fines, and concentrates. The remainder consisted of scale, coke, limestone, and small amounts of other materials. Pellets charged to the blast furnaces amounted to 58.5 million tons and sinter amounted to 49.9 million tons. Total metalliferous materials consumed per ton of pig iron produced was 1.682 tons, slightly less than the average for the prior 5-year period.

According to AISI, total blast furnace oxygen consumption was 9.1 billion cubic feet, compared with 6.7 billion in 1968 and 8.7 billion in 1967.

Bureau of Mines data collected from the iron and steel industry showed that 52.1 billion cubic feet of natural gas, 4.4 billion cubic feet of coke-oven-gas, and 120.8 million gallons of oil were consumed by blast furnaces in 1969.

PRODUCTION AND SHIPMENTS OF STEEL

The sharp upward trend in steel production that began in October 1968, after the year's lowest monthly average was reached in September, continued into 1969. Rising from a September weekly average of 1.9 million tons to a weekly average of 2.8 million tons in April, 1969 domestic output leveled off for the remainder of the year at an average rate of 2.7 to 2.8 million tons per week.

Total production of domestic steel, designated as raw steel by the AISI to include ingots, steel castings, and continuously cast steel, was 141.3 million tons. The steel index, based on average production of the three years 1957–59 as 100, was 145.4, compared with the 1968 index of 135.0. Open-hearth furnaces produced 43.1 percent of the domestic steel, the basic oxygen process (BOP) accounted for 42.7 percent, and electric furnaces the remainder. BOP steel gained 25 percent over 1968 production, and electric furnace steel gained 20 percent, while the open-hearth production declined 8 percent as new basic oxygen and electric furnaces went on line and open hearths were retired from service. August marked the end of the open-hearth furnace as the major steelmaking method, and the BOP led for the remainder of 1969. Net mill shipments of steel products in 1969 totaled 93.9 million tons, compared with 91.9 million tons in 1968. There were no major changes in percentages of market destinations other than the large export increase which took 5.9 percent of the total shipments compared with 2.7 percent in 1968; automotive shipments declined from 21.0 percent to 19.5 percent.

Materials Used in Steelmaking.—Pig iron continued to account for the highest percentage of metallics charged to the steelmaking furnaces. For each ton of domestic steel produced in 1969, the average metallics consumption was 1,192 pounds of pig iron, 1,053 pounds of scrap, and 47 pounds of iron ore including agglomerates. In 1968 the requirements were, in pounds, 1,216, 1,024, and 63, respectively. By comparison in 1964 each ton of steel required 1,353 pounds of pig iron, 1,103 pounds of scrap, and 142 pounds of ores. The shift from open hearth operations to the BOP and electric-arc furnace steelmaking has been the primary reason for the variations.

According to the AISI, the steelmaking furnaces in 1969 consumed 554,562 tons of fluorspar, 26.61 million tons of limestone, 5.73 million tons of lime, and 681,753 tons of other fluxes. Oxygen consumption in the furnaces totaled 183.4 billion cubic feet; 62.2 percent in the basic oxygen converters; 32.0 percent in the open hearths; and 5.8 percent for electric steelmaking furnaces.

CONSUMPTION OF PIG IRON

Domestic consumption of pig iron in steel furnaces increased in 1969 over 1968 by 5 percent. For the first time basic oxygen converters comsumed more than one-half of the pig iron going to furnace use, accounting for 53 percent, compared with 43 percent for the open hearths. Shipments made by the producers of pig iron for other than own use increased by 19 percent, reaching approximately 3.9 million tons for the year.

PRICES

Prices increased generally throughout the year for a wide range of steel mill products, following the pattern established in 1968. Announced price boosts by an individual steelmaker were usually met within a relatively short time by other producers. There was one difference in that increases, once made, tended to remain firmer than in 1968. However, near the end of the year a system of pricing using theoretical weight per square foot as a base for dimensional orders for certain types of steel, rather than the previously used actual weight system, became general practice in the industry. This option was offered by a number of companies for purchase of sheet steel products and carried an extra charge in the range of $2 to $6 per ton. Even so, overall savings to the consumer were reported to be well in excess of the extra charges and the new system gave the buyer, dimensionally speaking, the exact amount ordered.

Stainless nickel-bearing steel prices had the largest increases during the year, with three price rounds announced by most producers. Shortage of nickel and its accompanying rapid upward-price reaction was cited as the major cause. Increases also occurred in prices of other stainless alloying elements such as chromium, molybdenum, and manganese.

The composite price of pig iron, according to *Iron Age*, increased from $56.38 per short ton at the beginning of the year to $58.13 at yearend, while the composite base price of finished steel rose from the equivalent of $130.76 per short ton to $145.26 per short ton. Carbon steel plate increases of $7 were posted by most producers in July and brought the price of this product to $129 per short ton in most sections of the country. The price of high-grade commercial iron powder was reported at about 11.5 cents per pound with imported powder about 3 cents per pound less.

FOREIGN TRADE

A voluntary agreement by the major steel producers of Japan and the European Common Market countries was made which would limit steel shipments to the United States to a total of 14 million tons in 1969. The agreement, made with assistance of the U.S. State Department, was to be valid through 1971 and had the effect of reducing demands for immediate import legislation in the United States, since a majority of steelmakers appeared willing to allow the verbal pact a trial period. The acceptance of the agreement was considered important as United States commitments made under the General Agreement on Trade and Tariffs (GATT) would have been abridged by the application of tariffs or quotas.

Steel exports to the United States in 1969 were to be limited by Japan to 5.75 million tons and by Common Market members to 5.57 million tons. The remainder, approximately 2.7 million tons, was to be alloted other steel exporters, primarily Canada and the United Kingdom, although neither was a party to the quota agreement; actual shipments by the two countries to the United States amounted to 1.7 million tons in 1969.

Total imports of steel mill products into the United States in 1969 were 14.0 million tons, with Japan exceeding its 5.75 million-ton limit by 8 to 9 percent. However, the Japanese steel industry indicated that their 1970 shipments would be reduced by this amount, taking into account a 5 percent increase which was allowed each year under the agreement. With the 5 percent increase, U.S. steel imports could reach 14.7 million tons in 1970 and 15.4 million in 1971.

United States exports of major iron and steel products rose to 5.5 million tons in 1969, an impressive 124-percent gain over the 2.5 million tons exported in 1968. This increase resulted partly from steel strikes in Canada and several of the Western European steel-producing countries, from a worldwide rising consumer demand for steel products, increased construction in many countries, and indirectly from the failure of some Eastern European countries, particularly the U.S.S.R., to meet previously projected steelmaking targets. Consequently, these nations found it necessary to import steel products for domestic use which were in short supply rather than being able to export. Efforts were being made to increase production capacity by stepped-up purchases of rolling and finishing mills from free-world sources. Meanwhile, domestic steelmakers expected foreign demand for semifinished steel to continue at the higher level set in 1969.

WORLD REVIEW

The world's steel output reached a new high of 633 million tons in 1969, a gain of approximately 8 percent over the 1968 production of 584 million tons. With the exception of Italy and Canada, gains were registered in all the major steelmaking countries of the world. Strikes in the industrial sector of Italy were reported as responsible for over 1.5 million tons of lost production in that country, which resulted in an adverse trade balance for steel. West Germany also experienced production losses because of strikes but ended the year with a 10-percent increase over its 1968 steel production. Japan's steel industry had the highest percentage increase, 24 percent, and prepared for further increases in the 1970's. Overall world capacity for producing raw steel was believed to be at least 10 percent above the 1969 production figure, with additional facilities being added in practically all of the larger producing countries. However, shortages developed for specific items in 1969 such as nickel-bearing stainless steels due to nickel shortages, and certain flat rolled steel products such as thin coil and galvanized sheet, due largely to insufficient finishing facilities.

The International Iron and Steel Institute (IISI) held its third annual meeting in Tokyo in October. The Institute's 95 member companies from 24 countries represented about 95 percent of the free world's steel production. An objective of the organization is to promote better understanding of the internation aspects of the industry. The scope of the association's activities was expanded during the meeting by setting up a committee on steelmaking raw materials. The United Nations continued its studies of the world steel situation through the steel committee of the Economic Commission for Europe. A report was presented on the year's work which emphasized the contribution made to international cooperation in the world steel market between both industrialized and developing countries.

Studies were published by the United Nations titled, "World Trade in Steel and Steel Demand in Developing Countries," "Principal Factors Affecting Labour Productivity Trends in the Iron and Steel Industry," "Automation in the Iron and Steel Industry," and "Economic Aspects of Computer Control of the Oxygen Steelmaking Process." Studies under way included problems dealing with air and water pollution in the industry and with iron and steel scrap. New uses of steel were also being studied by the U.N. Steel Committee.

European Coal and Steel Community (ECSC).—Unprecedented demand for steel products both within ECSC and from outside customers raised raw steel production to a record of 118 million tons, about 9 percent more than produced in 1968. This was accomplished in spite of slowdowns in several ESCS countries due to strikes. Italy was the only country failing to better its 1968 record, with a 2 percent decline, due to a combination of strikes.

Significant sales were made to East European countries, particularily of flat-rolled products. Scarcity developed in several product lines including reinforcing bars, wire rods, and pipe. Overall, the increased market demand was reflected in an increase in imports from the United States and a decrease in exports to this country.

Algeria.—The first production from the new El Haajar iron and steel works at Annaba was shipped in August. The shipment, 15,000 tons of pig iron for Japan, was to be followed by additional pig iron exports pending completion of domestic steelmaking facilities scheduled for 1970.

Australia.—An international group headed by Armco Steel Corp., and including Hamersley Iron Pty. Ltd., and Conzinc Rio Tinto of Australia Ltd. were making a 2-year study on the economics of establishing a new steel complex in Australia. A Jervis Bay site, 100 miles south of Sydney, where Armco owns a block of land, was mentioned as the possible location, if the feasibility study proved favorable. An estimate of the investment was placed at about $350 million.

A major new steelmaking plant was being planned for Victoria on Westernport Bay, by the Broken Hill Pty. Co. Ltd. (BHP), Guest, Keen Nettlefords Ltd. of England, and John Lysaght (Australia) Ltd. This combine, pending agreement with the State Government, would have the first phase of the plant operating in 1972, and would coordinate the present steelmaking operations of the participants, eventually forming a multi-million-ton fully-integrated complex.

BHP also announced plans for a steelmaking center at Port Kembla, about 50 miles south of Sydney at the Hoskins Kembla works of a subsidiary company, Australian Iron and Steel Pty., Ltd. (AIS). The cost was estimated at $110 million and would raise steelmaking capacity by about 2 million tons annually. Plans include a new blast furnace and a basic oxygen steelmaking shop. The blast furnace, No. 5 for AIS, is to be constructed by IHI of Japan at a cost of approximately $22 million; operation is set for early 1971. Another BHP subsidiary, Commonwealth Steel Co., Ltd. (Comsteel) is slated to have a $15 million expansion at its stainless steel plant at Unanderra, near Port Kembla, increasing the annual capacity by 30,000 tons. Australian steel production under present plans is expected to expand from the 6.8-million-ton output in 1969 to about 9 million tons in 1971, and to 30 million tons in 1980.

Canada.—A government-controlled steelmaking corporation, Sidérurgie du Québec

(SIDBEC), acquired more than 90 percent of the shares of Dominion Steel and Coal Corp. Ltd. (Dosco), and assumed operation of four main divisions of Dosco near the first of the year. These divisions were: A rolling mill at Contrecoeur, Quebec; electric steel furnaces, a casting mill and wire plant in Montreal; a wire and nail plant in Ontario; and a steel fabricating plant at LaSalle, Quebec. Resale of other Dosco divisions to the parent organization, Hawker Siddeley Canada Ltd., reduced SIDBEC's cost for the divisions retained to about $20 million. Operations in 1969 were reported to be profitable, and a 3-year plan to invest $80 to $90 million was announced that would make the reorganization a fully integrated steel complex. The plan included facilities for pellet production and electric furnace steelmaking at Contrecoeur.

Long range plans of The Steel Co. of Canada Ltd. (Stelco) were released which envisioned a fully automated steel plant on a 6,600-acre plot acquired on the northern shore of Lake Erie near Nanticoke, which would be producing about 15 million tons of steel annually in 25 years. Dominion Foundries and Steel Ltd. (Dofasco) also was reported to have purchased an option on 5,000 acres on Lake Erie within 40 miles of the Stelco site for similar use as a future steel complex. Stelco expected the country's steelmaking capacity to more than double by 1980 from the 11 to 12-million-tons-per-year average in recent years.

Pollution control projects were being increased by the major steelmakers. Stelco, in a 5-year program, included immediate plans to eliminate waste pickle liquor discharges into Hamilton Bay at the Hilton plant by converting all pickling lines to the hydrochloric acid (HCl) process at a cost of $5 million. Dofasco also announced plans to convert the firm's pickling lines at Hamilton to the HCl process which allows reuse of the acid. The cost was given at $0.5 million. Algoma planned to install a $1 million phenol recovery plant in 1970 to prevent discharge of this pollutant into St. Mary's River from its Sault Ste. Marie operation.

Brazil.—In a move to decrease steel imports the Government issued a decree-law (No. 569 of May 7, 1969) which exempted from import taxes all imported raw materials, materials for consumption, and equipment for the operation, modernization or expansion of steel plants. This was to be in effect for 30 months.

Several plans drawn up in 1969, and the 2 preceding years were to provide for rapid steel expansion in the next few years. One installation owned by the Aços Finos Piratini Co. and costing about $50 million was expected to begin operation in 1970 at Charqueadas, Rio Grande do Sol. The Cia. Siderúrgica Paulista (COSIPA) was to double its steel ingot capacity, reaching 1 million tons by 1972, and the Intendente Câmara plant of Usinas Siderūrgicas de Minas Gerais, was to be increased from 624,000 metric tons to 1.4 million metric tons per year.

Charcoal is still used in Brazil for the production of over 1 million tons of pig iron annually. Under the present Forestry Code the steel plants using this process must create and maintain their own forest reserves.

Chile.—Steel expansion plans established in 1967 for Cía de Acero del Pacífico, S.A. (CAP), Chile's major steel producer, were revised during the year. The former target of 1 million metric tons capacity by 1971 was changed to 800,000 tons by 1973, due to financing problems and improvements needed in the company's present operations. A signed loan agreement with French, British, and Austrian interests to supply $18 million in foreign credits was the basis for placing equipment orders during the year for an oxygen converter shop, and January 1973 has been set for operation of two 100-ton converters. A new electrolytic tinplate line was completed and is expected to satisfy most of the domestic requirements previously supplied by imports.

Establecimientos Metalúrgicos Indac S.A. (INDAC) planned for a new plant in Rengo, south of Santiago to make high carbon and alloy steels. Production capacity was expected to be about 33,000 tons of ingots and 23,000 tons of rolled products on a one-shift operation. A contract was reported to have been awarded in 1968 to the Japanese firm Ishikawajima-Harima Heavy Industries Co., Ltd. (IHI), valued at about $4 million with construction to start in early 1970.

Colombia.—Colombia's only integrated steelmaker, Acerías Paz del Río S.A., proceeded with its expansion program to install a new blooming mill and a hot roll mill. Financing was sought for a new cold roll mill to complement the hot roll mill and to have the mill operating in 1971 or 1972. Each of the mills would have a capacity of 100,000 tons annually. Also planned is a second blast furnace for future installation.

Three smaller steel companies were in the process of installing electric furnaces that would provide a combined capacity of 60,000 tons annually.

Finland.—A $60 million expansion program of Rautaruukki Oy was under way during the year. This involved construction of a hot rolling mill at Raahe and a cold rolling mill plus a continuous galvanizing line with a hydrochloric acid (HCl) treatment plant at Hämeenlinna. All units were expected to be completed by 1972 and to greatly increase Finland's self-sufficiency in a number of major steel products such as galvanized roofing.

France.—The upsurge in demand for steel during the past 2 years, especially for internal consumption, coupled with the necessity to compete with large coastal steel complexes in other countries, resulted in agreement between French industry and the French Government to erect a new steel works with a capacity of about 7 million tons per year. The new complex would be a joint venture, tentatively planned for Fos-sur-Mer near Marseilles, at an estimated cost of $800 million, with a target date of 1973–75. Rolling mills to produce products that have been in short supply, such as thin plate, would be given installation priority. France had an effective annual steel capacity of 24.3 million tons at the beginning of 1969, and the new complex would increase its production capability by about 30 percent.

Germany, West.—A trend to reduce the Nation's independent steel producers to a limited number of large combines continued as a partial merger of August Thyssen-Huette AG (ATH) and Mannesmann AG, was approved by the Commission of the European Economic Community (ECC). All domestic pipe-making facilities of the two companies were combined under the name Mannesmannroehren-Werke, and in 1969 represented 75 percent of the national output.

Construction of a $40 million electric-arc-furnace steel mill, including a Midland-Ross metallized-pellet plant, was started in Hamburg. Scheduled to begin production early in 1971, the capacity will be 500,000 tons of products such as wire rod and bar steel. Korf Industrie and Handel GmbH. K. G., Baden-Baden, joined the Midland-Ross Corp. of Cleveland on a 50-50 basis to erect the mill.

Hoesch A.G., Dortmund, was reported to be planning a new joint steel complex with Hoogovens of the Netherlands. The site would be near Rotterdam, with the crude steel production to start in 1974 at about 2.5 million tons annually for the first phase.

India.—Three new steel plants were provided for in the Fourth 5-year Plan (1969–74); these would be constructed during the Fifth plan (1975–79) and together with the Bokaro plant which was under construction, was expected to raise India's steelmaking capacity to about 20 million tons. A revision in the expected completion date for the Bokaro plant moved it from 1969 to June 1972.

India's five integrated steel plants had a total capacity of 9.8 million short tons annually; 3.3 million tons in two private-sector plants, and the remainder in three public-sector plants.

Shortages of pig iron developed for domestic uses in 1969. This was due largely to increased exports, and caused the Government to place restrictions on shipments of pig iron and billet for 1970. Japan was the principal pig iron market.

Italy.—Domestic steel consumption continued at a high rate, with the per capita increase for 1967–69 reaching approximately 13 percent. Although Italy's steel producers showed a slight production drop from 1968, a need for new capacity was apparent based on future market forecasts. Italy's production capacity, about 19.1 million tons at the start of 1969, increased to an estimated 20 million tons during the year.

An expansion was underway during the year at the Taranto plant of the Finsider group to raise the annual steel capacity from 2.6 million tons to about 4.5 million tons. Installation of a 300-ton basic oxygen converter, said to be the largest in Europe, was the major project. The possibility of erecting a new steelworks was reported to be under study for future consideration.

Imposition of countervailing duties on some steel products imported from Italy, because of findings by the U.S. Government that the exports were subsidized, was expected to reduce Italian steel exports to the United States. Some of the items were: forged steel grinding balls; wheels and axles for railroad use; fabricated steel construction works; rails; bolts; nuts, and rivets.

Japan.—Japan's position as the third largest steel-producing country improved in 1969 as production increased by 24 percent over 1968 to over 90 million short tons. A number of new facilities were completed, and short term plans by the five leading steelmakers called for each to start construction of a large blast furnace by March 1970 to keep pace with planned expansion of the steel industry. Two of the record-making blast furnaces completed in 1969 were No. 2 at the Mizushima works of Kawasaki Steel Corp., blown in on January 13, and No. 3 at the Nagoya plant of Fuji Iron and Steel Co. Ltd. which was officially opened on April 5. The former with a hearth diameter of 37.7 feet and a volume of 2,857 cubic meters averaged 7,265 short tons of hot metal per day during August, and the latter had a capacity of 7,700 short tons per day. These will be exceeded by at least three larger furnaces including Mizushima's No. 4, designed to produce over 10,000 tons per day.

A voluntary steel import agreement between the United States, and Japanese and European Common Market steel producers to restrict steel shipments to the United States from 1969–71 was announced by the U.S. Secretary of State early in the year. Japan's quota for 1969 was 5.75 million short tons, with approximately the same product mix and distribution pattern as in 1968.

At midyear the Japanese steel companies, with approval of the Japanese Ministry of International Trade and Industry (MITI), formed eight cartels representing eight steel product groups. Each cartel established a quota for each member for the export of the cartel's product. The cartels, formed under the Japanese Export and Import Transaction Law, Article 5-3, covered (1) ordinary steel mill products, (2) galvanized iron sheets, (3) wire products, (4) welded ordinary steel pipes, (5) cold-finished ordinary steel bars, (6) cold-finished ordinary steel strip and hoop, (7) stainless steel sheets, and (8) special mill products other than stainless steel sheets. Member firms ranged from 79 for wire products to 6 for stainless steel sheets.

Of major interest during the year was the discussion surrounding the merger of Yawata Seitetsu and Fuji Seitetsu, Japan's two largest steelmakers. After public hearings, a formal examination, and some concessions made by the companies, the Japan Fair Trade Commission approved the merger in October, to become effective March 31, 1970. The new combine, Shin Nippon Seitetsu, (Nippon Steel Corp.) would produce about one-third of Japan's output, and would have capacity second only to the United States Steel Corp., the world's largest producer.

Kenya.—Construction of the first rolling mill in Kenya was started at midyear near Mombasa. A newly formed company, Kenya United Steel Co., was to operate the facility which will have an annual capacity of about 36,000 tons of rods and bars, when commissioned in 1970. Some of the plant output was expected to be exported. The mill will be supplied with imported input materials.

Mexico.—The major steel producers in Mexico—Altos Hornos, Fundidora, and Hojalata y Lamina—were completing projects during the year which would raise Mexico's raw steelmaking capacity to about 5 million tons. All were expected to be ready for full production by late 1970. In addition to these three producers, a number of smaller companies were undergoing or planning expansions that included electric furnace installations.

Additional steel capacity of about 500,000 tons could also be available by 1975 if the Las Truchas steel plant planned for Michoacán is completed.

New Zealand.—Construction on the steelmaking plant of New Zealand Steel Ltd. (NZS), at Glenbrook was sufficiently advanced to make initial test runs with the Stelco-Lurgi reducing kiln in December. At the same time the plant's two electric arc furnaces were operated on a trial basis with ferrous scrap. The sponge iron output was expected to reach the production stage and replace scrap early in 1970. The continuous billet-casting facilities also were undergoing trials. A continuous hot-dip galvanizing line reached full production in June at an annual rate of 100,000 tons, using cold-rolled coil from Japan. A pipe mill to be financed by Government-backed bonds will complete the first stage of the planned complex at Glenbrook.

Pacific Steel Ltd., owned 40 percent by NZS, installed a wire rod mill, and will use Glenbrook billets when available.

The New Zealand operations have been designed with the domestic market in mind. However, the chairman of NZS has stated that the company could compete with foreign producers and dispose of all output. NZS has built an export market for galvanized products with other Pacific Islands.

Philippines.—The Japanese sponsored Iligan Integrated Steel Mills Inc. operated its new cold reduction mill on a one-shift basis and continued work on placing a hot strip mill in operation. The next construction phase calls for building a blast furnace and basic oxygen furnace facilities, both scheduled for startup in 1973.

Singapore.—Meetings conducted by the Economic Commission for Asia and the Far East (ECAFE) resulted in the formation of the Southeast Asia Iron and Steel Institute which will establish headquarters in Singapore during 1970. The Institute will have six member nations: China (Taiwan), Philippines, Indonesia, Malaysia, Singapore and Thailand. Japan and Australia have been accepted as supporting member nations. The Institute will further the development of iron and steel industries within its member nations and encourage regional cooperation between the members.

The National Iron and Steel Mills Ltd. was reported to be planning an integrated iron and steel complex to be established within 3 or 4 years. Mayaysia and Australia would be the source of necessary iron ore.

Two small steel mills were scheduled for erection in 1970 to overcome steel shortages for the shipbuilding and repairing industries of Singapore.

South Africa, Republic of.—A third iron and steel complex for the Republic was announced by the Economics Affairs Minister in May. The plant, to be built in Newcastle, Natal, was scheduled to have an initial capacity of about 400,000 ingot tons per year beginning in 1973 and increase to 2.4 million tons in 1980. The Government-controlled South African Iron and Steel Industrial Corp. Ltd. (ISCOR) would coordinate production of the recently acquired African Metals Corp. Ltd. (AMCOR), a pig iron producer at Newcastle, with the new operation. Expansion plans of ISCOR, including the Newcastle works and expanded mining operations, call for expenditures of an estimated $1 billion by 1980.

Spain.—The Government, in an effort to expand the nation's steel industry, granted preferential credit facilities to integrated steel works having an annual ingot capacity of over 1 million tons. This covered the three largest producers, Altos Hornos de Vizcaya S.A. (Altos Hornos). Empresa Nacional Siderúrgica S.A. (ENSIDESA), and Unión de las Siderúrgicas Asturianas (UNINSA). All made substantial capital equipment improvements during the year with UNISA's new Veriña works scheduled to have a new blast furnace operating before 1971.

Although the Minister of Industry indicated that the industry was not operating profitably in 1969, the Government was hesitant to raise prices because of the effect on the domestic economic situation.

In May the Ministry of Industry confirmed a decision to locate a major steel complex in Sagunto north of Valencia, with a goal of 10 million tons of steel annually. However, a timetable on construction was not firm. Nisshin Steel Co. of Japan proposed to build a stainless steel mill in Spain, to be owned jointly with the Spanish interests, and submitted plans for Government approval at a site on Algeciras Bay.

Tunisia.—A wire mill with a total estimated cost of $4.2 million and a capacity of 10,000 tons annually was to be built under an agreement between the Government's Société El Fouladh and the French Compagnie des Ateliers et Forges de la Loire. To be located near Bizerte, operation was scheduled to begin late in 1970.

U.S.S.R.—The current 5-year plan (1966–70) continued as a period of extensive construction in the steel industry throughout the Soviet Union. Plans also called for two new steel works, one at Tayshet in eastern Siberia, and the other south of Moscow in the area of Kursk. Both would be fully integrated and equipped with 3,500-cubic-meter blast furnaces and 300-ton convertors.

During the first 3-year period (1966–68) of the current plan, steel output increased 10 percent, while the increase for the 3 prior years (1963–65), amounted to 13 percent, indicating a slowdown in the expansion program. This is borne out by a new target figure for 1970 of 117 million metric tons of steel as announced, to replace the original target set at 124 million tons.

Two new blast furnaces went into service in 1969, one at the Cherepovets works and the other at the Nizhny Tagil Combine. Both were to operate with a useful volume of 2,700 cubic meters. The average daily output of pig iron in the U.S.S.R. per cubic meter of useful blast furnace volume was given as 1.653 metric tons for 1969.

United Kingdom.—Modernization of the public sector of the United Kingdom steel industry since Vesting Day (July 28, 1967) has involved all four groups of the British Steel Corporation (BSC) working toward completion of approved projects totaling about $500 million. This includes modifications, replacement projects, and installation of new capacity. As part of the program, construction on a basic oxygen steel plant at the Margam Works of the South Wales Group was well advanced. The new plant has two 300-ton converters which began casting in October, with an annual capacity of about 3.5 million tons, and are part of the plan to increase capacity; they put the Post Talbot Steel complex on a more competitive basis. Included also are the deepwater harbor ore handling facilities which will service carriers using the new $36 million harbor being constructed by the British Transport Dock Board.

The BSC announced plans to increase steel production by about 10 million tons by 1975, with domestic demand expected to reach an estimated 22 to 23 million tons. A part of the expansion involves a plan to build a new steel plant at Scunthorpe, Lincolnshire, England. This would involve an expenditure of over $300 million. A plan to reorganize BSC into product divisions was approved in December and was expected to go into effect early in 1970. Product Divisions would be general steels, special steels, strip mills, and tubes. Two others, constructional engineering and chemicals, also would be included. The new organizational setup was expected to permit better utilization of all plants and to streamline overall operations.

Evidence that the private sector still offered opportunity to small producers was seen in the installation of a new electric arc furnace for stainless steel production at the Rotherham Stainless and Nickel Alloys Ltd., established in 1968.[3]

TECHNOLOGY

Blast Furnace.—Production of the major portion of the world's pig iron for steelmaking appeared committed to blast furnaces for at least the next decade as record-breaking furnaces with capacities of over 5,000 tons of hot metal per day came into production and plans were made for increasingly larger ones. Japan was the center of activity where a 7,000 ton-per-day furnace was operating, an 8,300 ton-per-day furnace under construction, and one to produce 10,000 tons per day was in the planning stage. Hearth diameters of the latter two were to exceed 40 feet. Plans were announced also for a 46-foot-diameter blast furnace at Dusiburg-Schwelgern, West Germany, at an estimated cost of about $67 million.

Technological improvements in helping attain the record productions of the large furnaces included high-temperature operations, uniform pelletized feed, high-top pressure, fuel and oxygen injection, and computer control. The use of three tap holes was planned for the new furnaces in Japan which were to have inner volumes of 3,000 cubic meters or more.

Texaco Inc. and Fuji Iron & Steel Co., Ltd. tested a new gas injection system developed jointly by the two companies for reducing coke requirements in blast furnace operation. Involved was the cracking of a heavy petroleum stock in a special furnace and injection of the resulting gas at 1,800° F or higher through a separate set of tuyeres. Blast furnace output was reportedly increased by 10 to 15 percent and the coke ratio reduced by about 10 percent. A Japanese Iron and Steel Institute committee also was said to be studying use of atomic power reactors preparatory to establishing an experimental set-up possibly by 1972. The plan was to utilize nuclear electric energy combined with nuclear-generated high temperature gas for steelmaking.

A blast furnace installation at Rohrort, West Germany was being operated under computer control as part of a research project of the ECSC to develop better furnace control methods.

[3] Metal Bulletin (London). A New United Kingdom Stainless Steel Producer. No. 5460, December 23, 1969, p. 27.

In the United States, data were given and performance discussed of the initial 2-year operation of Youngstown's latest blast furnace, which exceeded its rated capacity of 4,000 tons per day in September.[4]

Bethlehem began operation of the largest blast furnace in North America in December. The furnace was the first to use a computer-controlled belt feed system.

United States Steel reported that its technology for injecting pulverized coal directly into the bottom area of the blast furnace combustion zone had been successfully tested in a large furnace, and about 20 percent of the coke normally required could be economically replaced with injected coal.

Basic Oxygen Process.—The basic oxygen process (BOP) of steelmaking reached a world-wide annual capacity of 260 million short tons in 1969, with an addtional 102 million tons scheduled for the future.[5] Production by the Kaldo process would add another 5 million tons of capacity. The United States had a total existing capacity of 65 million tons compared with 79 million for Japan where 77 percent of its 1969 steel production was by the BOP. Also in Japan the Nation's first commercial stainless steel by the BOP was reportedly made at Fuji's Muroran Works and other installations were scheduled to start up in the future. Essentially all of the world's basic oxygen converters installed recently have a capacity in the range of 200 to 300 tons, with 310 tons being the largest.

Basic oxygen steel represented 42.6 percent of the domestic production in 1969, approximately the same as that produced in the open hearths. However, open hearth production was exceeded by the BOP in August for the first time, and the gap was expected to continue to widen until the open hearths were phased out.

The U.S. National Bureau of Standards offered for sale the first certified steel samples to be prepared by the BOP; these were available as carbon steel in chip form.[6]

Electric Furnaces.—Electric furnace production of steel was 14.3 percent of the domestic total in 1969, compared with 12.8 percent in 1968. The growth rate of electric furnace capacity has exceeded that of the basic oxygen furnace in the past few years and is expected to continue at about 10 percent until the open hearths are out of production. New electric furnace installations were being made by both the larger steel producers, and the smaller mini-steel mills where capital outlay, as well as pollution control, is usually a major factor. A review of the various aspects of electric furnace steelmaking and its future possibilities was published.[7]

Scrap availability may be a limiting factor in future electric steelmaking, but substitution of metallized iron ore as the furnace feed has been demonstrated and the production of both iron and steel by the electric furnace route in the smaller operations shown to be commercially feasible.

Use of electric furnaces in semi-integrated steelmaking plants for the developing countries of the world was recommended, and cost comparisons were presented for a plant operating at several capacity levels.[8]

Automation.—An on-line computer control system of operations at the Kimitsu Works of Yawata Iron and Steel Co. Ltd. was said to be the world's first successful attempt at integrated computerization of a steel works. Production techniques were improved and a large reduction of workers made possible.

The use of computers in solving complex problems including scheduling of about 1,100 patterns in a new foundry of the Caterpillar Tractor Co. was described.[9] Computerized automatic control systems for complete blast furnace operation developed and built by Westinghouse's Process Line and Metal Making Department were installed during 1969.

Computer control of a Sendzimer mill designed to roll steel strip as thin as 0.001 inch was reviewed.[10] Continuous monitoring and controlled roll settings combined with air conditioning and oil filtration was said to allow final finished tolerances to be held to plus or minus 50 millionths of an inch. The first commercial installation of the Taylor Mill, utilizing improved work roll deflection-compensation, at a J & L plant was expected to give a more uniform

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[4] Blast Furnace & Steel Plant. V. 57, No. 4, April 1969, pp. 287–291.

[5] Stone, J. K. World Growth of Basic Oxygen Steel Plants. Iron and Steel Engineer, v. 46, No. 12, December 1969, pp. 111–116.

[6] National Bureau of Standards Technical News Bulletin. May 1969, pp. 116–117.

[7] Schwartz, N. B. Electrics Turn to Carbon Steel. Iron Age, Mar. 13, 1969, pp. 65–72.

[8] Tietig, R., Jr. New Economics of Steelmaking—A Case for The Semi-Integrated Plant. Iron and Steel Engineer. v. 46, No. 9, September 1969, pp. 111–115.

[9] Foundry. Caterpiller Builds a New Foundry. V. 97, No. 5, May 1969, pp. F–1–F–24.

[10] Iron Age. Strip Mills Face the Generation Gap. V. 203, No. 24, June 12, 1969, pp. 96–97.

product and eliminate secondary processing equipment normally used for thin-rolled steel.

Continuous Casting.—Continuous casting gained in favor during the year with statements made by both producers and users of flat rolled goods that the quality of the product from the continuous caster was at least as good as that produced from the conventional ingot. An official of Continental Can Company Inc., indicated that continuous cast steel would become the standard grade in can making in 5 years.[11]

Inland's president reported that the company's new continuous slab caster at its Indiana Harbor Works incorporated innovations resulting from a 3-year research project which also included Bethleham, Republic, and Youngstown Sheet and Tube as participants.[12]

In April, the United States Steel Corp. had the first public showing of a new continuous slab caster which was said to be capable of producing a continuous strip of steel weighing over 1,600 tons; also to turn out slabs up to 76 inches in width. Other companies announcing initial continuous casting facilities or additions during the year included National Steel Corp., Lukens Steel Co., Armco Steel Co., The Timken Roller Bearing Co., Georgetown Steel Corp., Florida Steel Corp., and Kentucky Electric Steel Co.

Overall projections for continuous casting in the next 5 years point to a rapid growth and general acceptance by both the larger steel mills and the mini-steel plants. As in the case of the BOP replacing the open hearth, sufficient time having elapsed to prove the merit of continuous casting, production by ingot casting can be expected to be relegated to a successively smaller position each year.

A multi-metal continuous caster developed by Interlake Steel Corp. was described by a company official at a national meeting of the Wire Association. Operation of a pilot plant using this process was reported successful in casting as many as six metals in the same day. Metals processed in the continuous caster included cast iron, ductile iron, carbon steel, and stainless steel.

Bethlehem engineers described research efforts in evaluating the Hazelett Strip-Casting Process.[13] The system was judged to be impractical for casting of slabs less than 3 inches thick, but had the advantages of rapid changes in slab sizes and high casting speeds.

A United Nations study, Economic Aspects of Continuous Casting,[14] covering the technical aspects of existing processes, the economics involved, and possible future trends on a worldwide basis was made available for purchase.

Continuous steelmaking from ore was still being studied for some processes, but none have extended beyond the experimental stage. A review was given of recent results in this field.[15] Another article discussed continuous steelmaking from scrap sources.[16] Use of a six-electrode arc melting furnace was proposed for fast meltdown, and cost figures for plant operation were presented.

Work in the research department of Bethlehem Steel Corp. on a continuous oxygen steelmaking process was reviewed.[17] In this study progressive oxygen lancing of a hot metal stream was found to be technically feasible.

Steel Refining.—Allegheny Ludlum started installation of the Swedish developed ASEA-SKF process for vacuum refining at its Brackenridge works.[18] The process uses an oxygen blow under vacuum to rapidly decarbonize molten stainless steel while the metal is being agitated by means of induction stirring coils. Although used in several Swedish plants, this was to be the first U.S. installation.

A Republic Steel Corp. subsidiary, A. Finkl & Sons, introduced as commercially available a combination vacuum-arc degass-

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[11] McManus, G. M. The Push Begins for Slab Casting. Iron Age, v. 204, No. 13, Sept. 25, 1969, pp. 105–112.

[12] Hoeffer, El. Inland Joins March to Continuous Casting. American Metal Market, v. 76, No. 236, Dec. 15, 1969, pp. 1–2.

[13] Whitmore, B. C. and J. W. Hlinka. Continuous Casting of Low-Carbon Steel Slabs by the Hazelett Strip-Casting Process. J. Metals, v. 21, No. 8, August 1969, pp. 68–73.

[14] Economic Commission for Europe Steel Committee. Economic Aspects of Continuous Casting. ST/ECE/Steel/23, Sales No. 68. United Nations, N. Y. 1968, 210 pp.

[15] Worner, H. K., F. H. Baker, I. H. Lassam, and R. Siddons. The WORCRA Continous Steelmaking Process. Mining Magazine, v. 121, No. 4, October 1969, pp. 309–317.

[16] Zelle, A. S. Continuous Steelmaking—From Scrap to Billets. Iron and Steel Engineer, v. 46, No. 11, November 1969, pp. 62–69.

[17] Rudzki, E. M., et al. A Contribution to the Development of a Continuous Oxygen Steelmaking Process. J. Metals, v. 21, No. 6, June 1969, pp. 57–65.

[18] Callahan, Dick. New Vacuum Furnace for Allegheny Ludlum. American Metal Market, v. 76, No. 149, Aug. 7, 1969, pp. 1, 5.

ing process (VAD) which was developed in its Chicago plant. Controlled temperature and effective sulfur elimination was claimed.

A new electron beam refining process was announced by Air Reduction Co.'s Airco Temescal Division of Berkeley, Calif. Known as the Combined Refining Process (CRP), induction melting, vacuum-arc remelting, and electron beam refining were reportedly used to obtain ultra-pure alloy steels.

Electroslag remelting or refining (ESR) to produce high-purity ingots of high-strength steels was reviewed in an article by West German scientists.[19] A United States company was formed during 1969 to produce high alloy and stainless steels by this process. The Russians reportedly have improved the process since its inception and they have concluded an agreement with U.S. interests to market their processing rights.

Foundry.—The success of ductile (nodular) iron was apparent with domestic commercial production of this versatile material exceeding 1 million tons in 1969 for the first time. This was a sevenfold gain from the production of 153,000 tons 10 years previous, an increase due largely to conversion of motor vehicle parts such as crankshafts to this metal, and to increased pipe useage. World production for the year was estimated at approximately 3 million tons.

Some major technological advances have been made in recent years in foundry operations examples of which may be found in the nodular iron foundry of General Motors' Chevrolet Division at Saginaw, Mich. This plant is engineered to give an almost completely automated manufacturing process and is equipped with modern pollution controls.

About 85 percent of all nodular iron is thought to be made in basic cupolas, with electric induction furnaces being used when contamination of the metal must be avoided. An iron melting process said to use a down-draft cupola and thus reduce air pollution control costs, as well as provide better metallized control of the iron was announced as being under test at one plant.

A new method of producing cheaper nodular iron was reported developed by A. B. Jarnforadling, Halleforsnas, Sweden.[20] The method made use of sponge iron instead of nickel or ferrosilicon as a vehicle to introduce magnesium into the iron bath, and was said to give a high yield per unit of magnesium as an additional advantage.

A discussion of the use of tin to improve iron castings was published[21], also a general discussion on the uses of ductile iron for pipe uses.[22]

General Electric Co. through its Lamp Metals and Components Department, announced a program to assist companies in starting ferrous die casting. Iron and steel parts being cast in expendable molds or machine formed in several steps may often be die cast in refractory metal molds to produce a more uniform product at comparable costs.

A new centrifugal method of forming parts in molds was reported by TASS from the U.S.S.R. In addition to precisely reproducing the design, mild steel was said to become harder with centrifuge processing. Applications in powder metallurgy were said to be possible also.

A Japanese foundry reportedly cast several steel ingots weighing about 400 tons each to set a world's record. Some of the castings were to be used in manufacturing atomic power generator shafts.

Specialty Steels.—The shortage of nickel for alloy steels during the year spurred efforts to produce alternate types of steel to replace the high-nickel stainless grades. A number of specialty steel producers, such as Universal-Cyclops and Allegheny Ludlum, offered new steels with reduced nickel content. Armco announced a new high-strength low-alloy (HSLA) steel which was described as a major breakthrough. A yield strength of 60,000 p.s.i., with plate thickness to 3.5 inches and possibly more was claimed. Airco Vacuum Metals announced a new high-chromium stainless grade essentially immune to chloride stress corrosion cracking. High-strength steels for underwater-vehicle use were discussed in one

[19] Wahlster, M. and A. Choudhury. Electroslag Remelting—An Efficient Way to Make Clean Steel. Metal Progress, v. 95, No. 4, April 1969, pp. 107–116.

[20] Nodular Iron Method Found. American Metal Market, v. 76, No. 225, Nov. 28, 1969, p. 6.

[21] Thwaites, C. J. The Development of the Use of Tin to Improve the Quality of Iron Castings. Iron and Steel, v. 42, No. 3, June 1969, pp. 201–208.

[22] Andrews, E. N. Some Aspects of Ductile Iron Pipes and Pipelines. Iron and Steel, v. 42, No. 6, December 1969, pp. 399–404.

article,[23] and a general discussion of high-strength steels in another.[24] The U.S. Navy planned to use an advanced high-strength steel in the range of 180,000 to 200,000 p.s.i. for the pressure hull of a deep-sea search vehicle. A review of stainless steels for desalination equipment was given.[25]

Tin-free steel having a thin chromium coating and designed for container use was in production by two steel makers. One container manufacturer installed the first of 10 facilities for producing tin-free cans to be located at users' plants.

Several steel companies engaged in housing research, directing efforts toward mass production of modular steel units for both apartments and private permanent units as well as mobile homes.

The new stainless steel process developed by the Linde Division of Union Carbide Corp., and introduced in 1968 was licensed to the fifth company, Eastern Stainless Steel Corp., who scheduled production in 1970. The process involves argon-oxygen refining in a two-step process, chromium loss being reduced by the argon during decarburization under controlled conditions.

Iron Powder.—Iron powder capacity in the United States and Canada was placed at about 379,000 tons in 1969 by the Metal Powder Industries Federation, with domestic demand about one-third of this amount. A rise in capacity to 429,000 tons was expected in 1970. The first iron powder plant to use hot metal produced directly from iron ore for the manufacture of iron powder products was described.[26] The plant, located in Quebec, had an annual capacity of 70,000 tons, and used molten iron from the ilmenite operation of Quebec Iron and Titanium Corp. Another iron powder plant under construction in Canada to produce 50,000 tons annually of a 99-plus-percent-pure product also was described.[27] This plant is unique in that a hydro-metallurgical process will be used in the processing which involves the use of hydrochloric acid (HCl) to dissolve iron materials. Ferrous chloride ($FeCl_2$) formed by the reaction is reduced by hydrogen to give purified iron powder.

A resumé describing different methods of producing iron powders and finished products was presented by the staff of Metal Bulletin, who estimated capacity of major free world producers at about 700,000 tons.[28] Iron powder producers expect the advance of technology, including hot reforming, to continue and the products formed from iron powder by the improved methods to become more competitive in the production of castings, especially where machining can be a major cost factor.

Pollution.—All iron and steel operations were involved with the application of technology to meet increasing pollution standards being established by the Federal and local governments. Total authorized expenditures for pollution control in 1969 by the steel industry were estimated at $327 million, about evenly divided between equipment for air and water pollution controls. Armco Steel had two grants from the Federal Water Quality Administration to test water cleaning methods developed by the company. The National Society of Professional Engineers selected Armco's air and water pollution control project at its Middletown works as one of the outstanding engineering achievements of 1969. Expenditures for this project totaled $39 million.

Pollution control was a factor in the actual and planned conversion of many foundries from cupola to electric furnace operation; also in the accelerated changeover by larger steelmakers from open hearths to electric arc or basic oxygen furnaces which are more adaptable to control measures.

The AISI reported that it had at least seven committees working on air and water pollution problems, including two primarily concerned with employees health.

Several AISI-sponsored research projects were active, including design of equipment to minimize air pollution.

Research.—Research by the Bureau of Mines in 1969 included projects on continuous steelmaking, evaluation of variables in oxygen steelmaking, and the production of foundry iron from auto scrap.

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[23] Fairhurst, W. and J. E. Wilson. High-Strength Steels Assume Key Role in Underwater Research Vehicles. Steel Times, v. 197, No. 9, September 1969, pp. 597–600.

[24] Burns, R. S. High Strength Steels. Blast Furnace and Steel Plant, v. 57, No. 4, April 1969, pp. 296–304.

[25] Phelps, E. H., R. T. Jones, and H. P. Leckie. A Review of the Application of Stainless Steels in Desalination Equipment. J. of Electrochemical Society, v. 116, No. 6, June 1969, pp. 213C–217C.

[26] Production of High Compressibility Iron Powder. Metallurgia, v. 79, No. 471, January 1969, pp. 6–7.

[27] Peace River Iron Powder Plant in Ontario. Steel Times, v. 197, No. 6, June 1969, pp. 423–425.

[28] Iron Powder in Perspective. Metal Bulletin, No. 5384, Mar. 21, 1969, pp. 1–15.

A number of new developments were reported by research departments of various steel companies. These included an electron-beam welding technique to produce stainless steel tubing by Republic, which was said to be several times faster than conventional methods and a system by U.S. Steel for applying oil in place of water to hot strip mill rolls, which reduces roll wear as well as producing an improved product. New products developed included a vapor-deposited zinc-coated steel and new stainless steels with improved machinability by Republic, high-strength low-alloy titanium steel by Youngstown, low-nickel alloy steels by Armco, and high-strength galvanized sheet with improved ductility by Inland. Lukens dedicated a new $1-million research center and library.

Twenty-five U.S. and Canadian steelmakers joined in sponsoring a $360,000 study on energy use by the industry, to include all phases of iron and steelmaking and which was to project usage through 1985.

Table 2.—Pig iron produced and shipped in the United States, in 1969, by States

(Thousand short tons and thousand dollars)

State	Production	Shipped from furnaces	
		Quantity	Value
Alabama	4,894	4,992	$282,443
Illinois	7,134	7,262	414,891
Indiana	12,680	12,679	747,951
Ohio	16,878	16,988	1,045,031
Pennsylvania	22,335	22,379	1,292,187
California, Colorado, Utah	5,031	5,059	305,874
Kentucky, Maryland, Texas, West Virginia	12,067	12,073	697,423
Michigan, Minnesota	7,642	7,636	427,075
New York	6,341	6,404	365,885
Total [1]	95,003	95,472	5,578,759

[1] Data may not add to totals shown because of independent rounding.

Table 3.—Foreign iron ore and manganiferous iron ore consumed in manufacturing pig iron in the United States, by source of ore

(Thousand short tons)

Source	1968 [r 1]	1969 [2]
Brazil	383	477
Canada	2,373	1,487
Chile	592	1,155
Peru	104	9
Venezuela	4,851	4,882
Other countries	2,814	3,272
Total [3]	11,116	11,282

[r] Revised.
[1] Excludes 19,550 tons used in making agglomerates.
[2] Excludes 22,455 tons used in making agglomerates.
[3] Data may not add to totals shown because of independent rounding.

Table 4.—Pig iron shipped from blast furnaces in the United States, by grades [1]

(Thousand short tons and thousand dollars)

Grade	1968			1969		
	Quantity	Value: Total	Value: Average per ton	Quantity	Value: Total	Value: Average per ton
Foundry	1,611	$90,578	$56.22	2,380	$135,888	$57.10
Basic	83,560	4,756,441	56.92	89,580	5,237,698	58.47
Bessemer	1,496	84,889	56.74	1,228	72,075	58.69
Low-phosphorous	177	10,364	58.55	147	8,885	60.44
Malleable	1,880	105,156	55.93	1,730	100,536	58.11
All other (not ferroalloys)	361	20,389	56.48	407	23,677	58.17
Total [2]	89,085	5,067,817	56.89	95,472	5,578,759	58.43

[1] Includes pig iron transferred directly to steel furnaces at same site.
[2] Data may not add to totals shown because of independent rounding.

Table 5.—Number of blast furnaces (including ferroalloy blast furnaces) in the United States, by States

State	January 1, 1969 In blast	January 1, 1969 Out of blast	January 1, 1969 Total	January 1, 1970 In blast	January 1, 1970 Out of blast	January 1, 1970 Total
Alabama	9	9	18	12	7	19
California	4	---	4	4	---	4
Colorado	4	---	4	4	---	4
Illinois	13	5	18	14	4	18
Indiana	20	4	24	21	4	25
Kentucky	2	1	3	2	1	3
Maryland	7	3	10	8	2	10
Michigan	8	1	9	9	---	9
Minnesota	1	1	2	1	1	2
New York	12	3	15	12	3	15
Ohio	27	20	47	31	15	46
Pennsylvania	35	23	58	41	15	56
Tennessee	---	3	3	---	3	3
Texas	2	---	2	2	---	2
Utah	2	1	3	2	1	3
West Virginia	4	---	4	4	---	4
Total	150	74	224	167	56	223
Ferroalloy blast furnaces	4	2	6	2	3	5
Grand total	154	76	230	169	59	228

Source: American Iron and Steel Institute.

Table 6.—Iron ore and other metallic materials, coke and fluxes consumed and pig iron produced in the United States, by States

(Thousand short tons)

Year and State	Metalliferous materials consumed: Iron and manganiferous ores: Domestic	Foreign	Agglomerates	Net ores and agglomerates [1]	Net scrap [2]	Miscellaneous [3]	Net total	Net coke	Fluxes	Pig iron produced	Metalliferous materials consumed per ton of pig iron made: Net ores and agglomerates [1]	Net Scrap [2]	Miscellaneous [3]	Total	Coke and fluxes consumed per ton of pig iron: Net coke	Fluxes
1968:																
Alabama	1,863	W	4,445	7,531	142	24	7,697	3,342	668	4,378	1.720	0.032	0.005	1.758	0.763	0.153
Illinois	W	W	7,380	10,740	250	316	11,306	3,964	1,126	6,205	1.731	.040	.051	1.822	.639	.181
Indiana	W	W	15,629	19,746	258	522	20,526	7,236	1,178	12,475	1.583	.021	.042	1.645	.580	.094
Ohio	4,401	1,440	17,927	23,242	987	1,460	25,689	10,400	3,219	15,758	1.475	.063	.093	1.630	.660	.204
Pennsylvania	6,397	4,983	22,744	33,462	904	1,539	35,905	13,010	3,041	21,008	1.593	.043	.073	1.709	.619	.145
California, Colorado, Utah	3,430	W	W	8,160	178	149	8,487	2,872	861	4,873	1.675	.037	.031	1.742	.589	.177
Maryland, West Virginia, Kentucky, Texas	W	W	13,880	16,674	251	928	17,853	6,687	1,354	10,841	1.538	.023	.086	1.647	.617	.125
Michigan and Minnesota	1,231	W	10,394	11,281	223	207	11,711	4,421	1,317	7,324	1.540	.030	.028	1.599	.604	.180
New York	1,269	W	W	9,131	188	400	9,719	3,531	808	5,902	1.547	.032	.068	1.647	.598	.137
Total [4]	26,977	11,116	104,988	139,967	3,382	5,545	148,893	55,463	[5] 13,572	88,767	1.577	.038	.062	1.677	.625	.153
1969:																
Alabama	2,103	W	4,832	8,520	175	13	8,708	3,776	935	4,894	1.741	0.036	0.003	1.779	0.772	0.191
Illinois	W	------	9,778	13,855	215	280	14,350	4,396	1,169	7,134	1.942	.030	.039	2.011	.616	.164
Indiana	W	W	15,843	19,949	392	637	20,978	7,434	1,497	12,680	1.573	.031	.050	1.654	.586	.118
Ohio	4,527	1,041	20,030	24,957	1,140	1,624	27,721	11,021	3,477	16,878	1.479	.068	.096	1.642	.653	.206
Pennsylvania	6,016	4,118	24,452	33,788	973	1,835	36,596	14,077	2,761	22,335	1.513	.044	.082	1.639	.630	.124
California, Colorado, Utah	3,906	------	W	8,895	155	161	9,211	2,978	916	5,031	1.768	.031	.032	1.831	.592	.182
Maryland, West Virginia, Kentucky, Texas	W	W	14,416	18,440	232	1,026	19,698	7,454	1,329	12,067	1.528	.019	.085	1.632	.618	.110
Michigan and Minnesota	1,096	W	10,951	11,714	235	215	12,164	4,668	1,282	7,642	1.533	.031	.028	1.592	.611	.168
New York	1,892	108	W	9,872	226	299	10,397	3,884	931	6,341	1.557	.036	.047	1.640	.613	.147
Total [4]	28,599	11,282	113,475	149,990	3,743	6,092	159,825	59,689	[6] 14,297	95,003	1.579	.040	.064	1.682	.628	.150

W Withheld to avoid disclosing individual company confidential data; included with total.
[1] Net ores and agglomerates equal ores plus agglomerates plus flue dust used minus flue dust recovered.
[2] Excludes home scrap produced at blast furnaces.
[3] Does not include recycled material.
[4] Data may not add to totals shown because of independent rounding.
[5] Fluxes consisted of the following: 7,429 limestone, 5,824 dolomite, and 319 other fluxes excluding 5,151 limestone, 3,258 dolomite, and 181 other fluxes used in agglomerate production at or near steel plants and an unknown quantity used in making agglomerates at mines.
[6] Fluxes consisted of the following: 7,711 limestone, 6,003 dolomite, and 583 other fluxes excluding 4,988 limestone, 3,647 dolomite, and 423 other fluxes used in agglomerate production at or near steel plants and an unknown quantity used in making agglomerates at mines.

Table 7.—Steel production in the United States, by type of furnace [1]
(Thousand short tons)

Year	Open hearth		Bessemer	Basic oxygen process	Electric	Total
	Basic	Acid				
1965	93,866	327	586	22,879	13,804	131,462
1966	84,804	221	278	33,928	14,870	134,101
1967	70,550	140	(2)	41,434	15,089	127,213
1968	65,836	(2)	(2)	48,812	16,814	131,462
1969	60,894	(2)	------	60,236	20,132	141,262

[1] Excludes castings produced in foundries not covered by AISI.
[2] Included with basic open hearth.

Source: American Iron and Steel Institute.

Table 8.—Metalliferous materials consumed in steel furnaces in the United States
(Thousand short tons)

Year	Iron Ore		Agglomerates		Pig iron	Ferro-alloys [1]	Iron and steel scrap
	Domestic	Foreign	Domestic	Foreign			
1965	1,818	4,400	1,061	418	81,040	1,898	68,272
1966	1,348	3,768	870	348	83,947	1,915	68,778
1967	954	2,905	600	378	80,404	1,818	65,027
1968	958	2,514	684	337	r 79,948	r 1,676	67,281
1969	710	2,121	487	512	84,187	1,775	74,343

r Revised.
[1] Includes ferromanganese, spiegeleisen, silicomanganese, manganese metal, ferrosilicon, ferrochromium alloys, and ferromolybdenum.

Table 9.—Consumption of pig iron [1] in the United States, by type of furnace

Type of furnace or equipment	1969	
	Thousand short tons	Percent of total
Open hearth	37,447	43.0
Basic oxygen converter	46,408	53.2
Electric	332	.4
Cupola	2,911	3.3
Air	92	.1
Other [2]	3	-----
Total	87,193	100.0

[1] Excludes molten pig iron used for ingot molds and direct castings.
[2] Includes vacuum melting furnaces and miscellaneous melting processes.

Table 10.—Average value of pig iron at blast furnaces in the United States, by States
(Per short ton)

State	1969
Alabama	$56.58
California, Colorado, Utah	60.46
Illinois	57.13
Indiana	58.99
New York	57.13
Ohio	61.52
Pennsylvania	57.74
Other States [1]	57.05
Average	58.43

[1] Includes Kentucky, Maryland, Michigan, Minnesota, Texas, and West Virginia.

Table 11.—Consumption of pig iron [1] in the United States, by States
(Thousand short tons)

State	1969
Alabama	4,274
California	2,367
Colorado	W
Connecticut	20
Delaware	W
Florida	W
Georgia	10
Illinois	7,218
Indiana	12,863
Iowa	38
Kansas	3
Kentucky	W
Louisiana	W
Maine	W
Maryland	W
Massachusetts	27
Michigan	7,751
Minnesota	484
Missouri	20
Montana	(2)
Nebraska	W
Nevada	W
New Hampshire	W
New Jersey	70
New York	5,965
North Carolina	W
Ohio	16,074
Oklahoma	W
Oregon	1
Pennsylvania	23,247
Rhode Island	10
South Carolina	W
Tennessee	184
Texas	202
Utah	W
Vermont	7
Virginia	W
Washington	W
Wisconsin	164
Undistributed	13,636
Total	94,635

W Withheld to avoid disclosing individual company confidential data, included in "Undistributed."
[1] Includes molten pig iron used for ingot molds and direct castings.
[2] Less than ½ unit.

Table 12.—U.S. exports of major iron and steel products

Products	1968 Short tons	1968 Value (thousands)	1969 Short tons	1969 Value (thousands)
SEMIMANUFACTURED				
Ingots and other primary forms:				
Puddled bars and pilings, blocks, lump and other primary forms of iron or steel, n.e.c.	4,462	$729	8,643	$1,015
Blooms, billets, ingots, slabs, sheet bars and roughly forged pieces	551,708	48,201	1,810,490	142,767
Coils for rerolling	50,432	26,987	421,531	61,911
Blanks for tubes and pipes, iron or steel	2,095	241	12,159	1,400
Total	608,697	76,158	2,252,823	207,093
Bars, rods, angles, shapes and sections:				
Wire rods	12,317	2,316	95,498	16,003
Bars, rods, and hollow-drill steel	100,200	28,251	215,674	51,797
Concrete reinforcing bars	26,097	3,903	86,762	11,592
Angles, shapes and sections	121,899	20,757	170,424	29,261
Plates and sheets:				
Steel plates	15,584	7,878	25,441	12,603
Steel sheets	273,043	49,486	1,040,381	146,923
Black plate	27,867	3,097	49,723	6,789
Iron and steel plates, n.e.c.	209,269	43,628	403,715	66,152
Tinplate and terneplate	293,265	44,550	339,606	52,264
Tinplate circles, cobbles, strip and scroll	15,267	1,405	26,080	2,577
Hoop and strip	56,022	26,456	100,595	38,160
Total	1,150,830	231,727	2,553,899	434,121
MANUFACTURES				
Rails, and railway track material	89,526	16,660	73,136	12,995
Wire	63,710	28,960	85,227	37,518
Cast-iron pressure pipe, soil pipe and fittings	49,098	13,320	32,419	9,340
Steel tube and pipe fittings, union and flanges	29,922	41,138	29,985	46,105
Malleable iron tube and pipe fittings, n.e.c.	1,440	1,771	2,087	2,290
Electrical conduit fittings of iron or steel	12,123	6,806	12,317	7,965
Iron tube and pipe fittings, n.e.c.	6,650	8,562	7,191	10,562
Seamless tubes and pipe	228,877	83,999	251,996	99,235
Welded, clinched or riveted tubes and pipe	93,738	29,121	73,767	28,992
Castings and forgings	125,131	63,438	137,454	67,824
Total	700,215	293,775	705,579	322,826
Grand total	2,459,742	601,660	5,512,301	964,040

Table 13.—U.S. imports for consumption of pig iron, by countries

Country	1967 Short tons	1967 Value (thousands)	1968 Short tons	1968 Value (thousands)	1969 Short tons	1969 Value (thousands)
Australia	-------	-------	-------	-------	674	$31
Brazil	-------	-------	33,240	$976	-------	-------
Canada	408,066	$20,821	416,383	r 18,043	295,076	14,449
Finland	33,617	1,244	77,762	2,658	69,843	2,422
Germany:						
East	49,700	1,344	-------	-------	-------	-------
West	41,947	1,646	r 107,704	r 3,961	38,164	1,504
Mexico	28	1	-------	-------	-------	-------
Netherlands	9,869	381	r 330	r 15	-------	-------
Norway	10,900	399	61,616	2,037	2,811	107
Rhodesia, Southern	22,400	587	-------	-------	-------	-------
Spain	-------	-------	21,221	741	-------	-------
Sweden	1,922	137	r 41,219	r 1,252	-------	-------
United Kingdom	7,075	335	26,424	798	-------	-------
Venezuela	19,710	704	-------	-------	-------	-------
Total	605,234	27,599	785,899	r 30,481	406,568	18,513

r Revised.

Table 14.—U.S. imports for consumption of major iron and steel products

Products	1968		1969	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Iron products:				
Cast iron pipes, tubes and fittings	39,064	$9,433	34,395	$9,451
Bars of wrought iron	478	173	617	153
Total	39,542	9,606	35,012	9,604
Iron and steel products:				
Ingots, blooms, billets, slabs and sheet bars	298,678	42,359	195,176	37,514
Bars of steel:				
Concrete reinforcing bars	739,756	53,514	470,807	40,563
Other bars	r 975,244	r 108,078	903,756	119,510
Plates and sheets:				
Black plate	6,669	648	11,657	1,684
Steel plates	1,779,449	159,840	1,202,168	121,105
Steel sheets	6,359,405	627,234	3,943,628	423,318
Plates, sheets and strip of iron or steel	985,484	138,050	960,183	139,714
Strip of iron or steel	90,961	28,873	96,167	32,921
Hollow drill steel	3,708	1,351	5,412	2,036
Wire rods of steel	r 1,600,929	r 150,534	1,260,890	129,803
Sheet piling	67,545	6,654	65,957	6,854
Pipes, tubes and fittings	1,653,209	256,955	1,691,384	265,431
Angles, shapes and sections	r 2,194,028	r 205,468	1,992,410	206,875
Tinplate and terneplate	227,663	39,156	300,664	51,339
Rails and railway track material	34,216	3,105	44,141	4,043
Wire	r 824,114	r 161,982	822,162	167,602
Castings and forgings	12,029	5,576	17,242	7,859
Total	r 17,853,087	r 1,989,377	13,983,804	1,758,171
Grand total	r 17,892,629	r 1,998,983	14,018,816	1,767,775

r Revised.

Table 15.—World production of pig iron (including ferroalloys), by countries

(Thousand short tons)

Country [1]	1967	1968	1969 p
North America:			
Canada	7,108	8,549	7,665
Mexico (includes sponge iron)	1,830	2,228	2,800
United States	r 89,589	91,388	97,593
South America:			
Argentina	686	660	671
Brazil	3,435	3,771	4,150
Chile	560	498	546
Colombia	228	218	227
Peru [2]	34	122	194
Venezuela	465	594	573
Europe:			
Austria	r 2,363	2,733	e 2,980
Belgium	r 9,914	11,517	e 12,350
Bulgaria	1,133	1,222	1,323
Czechoslovakia	7,520	7,628	7,766
Denmark	83	83	e 90
Finland [2]	1,121	1,145	1,281
France	17,317	18,133	e 19,600
Germany:			
East [2]	2,783	2,572	2,313
West	30,166	33,406	e 37,250
Hungary	1,840	1,806	1,944
Italy [2]	8,040	8,627	8,577
Luxembourg	4,365	4,749	e 5,290
Netherlands	2,853	3,110	3,815
Norway [2] [3]	702	743	754
Poland	7,254	7,539	7,747
Portugal [2]	306	310	e 360
Rumania	2,707	3,298	3,833
Spain	3,047	3,170	3,776
Sweden	2,604	2,751	2,752
Switzerland [2]	26	24	28
U.S.S.R. [4]	82,466	86,862	90,000
United Kingdom	r 16,970	18,403	e 18,340
Yugoslavia	1,297	1,418	1,420
Africa:			
Algeria e	11	11	17
Israel e	40	40	40
Rhodesia, Southern e	220	220	220
South Africa, Republic of	4,177	4,546	4,801
United Arab Republic e	240	220	220
Asia:			
China, mainland e	15,400	20,900	22,000
India	r 7,790	8,247	8,303
Japan	45,227	52,306	65,525
Korea:			
North e	1,930	2,200	2,480
South [2]	r 44	57	e 60
Malaysia e	20	70	70
Taiwan	95	84	86
Thailand	7	19	12
Turkey	934	1,003	1,045
Oceania: Australia	r 5,671	6,224	6,810
Total [5]	r 392,618	425,424	459,697

e Estimate. p Preliminary. r Revised.

[1] Pig iron is also produced in the Congo (Kinshasa), North Vietnam, and a few other countries for which data are not available.

[2] Excluding ferroalloys.

[3] Excluding sponge iron.

[4] U.S.S.R. in Asia included with U.S.S.R. in Europe.

[5] Totals are of listed figures only.

Table 16.—World production of raw steel,[1] by countries

(Thousand short tons)

Country	1967	1968	1969 p
North America:			
Canada	9,694	11,251	10,307
Mexico	3,373	3,621	3,825
United States [2]	127,213	131,462	141,262
South America:			
Argentina	1,462	1,718	1,871
Brazil	r 4 4,105	4,909	5,407
Chile	696	628	713
Colombia	278	282	290
Peru	88	116	212
Uruguay	15	10	15
Venezuela	r 761	949	926
Europe:			
Austria	3,332	3,822	e 4,300
Belgium	10,710	12,751	e 14,000
Bulgaria	1,366	1,610	e 1,670
Czechoslovakia	11,025	11,635	e 11,910
Denmark	438	462	e 440
Finland	r 453	772	1,048
France	21,666	22,498	e 24,820
Germany:			
East	r 5,062	5,175	5,317
West	r 40,503	45,370	e 49,930
Greece	176	240	e 280
Hungary	3,019	3,200	3,347
Ireland	72	74	e 80
Italy	17,516	18,699	18,109
Luxembourg	4,939	5,329	e 6,060
Netherlands	r 3,750	4,086	5,195
Norway	r 875	908	941
Poland	11,524	12,133	12,446
Portugal	r 355	345	e 410
Rumania	4,505	5,237	6,107
Spain	5,064	5,532	6,559
Sweden	5,256	5,616	5,926
Switzerland	489	499	558
U.S.S.R. [3]	112,683	117,436	121,914
United Kingdom	26,760	28,964	e 29,590
Yugoslavia	2,019	2,201	2,447
Africa:			
Algeria	r 25	31	e 30
Rhodesia, Southern e	150	150	150
South Africa, Republic of	r 4,340	4,685	5,323
Tunisia e	50	90	90
United Arab Republic e	220	210	210
Asia:			
Burma e	20	20	20
China, mainland e	12,100	16,500	17,600
India [4]	r 6,962	7,392	e 7,940
Israel e	80	100	120
Japan	68,513	73,736	91,434
Korea:			
North e	1,600	1,930	2,210
South	353	410	574
Malaysia e	20	60	60
Pakistan e	100	110	110
Taiwan	r 251	267	299
Thailand	3	6	4
Turkey	1,164	1,222	1,290
Oceania: Australia	r 6,907	7,167	7,735
Total [5] [6]	r 544,100	583,626	633,431

e Estimate. p Preliminary. r Revised.

[1] Steel formed in first solid state after melting suitable for further processing or sale.

[2] Data from American Iron and Steel Institute. Excludes steel produced by foundries not reporting output to AISI but to Bureau of Census as follows: 1967—1,662; 1968—1,557; 1969— e 1,906; (in 1,000 tons).

[3] U.S.S.R. in Asia included with U.S.S.R. in Europe.

[4] Excludes castings.

[5] Steel was produced also in New Zealand, the Philippines, Singapore, North Vietnam, and a few other countries, but data are not available.

[6] Totals are of listed figures only.

Iron and Steel Scrap

By Frank L. Fisher [1]

Strong demand for iron and steel scrap continued throughout the year and was evidenced by a record total of scrap reclaimed and consumed, a high volume of exports, and a substantial increase in scrap prices. Junk automobiles continued to be the major source of scrap iron and steel with one-third of the domestic supply of iron and steel resulting from this source. Among the noteworthy advances in scrap utilization were the more widespread use of metal shredding devices, especially for handling scrap automobiles, and the use of reconstituted steel chips by major consumers. The national inventory of junked vehicles, estimated at more than 20 million units, continued to concern both industry and Government. To expedite the recycling of junked cars, five State legislatures considered enacting disposal fund bills. The State of Maryland passed a law in May which provides that the State will pay a $10 bounty to scrap processors for every car scrapped after July 1, 1970.

Table 1.—Salient iron and steel scrap, and pig iron statistics in the United States

(Thousand short tons and thousand dollars)

	1968	1969
Stocks Dec. 31:		
Scrap at consumer plants	7,882	6,552
Pig iron at consumer and supplier plants	2,342	1,723
Total	10,224	8,275
Consumption:		
Scrap	87,060	94,816
Pig iron	89,953	94,635
Exports:		
Scrap (excludes rerolling material)	6,565	9,036
Value	$197,005	$291,856
Imports for consumption:		
Scrap (includes tinplate and terneplate scrap)	294	335
Value	$11,325	$13,197

AVAILABLE SUPPLY

During 1969, iron and steel scrap consumers had 94.8 million short tons available at their plants, an increase of nearly 9 percent over the quantity available in 1968. Home scrap constituted 59 percent of the total, and purchased scrap, 41 percent. In 1968, home scrap made up 61.5 percent and purchased scrap, 38.5 percent.

CONSUMPTION

Domestic scrap consumption reached an alltime high in 1969, as a record 94.8 million tons was consumed. The previous high of 91.5 million tons was consumed in 1966. In 1968 consumption totaled 87.1 million tons. Of the tonnage consumed in 1969, manufacturers of steel ingots and castings took 76.6 million tons, or about 81 percent. Iron foundries and miscellaneous users consumed 14.8 million tons, or nearly 16 percent of the total; manufacturers of steel castings consumed the remainder.

STOCKS

On December 31, 1968, stocks of iron and steel scrap held by consumers were about 7.9 million short tons. Stocks gradually declined throughout the year to about 6.6 million tons on December 31.

[1] Physical scientist, Bureau of Mines, Minneapolis, Minn.

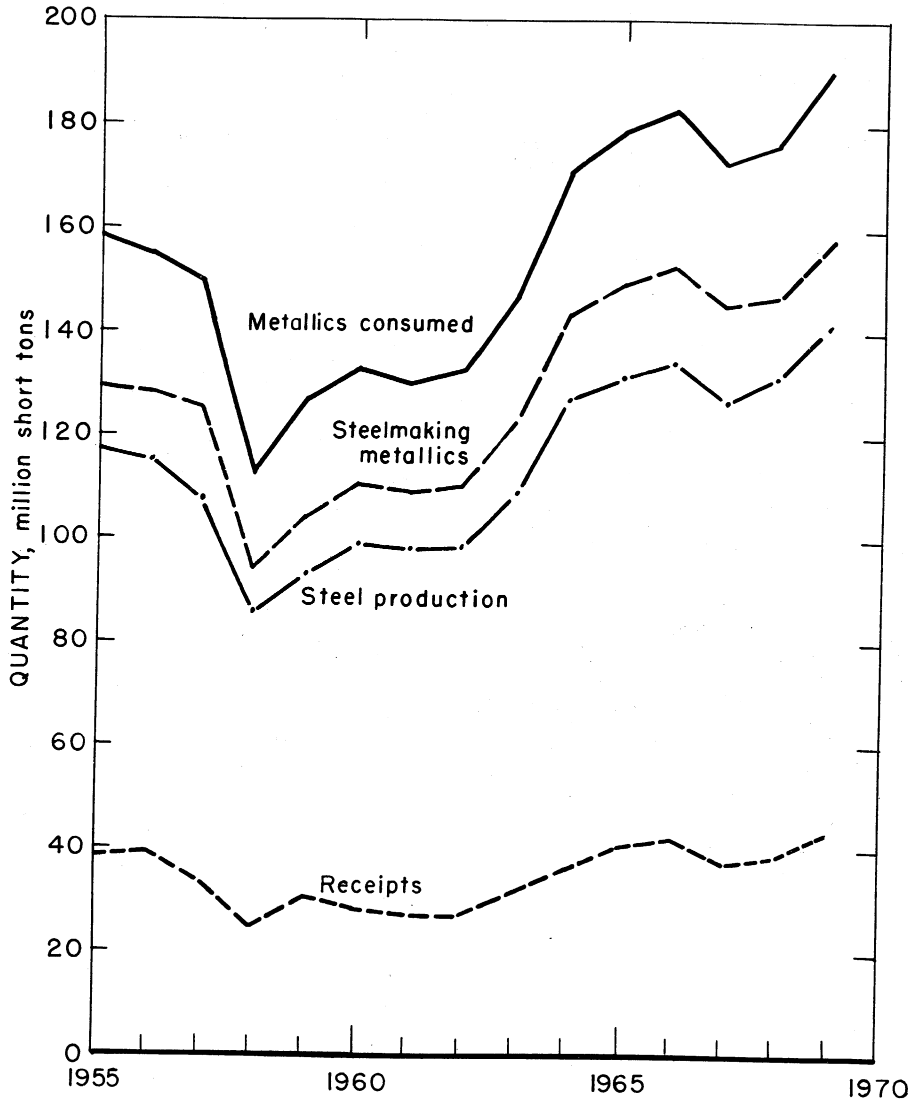

Figure 1.—Metallics consumed—Total iron and steel scrap plus pig iron; Steelmaking metallics—Total iron and steel scrap plus pig iron consumed in steelmaking furnaces; Steel production (AISI); Receipts of purchased scrap by consumers.

PRICES

Scrap prices, which had been in general decline for 4 years, reversed the downward trend at the beginning of the year. Prices increased gradually through August, rose sharply in September, and dropped slightly in the fourth quarter before closing strong at yearend. The average composite price of No. 1 heavy melting scrap, the industry's prime grade, at the end of 1969 was $35.70, compared with $24.90 at the close of 1968. Higher prices resulted primarily from a strong demand for scrap iron and steel, especially in the United Kingdom and Japan. Higher world prices contributed to the increase in domestic prices and also to the 9 million tons of iron and steel scrap exported during the year. High prices also brought forth demands for a scrap embargo, but at yearend no such action had been taken.

FOREIGN TRADE

A total of 9.3 million tons of scrap valued at $305 million was exported in 1969, compared with 6.7 million tons valued at $202.8 million in 1968. Imports totaled 335,000 tons valued at $13.2 million. The result benefited the U.S. balance of payments by $292 million during the year. Nearly two-thirds of the total exports consisted of Nos. 1 and 2 heavy melting steel scrap. Japan obtained about 45 percent of the total, followed by Spain with about 12 percent. Canada provided nearly 97 percent of the total U.S. imports.

The United States was the major scrap exporting nation in 1969. The United Kingdom, which formerly exported significant quantities of scrap to Europe, stopped all exports in 1969. The U.S.S.R. exported an estimated 400,000 tons of scrap iron and steel during the year with the bulk going to Sweden, Japan and Western Europe. Spain became a major importer of scrap in 1969 with an annual requirement of 1.5 million tons, most of which must come from the United States. The establishment of an electric furnace industry in Northern Spain in 1969 has increased the country's normal demand by 800,000 tons annually.

TECHNOLOGY

Higher prices, emphasis on the junked automobile blight, and an announcement by General Motors Corporation that it had developed a method for reconstituting its plant scrap spurred the iron and steel scrap metal industry to focus its attention on more advanced applied technology.

Several advances were made in 1969 in the area of fragmentation of iron and steel scrap. This includes crushing, pulverizing, separating, and sizing equipment. One device, known as the nuggetizer, has a unit capacity of 30 tons of scrap per hour. A variety of shredders with a wide range of sizes were introduced during the year with tonnages ranging from 10–25 tph for small sizes to 80–100 tph for large installations.

Research to close the technology gap impeding prompt and complete reuse of certain types of ferrous waste was in progress at six Bureau of Mines research centers throughout the year. Considerable interest was shown in a continuous processing plant completed near yearend that will be capable of recovering major metal and mineral values, including iron, from incinerator residues. A low-cost way to avoid air pollution from open-air burning of junked automobiles has resulted from research at the Bureau's Metallurgy Research Center in Salt Lake City, Utah. The incinerator used in the operation can efficiently process all the junked cars from a metropolitan area with a population of 300,000. Cost of the incinerator, capable of processing 50 junked cars every 8 hours, is about $22,000. Once incinerated, the junked auto can be dismantled in the usual manner for its metal values and the iron and steel scrap sorted, baled, or bundled for sale or reuse.

Intensive basic and applied research on the use of ferrous scrap as a reductant for nonmagnetic taconite ore continued at the Bureau's Twin Cities Metallurgy Research Center. Pilot plant studies of continuous electric furnace iron making and steelmaking using preheated comminuted scrap and prereduced iron ore were continued. Project plans include the production of synthetic pig iron from fragmented auto scrap. A pilot plant study to produce foundry pig iron in a basic cupola, using auto and low-grade ferrous scrap was underway during the year. Improved techniques to sample and produce high-grade iron ore pellets from steel furnace flue dust were begun in 1969. Considerable research effort was expended to develop physical and chemical methods for recovering a wide range of high-value nonferrous metals from ferrous, superalloy, and electronic scrap. A procedure was developed to separate nonmetallic material from nonferrous scrap in the auto shredder reject stream by an air-fluidizing technique. A comprehensive analysis of economical dismantling procedures for typical junked cars continued and a final report was published.[2] Other Bureau publications describing ferrous scrap and related research were issued.[3]

The Bureau's Solid Waste Contract and Grant Program, which supplements in-house research, had 12 grants in effect at nine academic institutions with a total funding of $578,807. A new $108,445 research grant to the University of Wisconsin was made to determine exact tolerance levels of nonferrous metal contaminants in ferrous castings and steel.

[2] Dean, K. C. and J. W. Sterner. Dismantling a Typical Junk Automobile To Produce Quality Scrap. BuMines Rept. of Inv. 7350, 1969, 17 pp.
[3] Brooks, P. T., D. A. Martin, and G. M. Potter. Chemical Reclaiming of Superalloy Scrap. BuMines Rept. of Inv. 7316, 1969, 28 pp.
Hass, L. A., S. E. Khalafalla, and H. W. Kilau. Extraction of Copper from Oxides Using Iron and Steel Scrap. Principles and Application to Pure Systems. BuMines Rept. of Inv. 7301, 1969, 13 pp.

Table 2.—Iron and steel scrap supply [1] available for consumption in 1969, by States
(Thousand short tons)

State	Receipts	Production	Total new supply	Shipments [2]	New supply available for consumption
Alabama	1,804	2,021	3,825	296	3,529
Arizona	W	W	W	W	W
Arkansas	W	W	W	-----	W
California	1,513	1,380	2,893	117	2,776
Colorado	W	W	W	W	W
Connecticut	100	68	168	7	161
Delaware	W	W	W	W	W
Florida	W	W	W	W	W
Georgia	W	W	W	W	W
Illinois	4,175	4,901	9,076	530	8,546
Indiana	3,760	8,500	12,260	1,288	10,972
Iowa	451	175	626	19	607
Kansas	68	41	109	(3)	109
Kentucky	W	W	W	W	W
Louisiana	W	W	W	W	W
Maine	W	W	W	W	W
Maryland	W	W	W	W	W
Massachusetts	51	61	112	2	110
Michigan	4,709	4,482	9,191	256	8,935
Minnesota	267	245	512	11	501
Mississippi	W	W	W	-----	W
Missouri	798	282	1,080	7	1,073
Montana	W	W	W	-----	W
Nebraska	W	W	W	W	W
Nevada	W	------	W	-----	W
New Hampshire	W	W	W	-----	W
New Jersey	576	149	725	19	706
New York	1,338	2,629	3,967	74	3,893
North Carolina	172	56	228	-----	228
Ohio	8,326	9,566	17,892	1,474	16,418
Oklahoma	205	52	257	1	256
Oregon	150	53	203	7	196
Pennsylvania	7,824	12,540	20,364	1,892	18,472
Rhode Island	W	W	W	W	W
South Carolina	W	W	W	-----	W
Tennessee	294	190	484	12	472
Texas	1,840	1,587	3,427	178	3,249
Utah	W	W	W	W	W
Vermont	15	9	24	(3)	24
Virginia	W	W	W	W	W
Washington	426	150	576	14	562
West Virginia	W	W	W	W	W
Wisconsin	485	533	1,018	75	943
Undistributed	4,332	6,617	10,949	471	10,478
U.S. total [4]	43,679	56,287	99,966	6,750	93,216

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] New supply available for consumption is a net figure computed by adding production to receipts and deducting scrap shipped, during the year. The plus or minus difference in stock levels at the beginning and end of year is not taken into consideration.
[2] Includes scrap shipped, transferred or otherwise disposed of during the year.
[3] Less than 500 tons.
[4] Data may not add to totals shown due to independent rounding.

Table 3.—Consumption of iron and steel scrap and pig iron [1] by States, by type of manufacturers in 1969

(Thousand short tons)

State	Steel ingots and castings [2]		Steel castings [3]		Iron foundries and miscellaneous users		Total [4]	
	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron
Alabama	2,479	3,599	136	(5)	984	675	3,599	4,274
Arizona	W	------	W	---	W	---	W	------
Arkansas	------	------	W	---	------	---	W	------
California	2,528	2,284	125	3	285	80	2,938	2,367
Colorado	W	W	W	(5)	W	(5)	W	W
Connecticut	73	------	3	(5)	83	20	159	20
Delaware	W	------	W	W	------	---	W	W
Florida	W	------	-----	---	W	W	W	W
Georgia	W	------	W	(5)	W	10	W	10
Illinois	7,175	6,814	497	13	1,262	391	8,934	7,218
Indiana	10,362	12,668	162	1	793	194	11,317	12,863
Iowa	------	------	58	---	552	38	610	38
Kansas	------	------	87	(5)	22	3	109	3
Kentucky	1,284	W	-----	---	242	W	1,526	W
Louisiana	------	------	13	W	------	---	13	W
Maine	------	------	-----	---	W	W	W	W
Maryland	3,243	W	25	---	98	W	3,366	W
Massachusetts	------	------	9	(5)	101	27	110	27
Michigan	5,610	7,102	120	1	3,283	648	9,013	7,751
Minnesota	338	446	54	1	89	37	481	434
Mississippi	W	------	-----	---	------	---	W	------
Missouri	843	1	120	1	95	18	1,058	20
Montana	------	------	-----	---	W	(5)	W	(5)
Nebraska	------	------	W	W	W	---	W	W
Nevada	------	------	W	W	------	---	W	W
New Hampshire	------	------	W	---	W	W	W	W
New Jersey	250	------	45	---	419	70	714	70
New York	3,118	5,869	153	12	703	84	3,974	5,965
North Carolina	W	------	-----	---	W	W	W	W
Ohio	13,856	15,401	445	31	2,247	642	16,548	16,074
Oklahoma	W	------	W	(5)	W	W	W	W
Oregon	139	------	60	(5)	9	1	208	1
Pennsylvania	17,422	23,082	416	34	767	131	18,605	23,247
Rhode Island	77	------	-----	---	50	10	127	10
South Carolina	------	------	-----	---	51	W	51	W
Tennessee	------	------	20	2	454	182	474	184
Texas	2,535	117	58	(5)	601	85	3,194	202
Utah	W	W	W	W	W	W	W	W
Vermont	------	------	-----	---	23	7	23	7
Virginia	------	------	174	W	459	W	633	W
Washington	554	W	18	W	10	---	582	W
West Virginia	1,647	W	31	W	47	W	1,725	W
Wisconsin	------	------	305	7	654	157	959	164
Undistributed	3,109	13,379	208	4	449	253	3,766	13,636
U.S. total [4]	76,641	90,761	3,342	113	14,833	3,761	94,816	94,635

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] Includes molten pig iron used for ingot molds and direct castings.

[2] Includes only those castings made by companies producing steel ingots.

[3] Excludes companies that produce both steel ingots and castings.

[4] Data may not add to totals shown due to independent rounding.

[5] Less than ½ unit.

Table 4.—Consumption of iron and steel scrap and pig iron [1] in the United States in 1969, by State, by furnace

(Thousand short tons)

State	Blast furnace	Basic oxygen converter		Open-hearth furnace		Electric furnace		Cupola furnace		Air furnace		Other furnaces [2]	
	Scrap	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron
Alabama	213	500	1,019	1,468	2,480	463	1	955	679	--	--	40	--
Arizona	---	---	---	---	---	W	--	---	---	--	--	--	--
Arkansas	---	---	---	---	---	W	--	---	---	--	--	--	--
California	22	370	1,166	1,265	968	979	8	295	79	--	--	7	--
Colorado	W	W	W	W	W	W	W	W	W	--	--	--	--
Connecticut	---	---	---	---	---	106	7	51	12	2	(3)	--	--
Delaware	---	---	---	---	---	W	(3)	---	---	--	--	--	--
Florida	---	---	---	---	---	W	W	---	---	--	--	--	--
Georgia	---	---	---	---	---	W	(3)	W	W	--	--	W	--
Illinois	297	1,739	3,769	1,770	1,767	3,839	19	1,158	96	27	10	105	--
Indiana	422	2,709	6,489	6,748	6,157	627	6	789	178	11	12	10	--
Iowa	---	---	---	---	---	272	(3)	338	38	--	--	--	--
Kansas	---	---	---	---	---	87	(3)	23	3	--	--	--	--
Kentucky	17	480	W	169	W	656	--	159	W	--	--	45	--
Louisiana	---	---	---	---	---	W	(3)	W	---	--	--	--	--
Maine	---	---	---	---	---	---	--	W	(3)	--	--	--	--
Maryland	127	823	W	2,172	W	121	W	122	W	--	--	--	--
Massachusetts	---	---	---	---	---	19	(3)	87	24	4	3	--	--
Michigan	287	2,756	6,421	835	618	1,033	11	4,100	559	--	--	2	--
Minnesota	2	---	---	336	446	42	1	101	36	--	--	--	--
Mississippi	---	---	---	---	---	W	--	---	---	--	--	--	--
Missouri	---	---	---	50	1	926	1	82	18	--	--	--	--
Montana	---	---	---	---	---	---	--	W	(3)	--	--	W	--
Nebraska	---	---	---	---	---	W	(3)	W	---	--	--	--	--
Nevada	---	---	---	---	---	W	(3)	---	---	--	--	--	--
New Hampshire	---	---	---	---	---	W	(3)	---	---	W	W	--	--
New Jersey	---	---	---	---	---	386	8	313	59	1	1	14	3
New York	332	1,325	3,997	1,368	1,666	270	8	637	84	--	--	42	--
North Carolina	---	---	---	---	---	W	(3)	W	W	--	--	--	--
Ohio	1,500	3,217	8,421	4,542	6,644	4,739	115	2,469	221	52	18	29	(3)
Oklahoma	---	---	---	---	---	W	W	W	W	--	--	--	--
Oregon	---	---	---	---	---	201	(3)	7	1	--	--	--	--
Pennsylvania	1,219	4,120	7,639	7,667	11,077	4,445	85	922	116	73	23	159	--
Rhode Island	---	---	---	---	---	77	--	50	10	--	--	--	--
South Carolina	---	---	---	---	---	3	--	48	W	--	--	--	--
Tennessee	---	---	---	---	---	48	9	426	175	--	--	--	--
Texas	138	---	---	1,080	79	1,508	19	465	104	--	--	1	--
Utah	W	---	---	W	W	W	W	W	W	--	--	W	--
Vermont	---	---	---	---	---	---	--	23	7	--	--	2	--
Virginia	---	---	---	---	---	203	W	428	W	--	--	--	--
Washington	---	---	---	---	---	576	W	6	(3)	--	--	--	--
West Virginia	80	1,352	W	7	---	235	W	37	W	10	W	--	--
Wisconsin	---	---	---	48	6	327	6	554	133	30	19	4	--
Undistributed	123	437	7,487	1,181	5,538	1,619	28	333	279	1	6	46	--
U.S. total [4]	4,779	19,828	46,408	30,706	37,447	23,807	332	14,978	2,911	210	92	506	3

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Excludes molten pig iron used for ingot molds and direct castings.
[2] Includes vacuum melting furnaces and miscellaneous melting processes.
[3] Less than ½ unit.
[4] Data may not add to totals shown due to independent rounding.

Table 5.—Consumption of iron and steel scrap and pig iron [1] in the United States in 1969, by type of consumer and type of furnace or equipment

(Thousand short tons)

Type of furnace or equipment	Manufacturers of steel ingots and castings [2]		Manufacturers of steel castings [3]		Iron foundries and miscellaneous users		Total all types [4]	
	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron
Blast furnace [5]	4,779	------	-----	---	------	-----	4,779	------
Basic oxygen converter [6]	19,828	46,408	-----	---	------	-----	19,828	46,408
Open-hearth furnace	30,252	37,397	454	50	------	-----	30,706	37,447
Electric furnace	19,575	213	2,466	42	1,767	77	23,807	332
Cupola furnace	1,832	154	365	6	12,782	2,751	14,978	2,911
Air furnace	32	6	57	14	121	72	210	92
Other furnaces [7]	343	------	1	---	163	3	506	3
U.S. total [4]	76,641	84,178	3,342	113	14,833	2,903	94,816	87,193

1 Excludes molten pig iron used for ingot molds and direct castings.
2 Includes only those castings made by companies producing steel ingots.
3 Excludes companies that produce both steel ingots and steel castings.
4 Data may not add to totals shown due to independent rounding.
5 Includes consumption in all blast furnaces producing pig iron.
6 Includes scrap and pig iron processed in metallurgical blast cupolas and used in oxygen converters.
7 Includes vacuum melting furnaces and miscellaneous melting processes.

Table 6.—Proportion of iron and steel scrap and pig iron used in furnaces in the United States

(Percent)

Type of furnace	1969	
	Scrap	Pig iron
Basic oxygen converter	29.9	70.1
Open-hearth furnace	45.1	54.9
Electric furnace	98.6	1.4
Cupola furnace	83.7	16.3
Air furnace	69.5	30.5

Table 7.—Receipts, production, consumption, shipments and stocks of iron and steel scrap and pig iron, by type of manufacturer, in 1969

(Thousand short tons)

	Manufacturers of steel ingots and castings [1]	Manufacturers of steel castings [2]	Iron foundries and miscellaneous users	Total
Scrap:				
Receipts	31,972	2,219	9,488	43,679
Production	49,257	1,216	5,814	56,287
Consumption	76,641	3,342	14,833	94,816
Shipments	6,078	174	498	6,750
Stocks Dec. 31	5,413	270	869	6,552
Pig iron:				
Receipts	5,128	109	3,712	8,949
Production	93,567	-----	-----	93,567
Consumption	90,761	113	3,761	94,635
Shipments	8,327	2	2	8,331
Stocks Dec. 31	1,467	16	240	1,723

1 Includes only those castings made by companies producing steel ingots.
2 Excludes companies that produce both steel ingots and castings.

Table 8.—Consumer stocks, receipts, production, consumption, and shipments of iron and steel scrap in 1969, by grades

(Thousand short tons)

Grades of scrap	Receipts	Production	Consumption	Shipments	Stocks Dec. 31
Carbon steel:					
Low phosphorous plate and punchings	1,747	286	2,042	8	122
Cut structural and plate	1,431	95	1,561	11	80
No. 1 heavy melting steel	7,967	20,442	27,195	1,913	1,897
No. 2 heavy melting steel	3,316	3,303	6,488	122	454
No. 1 and electric furnace bundles	6,674	1,459	7,632	757	492
No. 2 and all other bundles	3,905	384	4,270	206	309
Turnings and borings	2,858	497	3,217	254	222
Slag scrap (Fe content)	1,327	2,474	3,761	60	109
Shredded or fragmentized	799	------	809	-----	17
All other carbon steel scrap	5,601	13,417	17,863	1,572	1,015
Stainless steel	610	724	1,189	156	138
Alloy steel (except stainless)	683	2,771	3,295	126	403
Cast iron (includes borings)	6,162	9,806	14,395	1,426	1,246
Other grades of scrap	599	629	1,099	139	48
U.S. total [1]	43,679	56,287	94,816	6,750	6,552

[1] Data may not add to totals shown due to independent rounding.

Table 9.—Consumer stocks of iron and steel scrap, by grades, and pig iron, Dec. 31, 1969 by States

(Thousand short tons)

State	Carbon steel (excludes rerolling rails)	Stainless steel	Alloy steel (excludes stainless)	Cast iron (include borings)	Other grades of scrap	Total scrap stocks [1]	Pig iron stocks
Alabama	156	--	W	57	W	213	206
Arizona	---	--	--	---	--	---	---
Arkansas	W	--	--	---	--	W	---
California	141	1	2	40	1	185	22
Colorado	26	(2)	1	4	1	32	W
Connecticut	3	5	1	5	W	14	2
Delaware	W	--	W	W	--	W	---
Florida	W	--	--	---	--	W	W
Georgia	W	--	--	W	--	W	1
Illinois	552	6	21	58	1	638	66
Indiana	443	7	11	152	6	619	39
Iowa	42	(2)	W	4	1	47	2
Kansas	3	--	--	W	--	3	W
Kentucky	74	1	16	10	--	101	W
Louisiana	W	--	--	---	--	W	W
Maine	(2)	--	--	W	--	W	W
Maryland	104	13	15	23	W	155	W
Massachusetts	3	--	W	2	--	5	2
Michigan	223	19	1	116	2	361	132
Minnesota	69	--	W	11	W	80	10
Mississippi	W	--	--	---	--	W	---
Missouri	158	(2)	3	17	4	182	7
Montana	---	--	--	---	W	W	---
Nebraska	---	--	--	W	--	W	W
Nevada	(2)	--	--	W	--	W	W
New Hampshire	W	--	--	---	--	W	---
New Jersey	31	(2)	3	23	W	57	6
New York	267	32	12	102	W	413	308
North Carolina	W	--	--	W	--	W	3
Ohio	717	12	84	136	4	953	497
Oklahoma	W	--	--	W	--	W	2
Oregon	16	3	1	W	--	20	W
Pennsylvania	1,033	33	208	358	22	1,654	305
Rhode Island	W	--	W	W	--	W	1
South Carolina	(2)	--	--	1	--	1	W
Tennessee	5	--	W	6	1	12	6
Texas	220	(2)	12	54	W	286	17
Utah	W	--	W	W	--	W	W
Vermont	1	--	--	1	--	2	1
Virginia	12	5	W	8	--	25	W
Washington	62	(2)	3	8	1	74	1
West Virginia	83	--	3	5	W	91	4
Wisconsin	22	(2)	W	10	1	33	32
Undistributed	253	--	6	35	3	296	51
U.S. total [1]	4,717	138	403	1,246	48	6,552	1,723

W Withheld to avoid disclosing individual company confidential data, included in "Undistributed."
[1] Data may not add to totals shown due to independent rounding.
[2] Less than ½ unit.

Table 10.—Stocks of iron and steel scrap and pig iron at major consuming industries' plants Dec. 31

(Thousand short tons)

Year	Manufacturers of steel ingots and castings	Manufacturers of steel castings	Iron foundries and miscellaneous users	Total
Scrap stocks:				
1968	6,691	346	845	7,882
1969	5,413	270	869	6,552
Pig iron stocks:				
1968	2,028	22	292	2,342
1969	1,467	16	240	1,723

Table 11.—Average monthly price and composite price for No. 1 heavy melting scrap in 1969

(Per long ton)

Month	Chicago	Pittsburgh	Philadelphia	Composite price [1]
January	$26.50	$28.25	$27.00	$27.25
February	28.00	29.50	26.50	28.00
March	26.70	26.90	26.50	26.70
April	26.75	26.75	26.50	26.67
May	30.75	29.50	27.25	29.16
June	29.90	29.70	29.30	29.63
July	29.00	31.00	30.25	30.17
August	32.50	33.50	32.50	32.84
September	34.30	36.90	36.30	35.83
October	30.75	34.00	37.25	34.00
November	30.00	33.50	37.00	33.50
December	35.10	34.50	37.50	35.70
Average:				
1969	30.02	31.16	31.15	30.78
1968	24.57	26.67	26.30	25.85

[1] Composite price, Chicago, Pittsburgh, Philadelphia.
Source: Iron Age, Jan. 1, 1970.

Table 12.—U.S. exports of iron and steel scrap, by countries

Destination	Iron and steel scrap including tinplate and terneplate scrap				Rerolling material			
	1968		1969		1968		1969	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Australia	49	$2	694	$11	-----	-----	-----	-----
Belgium-Luxembourg	20,574	769	33,092	1,847	-----	-----	-----	-----
Canada	523,442	12,106	618,758	15,306	142	$27	117	$8
Colombia	5,214	174	7,011	259	-----	-----	-----	-----
France	14,820	1,634	47,286	2,867	-----	-----	35	5
Germany, West	57,857	2,952	92,963	5,345	-----	-----	-----	-----
Greece	9,150	194	-----	-----	-----	-----	-----	-----
Hong Kong	8,081	546	12,849	391	-----	-----	25,458	2,220
Italy	728,615	20,363	878,767	25,782	9,937	343	15,041	588
Japan	3,386,515	92,223	4,204,090	126,255	100,819	4,729	173,684	8,318
Korea, Republic of	304,181	10,003	553,008	20,346	9,470	447	22,027	1,103
Mexico	528,289	18,074	583,359	20,261	-----	-----	-----	-----
Netherlands	4,634	255	3,618	327	-----	-----	-----	-----
Pakistan	22,068	456	-----	-----	-----	-----	-----	-----
Peru	5,789	234	3,388	115	-----	-----	-----	-----
Philippines	19,103	451	20,037	477	-----	-----	-----	-----
Spain	357,393	7,664	1,103,697	30,150	-----	-----	-----	-----
Sweden	104,763	16,068	203,566	19,766	6,641	298	3,285	156
Taiwan	195,093	5,336	114,869	4,507	-----	-----	11,959	707
Thailand	47,081	1,323	60,741	1,950	-----	-----	-----	-----
Turkey	77,917	1,940	79,145	2,013	-----	-----	-----	-----
United Arab Republic	29,888	668	27,128	689	-----	-----	-----	-----
United Kingdom	2,657	268	309,824	10,514	-----	-----	2,041	65
Venezuela	29,813	783	57,806	1,683	-----	-----	-----	-----
Yugoslavia	69,586	1,889	11,040	450	-----	-----	-----	-----
Other	12,477	630	9,225	545	-----	-----	-----	-----
Total	6,565,049	197,005	9,035,961	291,856	127,009	5,844	253,647	13,170

Table 13.—U.S. exports and imports for consumption of iron and steel scrap by classes

(Thousand short tons and thousand dollars)

Class	1968		1969	
	Quantity	Value	Quantity	Value
Exports:				
Nos. 1 and 2 heavy melting steel scrap	3,265	$92,670	4,461	$144,406
Nos. 1 and 2 baled steel scrap	1,239	26,150	1,631	41,717
Borings, shovelings, and turnings	439	8,359	767	13,135
Iron scrap	416	10,868	627	20,481
Rerolling material	127	5,844	254	13,170
Other steel scrap (terneplated and tinplated)	1,206	58,958	1,550	72,117
Total	6,692	202,849	9,290	305,026
Imports:				
Iron and steel scrap	276	10,784	311	12,280
Tinplate scrap	18	541	24	917
Total	294	11,325	335	13,197

Table 14.—U.S. imports for consumption of iron and steel scrap, by countries

Country	1968		1969	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Australia	22	$7	---	---
Austria	---	---	115	$63
Belgium-Luxembourg	1,961	501	---	---
Canada	279,404	9,781	324,562	11,198
Dominican Republic	---	---	501	10
French West Indies	2,148	69	786	25
Germany, West	1,655	60	4,644	991
India	11	6	50	38
Italy	1,115	310	---	---
Japan	11	5	1,047	276
Korea, Republic of	---	---	56	14
Mexico	764	74	440	155
Netherlands	---	---	32	22
Norway	822	28	---	---
Sweden	236	66	2,107	152
United Kingdom	5,996	399	676	250
Other	80	19	183	3
Total	294,225	11,325	335,199	13,197

Iron Oxide Pigments

By Frank L. Fisher [1]

The quantity and value of crude iron oxide pigments sold or used declined in 1969; however, the quantity and value of finished pigments sold increased, with 12 companies reporting a total production of 142,900 short tons valued at $32.3 million. The value and volume of both exports and imports increased in 1969, with West Germany the major source of imports and Canada receiving the bulk of the exports.

DOMESTIC PRODUCTION

Production and consumption of crude iron oxide pigments declined in 1969. Eight companies in nine States reported production of crude iron oxide pigments; Cleveland-Cliffs Iron Co. in Michigan was the largest producer. Twelve companies produced finished iron oxide pigments from 18 plants in nine States. Charles Pfizer & Co., Inc., with plants in Illinois, Pennsylvania, and California, was the major producer of finished iron oxide pigments.

Table 1.—Salient iron oxide pigments statistics in the United States

	1965	1966	1967	1968	1969
Mine production short tons	57,000	63,200	39,900	57,600	40,600
Crude pigments sold or used do	56,200	63,900	41,800	57,600	40,800
Value thousands	$419	$476	$326	$457	$362
Finished pigments sold short tons	127,500	130,700	127,300	132,400	142,900
Value thousands	$23,549	$24,841	$26,720	$30,676	$32,289
Exports short tons	4,700	4,800	3,100	3,300	4,000
Value thousands	$1,380	$1,307	$1,312	$1,257	$1,439
Imports for consumption short tons	17,800	24,600	23,400	29,900	33,400
Value thousands	$2,165	$3,163	$3,203	$4,117	$5,044

CONSUMPTION AND USES

The total quantity of crude pigments sold or used dropped approximately 29 percent to 40,800 short tons. For the second consecutive year, sales of finished iron oxide pigments reached a record high with a reported 142,900 short tons sold, representing an 8-percent gain over the previous year. The total value was $32.3 million for finished pigments and $362,000 for crude iron oxide pigments. Pure synthetic iron oxide pigments found increased use in ferrite production where the ferrite applications include use in a wide variety of electrical and electronic devices such as computers, magnetic switches, microwave equipment, and other electrical hardware.

Data are not collected by the Bureau of Mines on specific uses of iron oxide pigments, and the figures given in table 2 do not necessarily reflect all sales of iron oxide pigment material except for that material used as pigments.

[1] Physical scientist, Bureau of Mines, Minneapolis, Minn.

Table 2.—Finished iron oxide pigments sold by processors in the United States, by kinds

Pigment	1968 Short tons	1968 Value [1] (thousands)	1969 Short tons	1969 Value [1] (thousands)
Natural:				
Brown:				
Iron oxide (metallic) [2]	14,245	$2,558	15,240	$2,419
Umbers:				
Burnt	3,877	849	4,341	970
Raw	1,063	231	1,192	270
Red:				
Iron oxide	28,199	1,607	36,301	2,245
Sienna, burnt	896	318	1,035	377
Pyrite cinder	3,949	262	(3)	(3)
Yellow:				
Ocher [4]	4,759	275	5,527	379
Sienna, raw	639	194	600	188
Total natural	57,627	6,294	64,236	6,848
Manufactured:				
Black: Magnetic	3,560	1,185	3,527	1,196
Brown: Iron oxide	6,177	3,622	7,163	4,110
Red:				
Pure red iron oxides:				
Calcined copperas	18,910	5,604	18,558	5,609
Other chemical processes [5]	14,838	4,111	14,322	3,909
Venetian red	594	99	603	110
Yellow: Iron oxide	25,670	7,455	26,334	7,903
Total manufactured	69,749	22,076	70,507	22,838
Unspecified including mixtures of natural and manufactured red iron oxides	5,007	2,306	8,150	2,603
Grand total	132,383	30,676	142,893	32,289

[1] Data may not add to totals shown because of independent rounding.
[2] Includes black magnetite and vandyke brown.
[3] Pyrite cinder included with red iron oxide for 1969.
[4] Includes yellow iron oxide.
[5] Includes other manufactured red iron oxide.

PRICES

Price increases for most iron oxide pigments were announced in April and became effective May 1. The increases were attributed to strong demand for domestic pigments plus a world-wide shortage that resulted in higher prices for imports. The high price of imported synthetics had a definite impact on the increased domestic price. Several selected specialty items were not subject to the higher price quotations.

Table 3.—Prices quoted on finished iron oxide pigments, per pound, in bags, unless otherwise noted, as of December 31, 1969

Pigment	Low	High	Pigment	Low	High
Black:			Red:		
Pure	$0.1650	$0.1675	Domestic primers	$0.0700	$0.0750
Synthetic	.1300	.1325	Persian Gulf [1]	.1000	.1200
Brown:			Pure synthetic	.1500	.1600
Pure, synthetic	.1775	.1800	Spanish, docks, New York [1]	.0750	.0850
Metallic	.0700	.0750	Sienna, American, burnt	.1725	.1825
Umber, American, burnt [1]	.0975	.1075	Yellow:		
Umber, American, raw [1]	.0975	.1075	Ocher, domestic	.0425	.0425
Vandyke, American [1]	.1100	.1200	Ocher, French type	.0900	.1100
Sienna, American, burnt [1]	.1725	.1825	Pure, light lemon	.1450	.1525
			Other shades [1]	.1375	.1425

[1] Barrels.

Source: Oil, Paint and Drug Reporter, American Paint Journal, and pigment processors.

FOREIGN TRADE

Exports of iron oxide pigments from the United States went to more than 40 countries in 1969 with total shipments of approximately 4,000 tons valued at $1.4 million. Canada received nearly one-half of the total exported with Australia, West Germany, and the United Kingdom receiving over 200 tons each.

Table 4.—U.S. exports of iron-oxide pigments, by countries

Destination	1968 Short tons	1968 Value (thousands)	1969 Short tons	1969 Value (thousands)
Argentina	63	$39	128	$56
Australia	326	169	278	192
Belgium-Luxembourg	17	6	12	4
Brazil	99	59	85	50
Canada	871	250	1,860	439
Chile	16	5	25	7
Colombia	15	7	29	11
France	200	80	195	99
Germany, West	541	164	233	77
Greece	-----	-----	21	14
Guatemala	49	13	30	9
Hong Kong	2	2	16	12
India	19	6	1	1
Iran	14	7	22	10
Italy	30	17	35	18
Japan	148	65	79	54
Mexico	111	94	79	54
Netherlands	96	14	125	57
New Zealand	55	9	13	5
Panama	1	1	7	3
Philippines	85	31	118	46
Sweden	19	11	11	4
United Kingdom	262	99	226	84
Venezuela	122	39	168	48
Vietnam, South	46	22	85	37
Other countries	114	48	111	48
Total	3,321	1,257	3,992	1,439

The United States imported 33,400 short tons of iron oxide pigments in 1969 valued at $5.0 million compared with imports of 29,900 short tons in 1968 valued at $4.1 million. Synthetic iron oxide and iron hydroxide made up the bulk of the imports in 1969 with 22,600 short tons valued at $4.4 million.

Table 5.—U.S. imports for consumption of selected iron-oxide pigments

Pigments	1968 Short tons	1968 Value (thousands)	1969 Short tons	1969 Value (thousands)
Natural:				
Ocher, crude and refined	126	$8	87	$6
Siennas, crude and refined	1,464	173	1,341	146
Umber, crude and refined	4,671	178	6,240	235
Vandyke brown	589	50	472	42
Other [1]	4,442	253	2,736	225
Total	11,292	662	10,876	654
Manufactured (synthetic)	18,596	3,455	22,555	4,390
Grand total	29,888	4,117	33,431	5,044

[1] Classified by the Bureau of the Census as "Natural iron-oxide and iron-hydroxide pigments, n.s.p.f."

Table 6.—U.S. imports for consumption of iron-oxide and iron-hydroxide and pigments, n.s.p.f. by countries

Country	Natural				Synthetic			
	1968		1969		1968		1969	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Belgium-Luxembourg	7	$9	-----	---	18	$2	------	------
Canada	-----	---	1	$1	6,052	1,275	7,169	$1,513
Finland	-----	---	-----	---	------	-----	240	87
France	(1)	1	-----	---	80	12	21	4
Germany, West	5	5	2	5	11,453	2,018	13,824	2,553
Iran	276	10	-----	---	------	-----	------	------
Japan	(1)	(1)	11	30	17	2	14	56
Netherlands	-----	---	-----	---	------	-----	10	1
Spain	3,866	196	2,517	160	3	1	85	6
Switzerland	-----	---	-----	---	------	-----	(1)	1
United Kingdom	288	32	205	29	973	145	1,192	169
Total	4,442	253	2,736	225	18,596	3,455	22,555	4,390

[1] Less than ½ unit.

TECHNOLOGY

Research and development was focused on the improved use of iron oxides as pigments and on wider applications for the magnetic and electrical properties which certain oxides possess. Improvements in calcining and sintering methods for producing ferrites made notable progress during 1969. New techniques developed during the year have increased the preferred orientation of a variety of ferrites, particularly lead ferrite.

Precise temperature control in the kiln has been established as the key to the mass production of ferrite-ceramic permanent magnets. Sintering facilities with complete automation are now in operation with a temperature variation maintained at 2.5° F in kilns with a maximum temperature of 2500° F.

Kyanite and Related Minerals

By J. Robert Wells [1]

The quantity of kyanite sold or used by domestic producers in 1969 was 3 percent greater in tonnage and 6 percent higher in total value than in 1968, and established a new record by going slightly over the previous high mark reached in 1966.

Kyanite, sillimanite, andalusite, dumortierite, and topaz are conveniently considered as a group, because they are natural silicate minerals with many similarities in composition and properties. In common with synthetic mullite, they all can be used as materials for the manufacture of mullite-type refractories.

The United States and India are the world's principal suppliers of kyanite. Large-scale production of sillimanite is mostly confined to India and the Republic of South Africa; South Africa is also the most important source of andalusite. Australia, Spain, territory of South-West Africa, Southern Rhodesia, and South Korea also produce minor quantities of kyanite-group minerals. There is little or no industrial utilization of dumortierite or of topaz (non-gem-grade) at present.

The Bureau of Mines concluded research on developing improved methods of beneficiating kyanite ores at the Tuscaloosa Metallurgy Research Laboratory, and reports covering this work were either completed or in advanced stages of preparation. Bureau engineers reported on Kyanite deposits in the Northwestern United States and presented the results of a study of actual and potential markets for western kyanite ores.[2] Another Bureau report on kyanite, of primary interest but for some time out of print, became available as a reprint.[3]

Legislation and Government Programs.—The Government, through the Office of Minerals Exploration, provides loans up to 50 percent of the approved costs to be incurred in the exploration of strategic kyanite deposits, but no loans were made for that purpose during 1969.

Holdings of kyanite-mullite in the strategic stockpile, as of June 20, 1969, amounted to 4,800 tons, which was the announced stockpile objective.

The Tax Reform Act of 1969, signed by the President on December 30, provided for a reduction of 1 percent in each of the depletion rates applicable to kyanite; specifically, the domestic rate was lowered from 23 percent to 22, and the foreign rate from 15 percent to 14, to be effective in taxable years beginning after October 9, 1969.

New tariff regulations established in 1969 continued to provide for duty-free import of kyanite, sillimanite, andalusite, and dumortierite. The ad valorem duty on mullite, set at 13 percent at the start of 1968, was reduced to 12 percent on January 1, 1969, and was scheduled for a further reduction in 1970.

DOMESTIC PRODUCTION

Kyanite was mined in 1969 in three States and was recovered as a byproduct in a fourth. Kyanite Mining Corp., the largest domestic producer, operated two mines in Virginia, one at Dillwyn in Buckingham County and, the other at Farmville in adjacent Prince Edward County. Aluminum Silicates, Inc., and Commercialores, Inc.,

[1] Physical scientist, Bureau of Mines, Knoxville, Tenn.

[2] Van Noy, Ronald M., Normas S. Petersen, and Jerry J. Gray. Kyanite Resources in the Northwestern United States (in Two Sections). 1. An Investigation of Selected Kyanite-Group Mineral Deposits. 2. A Market Study for Western Kyanite Ores. BuMines Rept. of Inv. 7426, 1970, 81 pp.

[3] Klinefelter, T. A., and James D. Cooper. Kyanite, A Materials Survey. BuMines Inf. Circ. 8040, 1961, 55 pp.

both subsidiaries of Combustion Engineering, Inc., produced kyanite from the Graves Mountain mine in Lincoln County, Ga., and from the Henry Knob mine in York County, S.C., respectively. Kyanite was also recovered in Florida as an accessory product in the Trail Ridge plant of E. I. du Pont de Nemours & Co., Inc., in the course of operations for the extraction of heavy minerals from the complex sands of an extensive deposit in Clay County.

Kyanite production in 1969 was approximately 3 percent more than in 1968, but actual figures are company confidential information and cannot be published.

Synthetic mullite, in the extra-quality grades, was manufactured by high-temperature treatment of mixtures of Bayer-process alumina with pure silica sand, while siliceous bauxite and bauxite-clay mixtures served for the making of materials to meet less exacting specifications. Rotary, periodic, and tunnel kilns were employed for sintered material, but the production of fused mullite was, of necessity, accomplished only at the higher temperatures attainable in electric-arc furnaces.

Table 1.—Synthetic mullite production in the United States

Year	Short tons	Value (thousands)
1965	40,049	$4,866
1966	49,551	5,961
1967	40,288	4,811
1968	36,014	5,758
1969	48,588	6,847

Synthetic mullite, amounting to over one-third more in tonnage than in 1968, and almost one-fifth higher in total value, was produced in 1969 by seven firms: The Babcock & Wilcox Co., Refractories Division, New York, N.Y. (plant at Augusta, Ga.); The Carborundum Co., Niagara Falls, N.Y. (plant at Niagara Falls, N.Y.); Harbison-Walker Refractories Co., Pittsburgh, Pa. (plant at Eufaula, Ala.); Norton Co., Worcester, Mass. (plant at Huntsville, Ala.); H. K. Porter Co., Inc., Refractories Division, Pittsburgh, Pa. (plant at Shelton, Conn.); Remmy Division of A. P. Green Refractories Co., Philadelphia, Pa. (plant at Philadelphia, Pa.); The Chas. Taylor Sons Co., subsidiary of National Lead Co., Cincinnati, Ohio (plant at South Shore, Ky.).

The Mullite Co. of America (Mulcoa), a subsidiary of Combustion Engineering, Inc., completed construction of a new $3 million plant at Andersonville, Ga., for the production of calcined bauxite, at least part of which will enter into the manufacture of synthetic mullite. An industrial journal published a detailed account of an extensive program undertaken by a major manufacturer to reorganize and modernize facilities at South Shore, Ky., for the production of mullite and other refractory materials for special applications.[4]

CONSUMPTION AND USES

Kyanite, either domestically produced or imported and mostly ground to 35 mesh or finer, was consumed chiefly in the preparation of refractory mortars, ramming mixes, and plastic refractories. Synthetic mullite was used, for the most part, in the fabrication of high-alumina refractory brick and shapes for structures exposed to extreme and long-continued heat. Applications were in furnaces for ferrous and nonferrous smelting, the electric-arc preparation of special alloys, and the manufacturing of glass.

In addition to the refractories applications, kyanite was incorporated in certain ceramic mixtures, in which it confers a number of important advantages. Its presence in a ceramic body often improves the workability, and because of the interwoven texture of the mullite crystals that are formed on firing, also provides superior mechanical strength in the finished products. The increase in volume that accompanies the conversion to mullite is often advantageous, furthermore, in that it can compensate for the reduction caused by the shrinkage of the clays that usually are the principal components of the mixture.

According to a ceramic raw materials survey conducted by C. H. Kline & Co., domestic consumption of kyanite in 1969 may have amounted to 75,000 tons, valued at $4.5 million. Consumption of synthetic mullite was estimated at 36,000 tons with a value of $5.8 million.[5]

[4] Svec, J. J. Chas. Taylor's $8-Million Start toward 2-Phase Modernization. Brick & Clay Record, v. 155, No. 2, August 1969, pp. 27–34.

[5] Ceramic Age. U.S. Consumption of Ceramic Raw Materials. V. 86, No. 1, January 1970, p. 29.

PRICES

Prices were quoted in the December 1969 issue of Engineering and Mining Journal as follows for kyanite, f.o.b. shipping point, South Carolina, Georgia, in bags per short ton (bulk shipments $3 less per ton):

35 mesh	$56
48 mesh	$58
100 mesh	$59
200 mesh	$64
325 mesh	$79

The November 1969 issue of the Journal quoted imported Kyanite, 60 percent grade, c.i.f. Atlantic ports, $86 to $91 per short ton; in paper bags $1.75 extra.

FOREIGN TRADE

Kyanite exports declined slightly in 1969, while imports showed a small upturn. There was not, however, even a remote threat to the favorable balance of recent years, because nearly 10 times more kyanite was exported than was received from abroad—a marked contrast to the situation of two decades ago when a typical year's exports might be outweighed 15 to 1 by imports. In terms of dollars, the shift has been from a drain of about $1.5 million in 1950 to a net advantage of more than $1.5 million in 1969.

Japan, for several years the leading destination for U.S. kyanite exports, yielded place in that respect to Canada, Italy, and West Germany. India, meanwhile, remained without challenge as the principal supplier of the material that was imported by the United States.

Table 2.—U.S. exports and imports for consumption of kyanite and related minerals

	1967		1968		1969	
	Short tons	Value	Short tons	Value	Short tons	Value
EXPORTS						
Argentina	24	$2,236	22	$1,420	19	$1,462
Australia	393	28,328	704	46,743	692	49,438
Belgium-Luxembourg	582	52,448	876	61,464	487	34,480
Canada	5,012	337,954	3,861	252,084	4,342	306,801
Colombia	------	------	182	11,566	209	9,381
France	291	51,037	398	49,074	157	26,045
Germany, West	1,492	87,958	1,740	104,527	2,559	168,145
Italy	1,564	120,887	1,557	116,490	2,845	211,864
Japan	7,143	427,477	5,576	331,262	2,338	151,762
Mexico	1,610	110,706	1,438	88,987	1,498	105,796
Netherlands	60	2,280	61	3,990	22	634
South Africa, Republic of	37	3,181	144	8,404	77	6,319
Sweden	169	6,935	575	27,082	1,124	64,673
Taiwan	------	------	------	------	589	20,750
Thailand	34	2,368	582	35,973	------	------
United Kingdom	2,414	111,498	1,687	79,481	1,476	85,989
Venezuela	291	15,816	621	39,675	740	67,923
Other countries	312	47,333	453	52,472	522	41,923
Total	21,428	1,408,442	20,477	1,310,694	19,696	1,353,385
IMPORTS						
Canada	------	------	------	------	306	$17,921
India	1,821	$75,158	1,391	$49,414	1,167	48,439
Mozambique	------	------	------	------	277	9,921
South Africa, Republic of	------	------	59	1,967	338	11,928
Total	1,821	75,158	1,450	51,381	2,088	88,209

WORLD REVIEW

Australia.—Mine production of sillimanite, January through June 1969—approximately two-thirds from New South Wales, one-third from South Australia—amounted to 1,113 short tons. Australia imported, in that same period, 328 tons of sillimanite and 1,267 tons of kyanite.

Canada.—North American Refractories, Ltd., Canadian affiliate of North American Refractories Company of Cleveland, Ohio, continued investigation of the Témiskaming kyanite deposit in Quebec. Contrary to previous forecasts anticipating early production from this site, it was implied in a paper presented at the annual meeting of the American Institute of Mining, Metallurgical, and Petroleum Engineers at Denver, Colorado, in February 1970 that operations there are still somewhat exploratory. Other kyanite deposits, shown by preliminary investigations to be potentially favorable for commercial exploitation, have been found at Wanapitei, 12 miles east of Sudbury, and near Mattawa, both in Ontario, and in the Big Bend area of British Columbia.[6]

Hungary.—Pilot-plant production of synthetic mullite, of a quality suitable for use in high-performance refractories, was started at Nyiregyhaza to provide experience for construction of full-scale facilities —prospective capacity not yet disclosed— planned for 1970. Bauxite or Bayer-process alumina for high-temperature reaction with kaolin or silica—all readily available within Hungary—were mentioned as optional combinations of starting materials. Output from the new plant offers the promise of relief for Hungary from the present compulsory dependence on imports of calcined kyanite.

India.—The Mineral Ores Export Advisory Committee recommended that the raw kyanite export duty, hitherto charged at a flat rate, be revised to provide for a progressive scale keyed to the grade of mineral involved. In 1968, production of kyanite in India amounted to 70,945 tons, of which 78 percent was exported—2 percent to the United States. Exports of Indian sillimanite in 1968, all to Asian and European destinations, accounted for 54 percent of the 5,127 tons produced.

Kenya.—A report became available that described the geographical setting, geology, mineralogy, history, and marketing possibilities of what is stated to be one of the largest kyanite deposits in the world. An abundance of supplemental information was included, dealing with a number of practical, legal, and economic factors that would require consideration in evaluating the potentialities of this ore body for profitable exploitation.[7]

Liberia.—Interest was aroused by an announcement of the discovery of kyanite deposits, possibly of commercial significance, in the vicinity of the barite concession of Dresser Industries, Inc., in Grand Bassa Country. Development of substantial kyanite production for the export trade might provide a welcome adjunct to Liberia's industrial capacity, which is dominated by the growing of rubber and the mining of iron ore.

South Africa, Republic of.—Mine output of andalusite in the first three quarters of 1969 was 34,257 tons, almost double the quantity reported for the same period of 1968. Sillimanite production in those nine months—23,823 tons—was about 15 percent below the comparable figure for 1968. Exports of the two minerals in the nine-month period of 1969 were up and down, respectively, from 1968 in almost the same proportions as the production figures. The quantity of sillimanite sold locally in that period of 1969 was about the same as in 1968, but local sales of andalusite more than doubled.

TECHNOLOGY

Synthetic mullite in grain form and also fabricated into brick and shapes for specialized refractories applications is a major production item in a newly expanded and modernized plant at South Shore, Ky., described in a recent issue of Brick & Clay Record. Technical details of the plant layout, equipment, and operation were presented, together with some account of the testing procedures for quality control that are applied both to raw materials and to the finished products. An extensive description was included of the structural features, dimensions, and temperature specifications of the various sections of the newly installed dual-unit shuttle kiln system.[8]

The behavior of a kyanite-sillimanite

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[6] Wyman, R. A., R. K. Collings, and R. M. Buchanan. Some Interesting Aspects of Canadian Industrial Minerals. Dept. of Energy, Mines and Resources, Mines Branch (Ottawa, Canada). Mineral Processing Division Report MPI (0) 69-59, February 1970, 22 pp.

[7] Mason, J. E. The Murka Kyanite Deposit—Coast Province Kenya. Mines and Geological Department, Ministry of Natural Resources, Wildlife, and Tourism, Republic of Kenya, Inf. Circ. 1, January 1966, 20 pp.

[8] Work cited in footnote [4].

concentrate extracted from Florida beach sand as a raw material for refractory ceramics was assessed. Ceramic shapes incorporating the beach-sand concentrate were equal in pyrometric cone equivalent to others containing hard-rock kyanite, showed 50 percent less mullitization expansion on firing, and had somewhat greater mechanical strength in the fired condition.[9]

Results were published of an investigation of the changes that take place during the process of mullite formation in the firing of the closely related minerals, sillimanite, andalusite, and kyanite, all of which are identical in chemical makeup but differ in crystal character. An effort was made to determine the rates of mullite formation from each of the minerals over a range of temperatures. It was found that conversion rates for the three substances are strongly influenced by variations in grain size and by the presence or absence of impurities.[10]

Information that may have an important bearing upon the production of synthetic mullite was obtained. In an investigation of the reactions of alumina with silicic acid at 1,500° to 1,550° C, it was found that supplying the alumina in the form of coarsely powdered corundum led to the formation of varying amounts of noncrystalline material and consequent reduction of the mullite yield to as little as 17 percent of the quantity expected. Much less noncrystalline substance and proportionately more mullite were obtained when the corundum was reduced to a fine powder. It was thought that the undesirable glassy material constituted a transition phase in the temperaure range of the study.[11]

A Bureau of Mines study of the beneficiation of southeastern kyanite ores was reported.[12] Three other articles dealing with kyanite technology were being prepared.

Kyanite and mullite were two of the specified ingredients in a patented mixture for the production of zircon refractories to be used in situations requiring contact with molten glass.[13]

A patent was issued for a plastic-refractories mixture containing, as an essential component, up to 15 percent of crushed Virginia kyanite. It was claimed that the resulting material fires to a high-strength product with unusually low spalling loss.[14]

A mullite-based refractory of the ramming-mix type, capable of being fired at a relatively low temperature, was one of the materials described in a recent patent.[15]

Kyanite was a required constituent in a ceramic composition to be sprayed or coated on metals, for which a patent was granted.[16]

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[9] Van der Beck, Roland R. Refractory Properties of a Florida Kyanite-Stillimanite Concentrate. Am. Cerm. Soc. Bull., v. 48, No. 7, July 1969, pp. 703–706.

[10] Wilson, H. H. Mullite Formation From the Sillimanite Group Minerals. Am. Ceram. Soc. Bull., v. 48, No. 8, August 1969, pp. 796–797.

[11] Staley, W. G., Jr., and G. W. Brindley. Development of Noncrystalline Material in Subsolidus Reactions Between Silica and Alumina. J. Am. Ceram. Soc., v. 52, No. 11, November 1969, pp. 616–619.

[12] Browning, James S. Flotation of Southeastern Kyanite Ore. Trans. AIME, v. 244, 1969, pp. 283–287.

[13] Horak, W., and G. R. Rowland (assigned to Emhard, Corp., Bloomfield, Conn.). Glass Contact Refractory and Method of Making the Same. U.S. Pat. 3,437,499, Apr. 8, 1969.

[14] Jacobs, L. J. (assigned to the S. Obermayer Co.). Canadian Pat. 813,387, May 20, 1969.

[15] Wood, T. H., and M. Palfreyman (assigned to R. & D. Polymers, Ltd.). , British Pat. 1,142,201, Feb. 5, 1969.

[16] Mueller, E. E. (assigned to SCM Corp., New York, N.Y.). High Temperature Readily Removable Ceramic Coating Composition for Metals, and Resulting Coated Metal Articles. U.S. Pat. 3,459,601, Aug. 5, 1969.

Lead

By Donald E. Moulds [1]

The record-breaking expansion of world production and consumption of lead continued in 1969. World mine production, indicated at 3.52 million tons, increased 6.7 percent above 1968 output, and smelter output of 3.67 million tons, including some foreign secondary output, represented a rise of over 10 percent. The free world mine production of 2.64 million tons and smelter production of 2.67 million tons was insufficient to cover demand during the first three-quarters of the year, which resulted in a producer-stock drawdown of 11,000 tons and a continued drawdown of the U.S. stockpile. The expanded supply, however, exceeded demand in the last quarter, and free world producer stocks climbed to an indicated 185,000 tons, a gain of 22,000 tons during the year.

A factor in free world demand was trade in bullion and metal with the Socialist countries, which resulted in a net export of almost 10,000 tons during the first 9 months of the year. Mainland China was an especially large market with almost 35,000 tons imported, mainly from the United Kingdom.

The domestic lead industry experienced a phenomenal year in 1969 with mine production increasing 42 percent to 509,000 tons, the largest amount since 1930. The increase was due in part to uninterrupted mine operation and, mainly to the output of newly developed mines in Missouri, which added almost 143,000 tons of lead to the State's 1968 total. The production of lead, primary and secondary, was almost 1.26 million tons and represented over 90 percent of reported domestic consumption. Primary materials accounted for 655,000 tons or 52 percent and secondary materials for 604,000 tons.

Domestic consumption of lead established a new record of 1.39 million tons, a 4.6-percent increase over 1968 consumption. The major advances in requirements were batteries, 13.4 percent, and gasoline additive, 3.5 percent. The various other uses were relatively stable in requirements and approximately equal in advances and declines in comparison with the prior year. Sale of stockpiled lead was resumed in the second half of the year with light sales and shipments amounting to 11,900 tons of refined lead for the year plus 10,300 tons of antimonial lead. The available domestic supply from all sources including primary and secondary production, metal imports less exports and changes in commercial and Government stocks indicates an apparent consumption of 72,000 tons of lead in addition to the reported consumption of 1.39 million tons.

The world price of lead reflected the high demand. The London Metal Exchange monthly average price steadily rose from 11.46 cents per pound (U.S. equivalent) in January to 14.24 cents in August. A slight decline in September and October was followed by an upward trend to 15.12 cents in December. The domestic price at New York, opening the year at 13 cents per pound, began an upward trend on January 8 and in seven actions during the year reached 16.5 cents effective December 15.

Legislation and Government Programs.—The price of lead on April 8 reached the 14.5-cent-per-pound floor under which payments to eligible domestic producers are authorized by "The Lead and Zinc Mining Stabilization Program" Public Law 89–239. Payments in 1969 on 2,296 tons of lead produced prior to the April price increases amounted to $30,860. Since its inception in October 1961, this program has paid $2,589,597 to certified domestic producers of lead and zinc. Under revised regulations of June 1, 1966, a total of 61 mines participated of which Oklahoma lead with

[1] Physical scientist, Division of Nonferrous Metals.

Table 1.—Salient lead statistics

	1965	1966	1967	1968	1969
United States:					
Production:					
Domestic ores, recoverable lead-content____short tons__	301,147	327,368	316,931	359,156	509,013
Value____thousands__	$93,959	$98,964	$88,741	$94,903	$151,635
Primary lead (refined):					
From domestic ores and base bullion____short tons__	305,007	318,646	258,507	349,039	513,931
From foreign ores and base bullion____short tons__	113,242	122,089	121,387	118,271	124,724
Antimonial lead (Primary lead content)____short tons__	6,612	11,182	9,083	19,494	16,250
Secondary lead (Lead content) short tons__	575,819	572,834	553,772	550,879	603,905
Imports, general:					
Lead in ores and matte____do____	122,661	143,991	124,067	87,836	109,252
Lead in base bullion____do____	566	2,012	569	8	1,993
Lead in pigs, bars, and old short tons__	226,883	293,085	373,887	344,601	285,342
Exports of lead materials excluding scrap____short tons__	7,811	5,435	6,536	8,281	4,968
Stocks Dec. 31 (lead content):					
At primary smelters and refineries short tons__	83,443	115,473	125,479	90,427	101,860
At consumer plants____do____	109,195	90,306	105,786	88,900	156,404
Consumption of metal, primary and secondary____short tons__	1,241,482	1,323,877	1,260,516	1,328,790	1,389,358
Price: New York, common lead, average, cents per pound____	16.00	15.12	14.00	13.21	14.93
World:					
Production:					
Mine____short tons__	2,966,508	3,138,779	3,159,343	3,298,741	3,523,401
Smelter____do____	2,910,884	3,026,266	3,182,316	3,330,912	3,670,848
Price: London, common lead, average, cents per pound____	14.37	11.87	10.28	10.88	13.09

21, Utah, 15, and Idaho, 8. The program terminated as of January 1, 1970.

Government participation in exploration, primarily for lead, was withdrawn in June 1962. The program, under the Office of Minerals Exploration, Geological Survey, U.S. Department of the Interior, continued active in exploration for other base-metal deposits, often in association with lead.

Sales of Government surplus lead from the strategic stockpile to commercial users were suspended until approval of Public Law 91–46 on July 19, which authorized the sale of 100,000 tons as an off-the-shelf item. Sales in 1969 totaled 22,698 tons leaving 77,312 tons authorized at the end of the year. In addition 3,085 tons was transferred to Government agencies under authorization of Public Law 89–9. The actual drawdown of Government stocks of refined lead during the year amounted to 11,866 tons. In addition to the refined lead, 10,336 tons of antimonial lead in nonstrategic Government stocks was sold and delivered to commercial consumers. The strategic stockpile objective for lead was revised upward on December 3 to 530,000 tons. The stockpile inventory of 1,152,737 tons at the end of 1969 thus provided a surplus of 622,727 tons.

The International Lead and Zinc Study Group convened in Geneva, Switzerland, for its 13th session on October 8. The meeting marked the 10th anniversary of the international work on lead and zinc problems by the 30-country membership. The supply and demand situation was reviewed and found to be in close balance at that time, but a possibility was indicated of a growing surplus of supply and mounting producer stocks. It was noted that since the study group was organized lead consumption in the free world had increased at an average compound rate of 3.8 percent per year.

The International Lead-Zinc Research Organization, incorporated in 1965 by producers and consumers of lead and zinc and representing a major portion of that free world industry, continued to sponsor research and development programs to promote new and expanded use of lead and zinc.

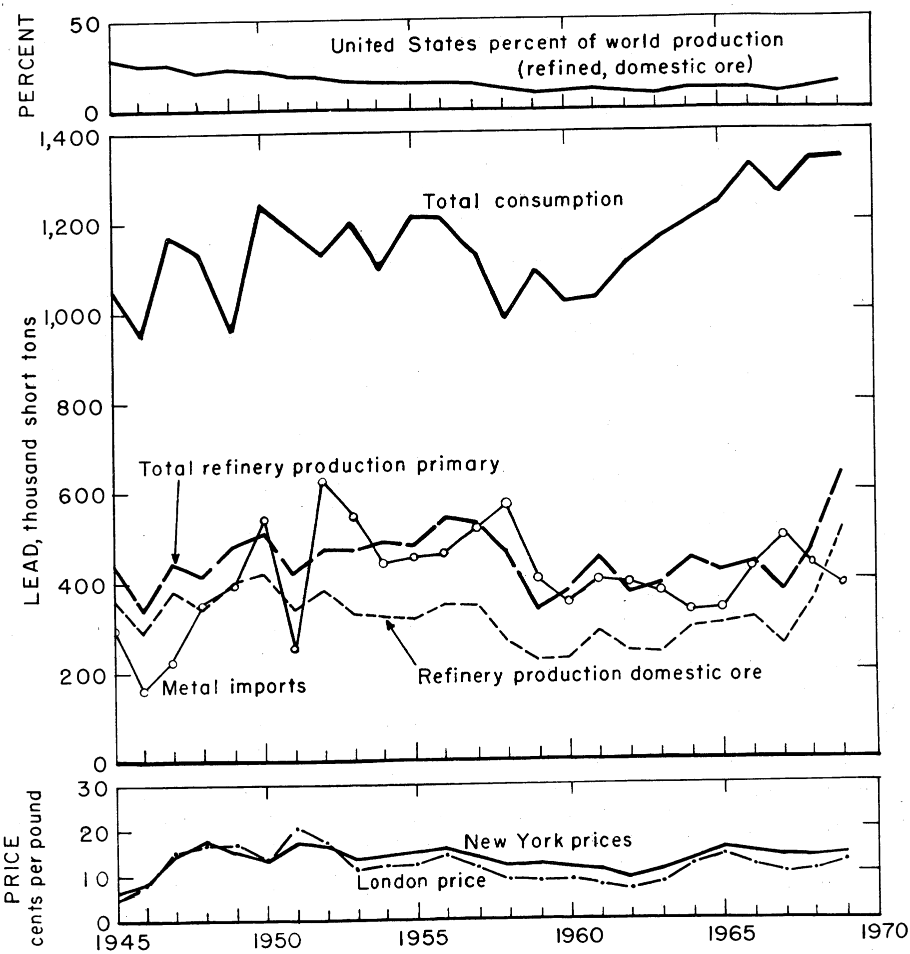

Figure 1.—Trends in the lead industry in the United States.

DOMESTIC PRODUCTION

MINE PRODUCTION

Mine production of recoverable lead gradually increased during the first 6 months of the year to reach 45,124 tons during June; during the last 6 months it ranged from 42,300 to 46,200 tons monthly. The total of 509,013 tons for the year compares with 359,156 tons in 1968 and represents a 42-percent increase. This output level was exceeded only in 1930 when production was 558,300 tons. The increase resulted from uninterrupted operations following the labor settlements in 1968 and, primarily, from full-scale production of the four new lead mines in the new Missouri lead belt. The 355,452 tons produced in Missouri, an increase of 67 percent over 1968, increased that State's component of domestic supply to 70 percent. Idaho, the second largest producer, provided 13 percent of domestic supply, followed by Utah with 8 percent, and Colorado with 4 percent. These four States combined delivered 95 percent of the domestic primary lead supply.

Southeast Missouri lead operations continued to be the center of developments. More than 75 percent of the ore produced in Missouri in 1969 came from mines opened since 1960, and seven mines are represented in the leading 10 domestic producers. Improvements in technology, mine design, and mining methods permit increased labor efficiencies and metal recoveries substantially above those of older mines and concentrators.

St. Joseph Lead Co., the leading domestic producer, operated the Fletcher, Viburnum, Federal, Indian Creek, and Goose Creek mines and produced 354,131 tons of lead concentrate.[2] A new mine development, Brushy Creek, was started and will become operational in 1972 with a capacity approaching 50,000 tons of lead. The Magmont mine, a joint venture of Cominco American Inc. and Dresser Industries, Inc., operated at full capacity throughout the year. Ozark Lead Co., a subsidiary of Kennecott Copper Corp., gradually increased output at the Ellington mine to achieve the designed rate by midyear. The Buick mine of Missouri Lead Operating Co., a joint venture of American Metal Climax Inc. and Homestake Mining Co., also gradually increased output during the year although ground-water and labor problems delayed full-scale output. Construction of the concentrator was completed during the year.[3]

Kennecott Copper Corp. became a major lead producer in 1969 with an output of 48,700 tons from operations in Missouri and Utah.[4] The production at the Burgin mine, Eureka, Utah, was limited by a critical shortage of miners, which, together with caving ground and ground-water conditions, hindered mine development and stope preparation. Completion of the 1,300-foot-level loading facilities and initiation of stope development assisted in production improvements late in the year. The new development shaft for the Trixie area was completed to the planned depth of 860 feet. The Burgin operation is the first attempt to handle large quantities of the hot, corrosive water of the Tintic District and to use this water in the concentrator, which began operation in June. The Mayflower mine of Hecla Mining Co. and mines of United Park City Mines Co. and of United States Smelting, Refining, and Mining Co. were other large Utah lead producers.

Homestake Mining Co. completed facilities at the Bulldog Mountain mine near Creede, Colo., in March 1969 and achieved near capacity output by July 1, with 49,200 tons milled during the last 6 months of the year. Reserves of ore as of January 1, 1970, were 409,480 tons with an average grade of 218 ounces of silver per ton and 2.7 percent lead.[5] American Smelting and Refining Company continued development of the Black Cloud mine near Leadville, Colo. for production in 1971. The shaft was nearing completion at the 1,650-foot depth. Federal Resource Corp. began sinking a shaft to mine a large lead-zinc copper-silver ore body at the old Camp Bird mine near Ouray, Colo. The Keystone mine near Crested Butte, Colo., owned by Park City Consolidated Mines Co. and American Smelting and Refining Company, resumed operation in September under lease by Keystone Mines Co. Idarado Mining Co., a subsidiary of Newmount Mining Corp., was the leading producer in Colorado, and New Jersey Zinc Co. and Rico-Argentine Mining Co. were the other major lead producers.

American Smelting and Refining Co. resumed operations at the Van Stone mine, Northport, Wash., in April and produced 968 tons of lead. The Ground Hog mine near Silver City, N. Mex., was also reopened in May by American Smelting and Refining Company. A new flotation mill near Kingman, Ariz., was completed in February by Standard Metals Corp. to process ore from the Antlers mine and other adjacent properties.

SMELTER AND REFINERY PRODUCTION

The essentially uninterrupted operations, expanded domestic concentrate supply, and full-year operation of the two new Missouri smelters resulted in a primary plant production of 666,280 tons of refined and antimonial lead, a 34-percent increase over 1968 production and the largest total since 1930. Monthly output ranged from a low of 46,700 tons in February to a high of 59,800 tons in November and averaged over 55,500 tons.

Continuous operation of the Herculaneum smelter of St. Joseph Lead Co. and full utilization of the expanded capacity produced a record tonnage of 223,500 tons, up 31 percent from the 1968 level and 86

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[2] St. Joseph Lead Co. Annual Report. 1969, p. 6.
[3] Homestake Mining Co. Annual Report. 1969, p. 7.
[4] Kennecott Copper Corp. Annual Report. 1969, p. 12.
[5] Homestake Mining Co. Annual Report. 1969, p. 12.

percent above the 1967 level. In October a sulfuric acid plant was placed in operation in conjunction with the smelter.[6]

The new smelter of American Smelting and Refining Co. at Glover, Mo., became operative in the first quarter of the year after being delayed by a strike initiated in September 1968. Production of all of the American Smelting and Refining Co. smelters and refineries in 1969 was 207,275 tons of lead, a 35-percent increase over the 1968 strike-curtailed output.[7]

The Bunker Hill Co., a division of Gulf Resources and Chemical Corp., produced 124,000 tons of refined lead, approximately the same output as in 1968. Installation of an updraft sintering machine was in progress, and construction of a new sulfuric acid plant was authorized.[8]

The United States Smelting Lead Refinery, Inc., East Chicago, Ind., a subsidiary of United States Smelting, Refining and Mining Co. produced almost 31,000 tons of lead. This refinery processes bullion from the Tooele, Utah, smelter of International Smelting and Refining Co., a subsidiary of The Anaconda Company.[9]

Secondary lead production in 1969 was a record 603,900 tons, a 9.6-percent increase over 1968 output. Secondary plants and foundries contributed 592,500 tons, or 98 percent, of the total. The ratio of class of material produced remained essentially unchanged from the 1968 pattern, with soft lead comprising 25.5 percent, antimonial lead 56.7 percent, and other lead alloys 17.8 percent. Secondary lead contributed 48.6 percent of the domestic lead production and 39.7 percent of new supply, including metal imports, compared with 53 percent and 40 percent in 1968 and 59 percent and 42 percent in 1967, respectively. Plants reporting secondary production in 1969 consisted of 154 smelters, including 5 primary plants, and 18 manufacturers and foundries.

RAW MATERIAL SOURCE

Domestic mines in 1969 contributed over 525,400 tons of lead in concentrates to the domestic primary smelters. This represents 80 percent of the primary feed material, compared with 75 percent in 1968 and 68 percent in 1967. Imported concentrates smelted during the year totaled 129,500 tons. The availability of primary materials resulted in a scrap intake at primary plants of 22,700 tons of recovered lead, slightly over 3 percent of the total. Raw materials and material in process at the beginning of the year amounted to 139,100 tons, of which 85,200 tons was of primary origin. Stocks declined in the first quarter to a total of 123,000 tons, then gradually increased to 169,100 tons at the end of October, and ended the year at 162,400 tons. Of the total, 100,100 tons was of primary origin, 3,600 tons was secondary, and 58,800 tons was in process.

Consumption of scrap in 1969 increased to 797,800 tons, gross weight, compared with 725,700 tons in 1968 and 726,300 tons in 1967. New scrap in the form of reprocessed drosses and residues amounted to 115,000 tons, or 14 percent, of the total. Battery scrap contributed 65 percent of the total, compared with 64 percent in 1968 and 62 percent in 1967. Receipts of scrap, particularly battery plates, reflecting the unusually high battery replacements in 1969 exceeded consumption during the year, and stocks increased from 57,800 tons to 73,600 tons.

CONSUMPTION AND USES

Consumption of lead again moved upward to a new record of 1.39 million tons, an increase of 60,600 tons, or 4.6 percent, over 1968 comsumption. The increase of 68,800 tons in battery requirements and 9,200 tons in gasoline additives represented the major areas of increase. Metal products excluding batteries, reflected a decrease of 11,200 tons, with most of the historical metal uses below the 1968 levels; only collapsible tubes increased significantly. Pigments also decreased in total because of a substantial drop in lead consumed in red lead and litharge. Examination of domestic supply sources indicated that metal production, imports, stock changes, and stockpile shipments during 1969 totaled 72,000 tons of lead above the amount accounted for by reported consumption and exports. This disappearance in 1969 compares with

[6] St. Joseph Lead Co. Annual Report. 1969, p. 12.
[7] American Smelting and Refining Company. Annual Report. 1969, p. 7.
[8] Gulf Resource and Chemical Corp. Annual Report. 1969, p. 6.
[9] United States Smelting, Refining and Mining Co. Annual Report. 1969, p. 31.

92,000 tons in 1968 and an annual average of 48,900 tons for the 1963–67 period. The disappearance is presumed to be unreported consumption or stocks especially at small users and dealers. Consumption averaged 115,800 tons monthly, with July and October continuing to be the historical low- and high-demand periods during the year. The daily average consumption of 3,806 tons compares with 3,641 tons in 1968.

Metal products other than batteries consumed 390,600 tons, a decrease from the 401,800 tons used in 1968. The total use of lead in these products has slowly declined in tonnage and percentage from 440,100 tons, 48.2 percent, in 1966 to 390,600 tons, 40.1 percent in 1969. Examination of the 1966 and 1969 requirements indicates a decline in most of the metal products, except ammunition, casting metal, collapsible tubes, foil, and terne metal, that ranges from 30 percent for calking, 18 percent for cable covering, and 14 percent for type metal, downward to 5 percent for pipes, traps and bends.

The manufacture of lead-acid storage batteries again posted a record requirement of 582,500 tons of lead, approximately 41 percent of the total reported lead consumption. The increased lead requirements reflect the record manufacture and shipment of automotive-type batteries which reached 46.4 million units according to statistics of the Association of American Battery Manufacturers, Inc. Batteries installed as original factory equipment totaled 10.1 units and 35.5 million batteries were classified as replacements. Export of batteries increased to 760,000 units compared with 450,000 units in 1968. The expanding use of automotive type batteries in non-highway use for recreational and farm equipment as well as use of large, industrial-type batteries for emergency power in hospitals and communications, has resulted in an average annual growth of 6.5 percent in battery lead consumption since 1968.

Lead requirements for gasoline antiknock additives was a record 271,700 tons, an increase of 3.5 percent, but well below the 6-percent increase achieved in 1968. A reported factor in the reduced growth was a substantial decrease, due to new foreign manufacturing capacity, in exports of antiknock fluid.

Lead consumed in pigments was the lowest since 1963 with the decrease mainly in the manufacture of red lead and litharge. A small tonnage increase occurred in white lead and also in pigment colors, an area of gradual growth in recent years.

LEAD PIGMENTS

Production of lead pigments and oxides required 378,400 tons of lead, an increase of almost 10 percent over 1968 requirements. All the lead, except 600 tons, used in leaded zinc oxide was derived from pig lead. Use increased in white lead and decreased slightly in red lead. Lead in oxides, litharge, and black oxide increased 33,100 tons over 1968 requirements to a new record of 348,100 tons.

White lead requirements by the paint and ceramic industries continued the downtrend of recent years, as did red lead in paints rubber, and various other uses. The miscellaneous uses of red lead were especially reduced to less than 4,000 tons in comparison with the large tonnages used in prior years. Litharge requirements declined in the ceramic industry and also in oil refining and rubber manufacture. The largest use of litharge, however, is in the battery industry. The amount cannot be published and is included in other uses in table 20.

Prices.—The quoted price of lead pigments, with the exception of basic carbonate white lead, moved upward throughout the year in accord with the rising price of refined lead. The price of white lead, stable at 20.5 cents per pound, carload lots, freight allowed, since 1966, decreased to 20 cents in early February, increased to 21.5 units per pound in early August, and continued at that price for the remainder of the year. The price of red lead, 95 percent Pb_3O_4, in carload lots, at works, quoted at 15.75 cents per pound at the beginning of the year, moved upward in 0.5-cent steps beginning in early January to reach 19.75 cents in late December. The price of litharge, commercial grade, powdered, in carload lots, at works, likewise moved upward in unison with the price of lead to reach 19 cents per pound in late December.

The value of shipments of white lead, red lead, and litharge amounted to $57.6 million, an average of $342 per ton, compared with $52.8 million and $317 per ton in 1968, respectively.

Foreign Trade.—Export of lead oxides, pigment grade, including lead arsenate and other compounds, continued to decline in gross weight and value from 1,877 tons valued at $770,000 in 1968 to 1,688 tons valued at $685,700 in 1969. A total of 46 countries received shipments ranging in value from a high of $171,800 for Canada to $500 for Bermuda. South Vietnam was the second largest importer with a total import value of $40,600.

Imports for consumption of lead pigments and compounds in 1969 increased about 500 tons in weight and $1,000 in value compared with the 1968 totals. Lead compounds, including lead arsenate, acetate, and nitrate, totaled 355 tons valued at $105,100, of which lead nitrate accounted for 78 percent of the value. West Germany and the Republic of South Africa were the leading sources of lead nitrate, while Mexico and Sweden supplied the lead acetate. Lead compounds and organic lead salts not specified by name amounted to 546 tons and $203,600 in value. These were supplied mainly by Canada and West Germany. Leaded zinc oxide, not over 25 percent lead, totaled 243 tons valued at $56,800 and principally originated in West Germany. Poland contributed almost 9 tons of red lead during the year.

STOCKS

Producer stocks of refined and antimonial lead at the start of the year totaled 15,300 tons. These stocks were reduced in January and February to a low of 10,000 tons of metal. A rise initiated in March increased the total to 18,700 tons at the end of May. A decrease in June and July was followed by a buildup culminating in the yearend total of 25,700 tons. Stocks of base bullion increased slightly during the year. Raw material stocks at primary plants declined in the first quarter from 87,000 tons to 75,000 tons, then built up to a high of 112,000 tons at the end of October, and closed the year at 102,000 tons. Material in process also increased from a low of 47,000 tons to 59,000 tons at the end of the year.

Consumer stocks of lead gradually increased during the year from 88,900 tons to 156,400 tons at the end of 1969, the largest total since the middle of 1959. Approximately 30 percent of the stock was at secondary smelters; 70 percent was in the hands of other consumers and foundries. The Government inventory of lead in stockpile was reduced about 15,500 tons to 1,149,060 tons by authorized shipments to commercial and Government consumers.

PRICES

The strong demand for lead, competition in the world market for concentrates, and critically by low stocks of free world producers at the end of 1968 resulted in continuation of the upward trend in price initiated in October of 1968. Beginning on January 8 a 0.5-cent-per-pound increase to 13.5 cents per pound was followed by like increases on January 30, April 7, June 9, July 3, November 24, and December 15, thus culminating in a price of 16.5 cents per pound which continued in effect through the end of the year. The London Metal Exchange price moved steadily upward throughout the year, except for a slight decline in October, and reached a daily, spot quotation, high of 15.5 cents per pound (U.S. equivalent) in early December.

FOREIGN TRADE

Exports of lead metal decreased in 1969 to about 5,000 tons and consisted of relatively small shipments to over 18 countries. Export of lead scrap, however, was the largest in recent years at 2,340 tons. The increase was primarily due to a substantial shipment to the United Kingdon and to increased purchases by secondary processors in Canada, West Germany, the Netherlands, and Spain.

Imports of lead in ores increased about 21,400 tons compared with those in 1968, and imports for consumption of 115,300 tons indicate a warehouse withdrawal for duty paid entry of 6,000 tons. Canada supplied 39 percent of the imports for consumption, followed by Australia, 21 percent; Mexico, 19 percent; and Honduras, 12 percent. Australia supplied about 2,000 tons of bullion in addition to ore. Imports of lead metal for consumption decreased for the second successive year to 278,900 tons compared with 363,600 tons in 1967 and 337,600 tons in 1968. Australia supplanted Peru as the leading source with 22 percent; followed by Mexico, 21 percent; Peru, 21 percent; Canada, 16 percent; and Yugoslavia, 10 percent.

Imports of lead scrap mainly from Canada and Mexico, increased to 6,700 tons and thus exceeded exports of scrap by some 4,300 tons. Semiprocessed sheet, pipe, and shot imported from Canada and West Europe totaled 518 tons with an indicated value of 16.8 cents per pound, and imports of babbitt metal, solder, and other alloys totaled 667 tons, lead content, with a per-pound value of $2.87 and a gross-weight value of 90 cents per pound.

WORLD REVIEW

Statistical reporting on the world lead industry varies in reporting base, reporting source, and scope of estimating. The Bureau of Mines reports indicate the basis, insofar as possible, used for each country, whereas the International Lead and Zinc Study Group reports on an ore-content basis. The American Bureau of Metal Statistics (ABMS) relies to a large extent on industrial trade associations, as well as Governmental agencies, in obtaining statistical information. Therefore, free world mine production of lead ranged from the Lead and Zinc Study Group total of 2.68 million tons[10] through the Bureau of Mines total of 2.64 million to the 2.56-million-ton total of ABMS. In addition the Bureau of Mines estimated production in Communist countries, excluding Yugoslavia, to be 887,000 tons and the world total is thus 3.52 million tons. Smelter reporting of metal output also varies, with the Bureau of Mines reporting, insofar as possible, only primary metal, whereas the Lead and Zinc Study Group reports metal output from both primary and secondary sources. Free world smelter output in 1969 thus ranged from the Study Group total of 3.23 million tons through the ABMS total of 2.94 million to the Bureau of Mines total of 2.67 million. An additional output of a million tons of metal was estimated for the Communist countries, excluding Yugoslavia, to provide a world output of primary metal of 3.67 million tons.

The United States became the leading producer during the year with 14 percent of the world total production. Australia and the U.S.S.R. shared second place with about 490,000 tons each. Canada, Mexico, Peru, and Yugoslavia were the other free world countries with an output over 100,000 tons each, and these seven countries contributed 69 percent of the free world lead and 52 percent of the world total.

Smelter production was also highlighted by the substantial increase in United States output which after a 2 year period in second place to the U.S.S.R., again became the leading metal producer with 24 percent of the free world total and 17 percent of the world total. Australia, Japan, Canada, West Germany, France, Yugoslavia and Belgium each had metal production in excess of 100,000 tons and the eight leading free world countries produced 72 percent of the free world lead metal.

Consumption of lead metal in the free world, including refined and antimonial lead from primary and secondary sources and excluding other secondary alloys, amounted to 3.43 million tons, according to the Lead and Zinc Study Group's preliminary totals. The United States was by far the largest consumer with 37 percent of the total. The United Kingdom ranked second, followed closely by West Germany, France, and Japan. The North and South American countries combined consumed 44 percent; West Europe, 44 percent; Asia, 9 percent; Australia-New Zealand, 2 percent; and Africa, 1 percent. The Study Group also reports consumption of refined and antimonial lead in the Free World and preliminary totals for 1969 indicate a metal supply surplus of 128,000 tons, of which 22,000 tons was an increase in free world producer stocks during the year.

Argentina.—Compañía Minera Aguilar S. A., a subsidiary of St. Joseph Lead Co,

[10] International Lead and Zinc Study Group. Monthly Bulletin, July 1970, pp. 10–12.

increased production of lead concentrates from 31,100 tons in 1968 to 46,860 tons in 1969, as the completion of the mill expansion permitted high-level production during the year.[11]

Australia.—Mount Isa Mines Ltd., 52.7-percent owned by American Smelting and Refining Company, increased lead production over 33 percent during the fiscal year ending June 30, 1969, to 131,388 tons. Since the close of the fiscal year, the ore-production rate has exceeded the 16,000-long-ton-per-day goal of the major expansion program started in 1959. Mount Isa announced plans to bring into production a new mine, to be known as the Hilton mine, located about 13 miles north of Mount Isa. Shaft sinking was initiated on the deposit outlined by drilling. The deposit reported contains 35 million tons of ore averaging 7.6 percent lead and 9.6 percent zinc.[12]

Broken Hill areas mines continued to expand production with a relatively quiet labor situation during the year except for a 3-week strike in August. Zinc Corp. of Australia increased lead output 17 percent over that of 1968. North Broken Hill, Ltd., and New Broken Hill, Consolidated, continued expansion programs designed to increase the area's annual production from 275,000 to 300,000 tons. The fourth major Broken Hill mine, Broken Hill South, is reaching the limits of its ore. The mine was able to increase production only from a residue treatment project.

Exploration continued at a high rate. Possible new deposits were reported by Texas Gulf Sulphur Co., Acmex Holdings N.L., and Electrolytic Zinc Co. of Australia, Ltd.

Canada.—The major highlight in Canada was the completion of the $60 million development and construction of Anvil Mining Corp., Ltd's, facilities in the Yukon, which were begun in 1967. The first concentrates from the open pit mine and 5,500-ton-per-day flotation mill and related facilities, owned 60 percent by Cyprus Mines Corp. and 40 percent by Dynasty Exploration, Ltd., were shipped to Japan on December 7. The concentrates were transported by truck 237 miles to Whitehorse and thence 110 miles by railroad to Skagway, Alaska, for transfer to oceangoing cargo ships. Toho Zinc and Mitsui Mining and Smelting will take the output for the first 8 years. Production from the Yukon in 1969, mainly fron Anvil, rose from 3,600 tons in 1968 to 15,400 tons.

Production of lead by Cominco, Ltd., from the mines and refineries in British Columbia was curtailed by the forced shutdown of a furnace early in July which continued into December. In March the company announced that the Trail, British Columbia, smelter had poured 8 million tons of lead since operations began in 1909. Production from all of the British Columbia mines was 102,500 tons for the year.

The Pine Point and Pyramid mines in the Northwest Territories produced 105,000 tons, a decline in production reflecting the depletion of high-grade shipping ore at Pine Point, which was not offset by an additional Pyramid milling capacity of 3,000 tons per day. The New Brunswick mines operated by Brunswick Mining and Smelting Corp., Health Steele Mines Ltd., and Nigadoo River Mines, Ltd., increased production to 56,000 tons, and the Ontario mines, principally the Kidd Creek mine of Texas Gulf Sulphur Co., maintained a level of 13,700 tons.

Ireland.—The Tynagh mine of Northgate Exploration, Ltd., produced 77,300 tons of lead concentrates, approximately 70 percent of the normal operating capacity. The decrease was due to a labor stoppage in the second and third quarters of the year.[13]

Mexico.—Production of lead declined slightly in 1969 although production of ore and metal at the Asarco Mexicana, S.A., operations increased. The new mill at the Plomosas mine achieved capacity operation by midyear. Expansion and modernization of the mill at the Santa Barbara mine and construction of the new mills at San Martin and at the San Antonio mine were in progress.[14]

Peru.—The Cerro de Pasco Corp's. production of base metals was seriously curtailed by two work stoppages in April and in August–September. These resulted in

[11] St. Joseph Lead Co. Annual Report. 1969, p. 16.
[12] American Smelting and Refining Company. Annual Report. 1969, pp. 13–14.
[13] Northgate Explorations Ltd. Annual Report. 1969, p. 22.
[14] American Smelting and Refining Company. Annual Report. 1969, pp. 14–15.

the loss of over a month's production in the smelters and refineries at La Oroya.

Cía Minera Santa Luisa S.A., a subsidiary of Mitsui Mining & Smelting Co. Ltd. of Japan, continued underground developments of the Huanzala mine in the Peruvian Andes.

Poland.—An imperial smelter was placed in operation early in the year at the zinc-lead smelter of Zjednocwenie Gorniczo-Hutnicze Metali Niezelazynch at Miasteczko.

Yugoslavia.—After 5 years of construction, the first open pit lead-zinc mine was placed in operation in Kosovska Mitrovica. This is the first stage of the new Kismica and Nova Brdo mine-and-pit complex. A modern flotation mill was also placed in regular operation not far from the new mine.

TECHNOLOGY

Research, development, and incorporation of new methods, equipment, and product uses continued to be a major activity in the lead industry. The International Lead Zinc Research Organization, Inc. (ILZRO), conducts cooperative research and development on behalf of major lead and zinc producers throughout the world. Currently there are 35 supporting companies in 12 countries, and some 60 lead research programs cover essentially all existing uses of lead as well as new product development. The Zinc and Lead International Service (ZALIS) was set up in 1969 to stimulate the consumption of lead and zinc in developing countries by providing up-to-date technical service to manufacturers and consumers.

In building, a major effort was development of a composite lead roofing competitive with asphalt-type roofing. Battery applications continue to receive major attention especially in the area of vehicle propulsion as air pollution problems increase in national concern. Cable sheathing of lead-plastic composition is under study and development to combine the corrosion resistance and impermeability of lead with the elasticity of plastics. The organolead compounds are showing technical and commercial potential in many applications warranting extensive research and development into tonnage levels of lead consumption.

Table 2.—Mine production of recoverable lead in the United States, by State

(Short tons)

State	1965	1966	1967	1968	1969
Alaska	W	14	-----	W	2
Arizona	5,913	5,211	4,771	1,704	217
California	1,810	1,976	1,735	4,001	2,518
Colorado	22,495	23,082	21,923	19,778	21,767
Idaho	66,606	72,334	61,387	54,790	65,597
Illinois	3,005	2,285	2,384	1,467	791
Kansas	1,644	1,109	1,031	1,227	395
Kentucky	756	484	845	W	-----
Missouri	133,521	132,255	152,649	212,611	355,452
Montana	6,981	4,409	898	1,870	1,753
Nevada	2,277	3,581	1,500	863	1,420
New Mexico	3,387	1,596	1,827	1,363	2,368
New York	601	1,097	1,653	1,396	1,686
Oklahoma	2,813	2,999	2,727	2,387	605
Oregon	W	-----	-----	W	(1)
South Dakota	-----	-----	-----	-----	1
Tennessee	-----	181	-----	-----	-----
Utah	37,700	64,124	53,813	45,205	41,332
Virginia	3,651	3,078	3,430	3,573	3,358
Washington	6,328	5,859	2,762	5,655	8,649
Wisconsin	1,645	1,694	1,596	1,126	1,102
Other States	14	-----	-----	140	-----
Total	301,147	327,368	316,931	359,156	509,013

W Withheld to avoid disclosing individual company confidential data; included in "Other States."
[1] Less than ½ unit.

Table 3.—Production of lead and zinc in the United States in 1969, by State and class of ore, from old tailings, etc., in terms of recoverable metals

(Short tons)

State	Lead ore			Zinc ore			Lead-zinc ore		
	Gross weight (dry basis)	Lead content	Zinc content	Gross weight (dry basis)	Lead content	Zinc content	Gross weight (dry basis)	Lead content	Zinc content
Alaska	50	2	-----	-----	-----	-----	-----	-----	-----
Arizona	571	63	4	-----	-----	-----	2,699	105	94
California	[1] 104,452	[1] 2,283	[1] 3,319	-----	-----	-----	(1)	(1)	(1)
Colorado	990	49	4	277,350	2,270	28,479	330,309	8,804	12,326
Idaho	246,472	24,729	2,842	(2)	(2)	(2)	[2] 735,370	[2] 35,181	[2] 45,667
Kansas	-----	-----	-----	59,399	395	1,900	-----	-----	-----
Missouri	[3] 7,873,545	[4] 355,452	41,099	-----	-----	-----	-----	-----	-----
Montana	2,691	342	70	(2)	(2)	(2)	[2] 12,446	[2] 187	[2] 1,085
Nevada	[1] 17,735	[1] 1,222	[1] 903	-----	-----	-----	(1)	(1)	(1)
New Jersey	-----	-----	-----	149,920	-----	25,076	-----	-----	-----
New Mexico	-----	-----	-----	221,563	243	17,216	54,683	2,124	6,428
New York	-----	-----	-----	740,825	1,686	58,728	-----	-----	-----
Oklahoma	-----	-----	-----	[5] 240,998	[5] 605	[5] 2,744	-----	-----	-----
Oregon	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pennsylvania	-----	-----	-----	630,587	-----	33,035	-----	-----	-----
South Dakota	-----	-----	-----	-----	-----	-----	-----	-----	-----
Tennessee	-----	-----	-----	4,288,502	-----	114,556	-----	-----	-----
Utah	2,116	522	91	(2)	(2)	(2)	[2] 450,071	[2] 34,167	[2] 29,886
Virginia	-----	-----	-----	660,142	3,358	18,704	-----	-----	-----
Washington	-----	-----	-----	[5] 261,613	[5] 1,055	[5] 5,478	215,703	7,594	4,265
Wisconsin	-----	-----	-----	846,233	1,102	22,901	-----	-----	-----
Other States	-----	-----	-----	502,437	442	20,486	-----	-----	-----
Total	8,248,622	384,664	48,332	8,879,569	11,156	349,298	1,801,281	88,162	99,751
Percent of total lead-zinc	-----	76	9	-----	2	63	-----	17	18

See footnotes at end of table.

Table 3.—Production of lead and zinc in the United States in 1969, by State and class of ore, from old tailings, etc., in terms of recoverable metals—Continued

(Short tons)

State	Copper-lead, copper-zinc, and copper-lead-zinc ores			All other sources [6]			Total		
	Gross weight (dry basis)	Lead content	Zinc content	Gross weight (dry basis)	Lead content	Zinc content	Gross weight (dry basis)	Lead content	Zinc content
Alaska	-----	-----	-----	-----	-----	-----	50	2	-----
Arizona	104,084	33	8,663	20,179,824	16	278	20,287,178	217	9,039
California	-----	-----	-----	6,599	235	8	111,051	2,518	3,327
Colorado	411,175	9,316	12,274	70,155	1,328	632	1,089,979	21,767	53,715
Idaho	-----	-----	-----	818,284	5,687	7,391	1,800,126	65,597	55,900
Kansas	-----	-----	-----	-----	-----	-----	59,399	395	1,900
Missouri	-----	-----	-----	-----	-----	-----	7,873,545	355,452	41,099
Montana	-----	-----	-----	78,169	1,224	4,988	93,306	1,753	6,143
Nevada	174	45	6	1,735,640	153	32	1,753,549	1,420	941
New Jersey	-----	-----	-----	-----	-----	-----	149,920	-----	25,076
New Mexico	-----	-----	-----	946,516	1	664	1,222,762	2,368	24,308
New York	-----	-----	-----	-----	-----	-----	740,825	1,686	58,728
Oklahoma	-----	-----	-----	(5)	(5)	(5)	240,998	605	2,744
Oregon	-----	-----	-----	212	(7)	(7)	212	(7)	(7)
Pennsylvania	-----	-----	-----	-----	-----	-----	630,587	-----	33,035
South Dakota	-----	-----	-----	35	1	-----	35	1	-----
Tennessee	1,574,140	-----	9,976	-----	-----	-----	5,862,642	-----	124,532
Utah	117,452	5,963	3,368	54,927	680	1,557	624,566	41,332	34,902
Virginia	-----	-----	-----	-----	-----	-----	660,142	3,358	18,704
Washington	-----	-----	-----	(5)	(5)	(5)	477,316	8,649	9,738
Wisconsin	-----	-----	-----	-----	-----	-----	846,233	1,102	22,901
Other States	-----	-----	-----	220,987	349	5,906	723,424	791	26,392
Total	2,207,025	15,357	34,287	24,111,348	9,674	21,456	45,247,845	509,013	553,124
Percent of total lead-zinc	-----	3	6	-----	2	4	-----	100	100

[1] Lead and lead-zinc ores combined to avoid disclosing individual company confidential data.
[2] Zinc and lead-zinc ores combined to avoid disclosing individual company confidential data.
[3] Includes minor amount of lead tailings comingled with ore at mill; excludes barium sulfate ore.
[4] Includes lead recovered from barium sulfate ore.
[5] Ore from "Other Sources" combined with zinc ore to avoid disclosing individual company confidential data.
[6] Lead and zinc recovered from copper, gold, silver, fluorspar, and uranium ores, and from smelter slags, mill tailings, and miscellaneous cleanups.
[7] Less than ½ unit.

Table 4.—Mine production of recoverable lead in the United States, by months

(Short tons)

Month	1968	1969	Month	1968	1969
January	24,493	36,805	August	33,163	45,099
February	24,282	34,944	September	31,119	43,178
March	24,083	38,816	October	36,567	46,231
April	27,440	42,253	November	33,188	42,289
May	31,052	43,816	December	33,943	46,128
June	28,965	45,124			
July	30,861	44,330	Total	359,156	509,013

Table 5.—Twenty-five leading lead-producing mines in the United States in 1969, in order of output

Rank	Mine	County and State	Operator	Source of lead
1	Fletcher	Reynolds, Mo	St. Joseph Lead Co	Lead ore.
2	Viburnum	Crawford, Iron, and Washington, Mo	do	Do.
3	Magmont	Iron, Mo	Cominco American, Inc	Do.
4	Federal	St. Francois, Mo	St. Joseph Lead Co	Do.
5	Ozark	Reynolds, Mo	Ozark Lead Co	Do.
6	Bunker Hill	Shoshone, Idaho	The Bunker Hill Co	Lead-zinc ore and silver tailings.
7	U.S. and Lark	Salt Lake, Utah	United States Smelting Refining and Mining Co.	Lead and lead-zinc ores.
8	Lucky Friday	Shoshone, Idaho	Hecla Mining Co	Lead ore.
9	Buick	Iron, Mo	Missouri Lead Operating Co	Do.
10	Indian Creek	Washington, Mo	St. Joseph Lead Co	Do.
11	Idarado	Ouray and San Miguel, Colo.	Idarado Mining Co	Copper-lead-zinc ore.
12	Pend Oreille	Pend Oreille, Wash	Pend Oreille Mines & Metals Co.	Lead-zinc ore.
13	Star-Morning	Shoshone, Idaho	Hecla Mining Co	Do.
14	Burgin	Utah, Utah	Kennecott Copper Corp	Lead and lead-zinc ores.
15	Mayflower	Wasatch, Utah	Hecla Mining Co	Copper-lead-zinc ore.
16	United Park City	Summit and Wasatch, Utah	United Park City Mines Co	Lead-zinc ore.
17	Page	Shoshone, Idaho	American Smelting and Refining Co.	Do.
18	Sunnyside	San Juan, Colo	Standard Metals Corp	Do.
19	Dayrock	Shoshone, Idaho	Day Mines, Inc	Lead ore.
20	Austinville and Ivanhoe	Wythe, Va	The New Jersey Zinc Co	Lead-zinc ore.
21	Eagle	Eagle, Colo	do	Zinc and silver ores.
22	Ophir	Tooele, Utah	United States Smelting Refining and Mining Co.	Lead-zinc ore.
23	Darwin	Inyo, Calif	West Hill Exploration Co., Inc.	Do.
24	Ground Hog	Grant, N. Mex	American Smelting and Refining Co.	Do.
25	Balmat	St. Lawrence, N. Y	St. Joseph Lead Co	Lead-zinc ore.

Table 6.—Refined lead produced at primary refineries in the United States, by source material

(Short tons)

	1965	1966	1967	1968	1969
Refined lead:					
From primary sources:					
Domestic ores and base bullion	305,007	318,646	258,507	349,039	513,931
Foreign ores and base bullion	113,242	122,089	121,387	118,271	124,724
Total	418,249	440,735	379,894	467,310	638,655
From secondary sources	13,140	9,004	2,538	2,259	4,966
Grand total	431,389	449,739	382,432	469,569	643,621
Calculated value of primary refined lead (thousands) [1]	$133,840	$133,278	$106,370	$123,463	$190,702

[1] Value based on average quoted price, New York, and excludes value of refined lead produced from scrap at primary refineries.

Table 7.—Antimonial lead produced at primary lead refineries in the United States

Year	Production (short tons)	Antimony content		Lead content by difference (short tons)			
		Short tons	Percent	From domestic ore	From foreign ore	From scrap	Total
1965	27,895	1,984	7.1	2,809	3,803	19,299	25,911
1966	24,059	2,119	8.8	6,025	5,157	10,758	21,940
1967	18,608	1,717	9.2	5,449	3,634	7,808	16,891
1968	28,363	2,007	7.1	15,788	3,706	6,862	26,356
1969	24,741	2,082	8.4	11,507	4,743	6,409	22,659

Table 8.—Stocks and consumption of new and old lead scrap in the United States in 1969

(Short tons, gross weight)

Class of consumers and type of scrap	Stocks Jan. 1 [r]	Receipts	Consumption			Stocks Dec. 31
			New scrap	Old scrap	Total	
Smelters and refiners:						
Soft lead	1,680	58,666	-----	57,674	57,674	2,672
Hard lead	1,362	15,593	-----	15,402	15,402	1,553
Cable lead	791	31,739	-----	31,909	31,909	621
Battery-lead plates	26,333	536,820	-----	520,913	520,913	42,240
Mixed common babbitt	326	4,248	-----	4,270	4,270	304
Solder and tinny lead	226	12,008	-----	11,853	11,853	381
Type metals	3,419	32,322	-----	32,462	32,462	3,279
Drosses and residues	23,376	113,922	114,988	-----	114,988	22,310
Total	57,513	805,318	114,988	674,483	789,471	73,360
Foundries and other manufacturers:						
Soft lead	2	115	-----	117	117	-----
Hard lead	44	127	-----	151	151	20
Cable lead	48	67	-----	74	74	41
Battery-lead plates	36	-----	-----	-----	-----	36
Mixed common babbitt	80	7,929	-----	7,950	7,950	59
Solder and tinny lead	-----	-----	-----	-----	-----	-----
Type metals	-----	-----	-----	-----	-----	-----
Drosses and residues	84	45	-----	-----	-----	129
Total	294	8,283	-----	8,292	8,292	285
All consumers:						
Soft lead	1,682	58,781	-----	57,791	57,791	2,672
Hard lead	1,406	15,720	-----	15,553	15,553	1,573
Cable lead	839	31,806	-----	31,983	31,983	662
Battery-lead plates	26,369	536,820	-----	520,913	520,913	42,276
Mixed common babbitt	406	12,177	-----	12,220	12,220	363
Solder and tinny lead	226	12,008	-----	11,853	11,853	381
Type metals	3,419	32,322	-----	32,462	32,462	3,279
Drosses and residues	23,460	113,967	114,988	-----	114,988	22,439
Grand total	57,807	813,601	114,988	682,775	797,763	73,645

[r] Revised.

Table 9.—Secondary metal recovered [1] from lead and tin scrap in the United States in 1969, by type of products

(Short tons, gross weight)

	Lead	Tin	Antimony	Other	Total
Refined pig lead	133,322	-----	-----	-----	133,322
Remelt lead	20,988	-----	-----	-----	20,988
Total	154,310	-----	-----	-----	154,310
Refined pig tin	-----	3,150	-----	-----	3,150
Remelt tin	-----	234	-----	-----	234
Total	-----	3,384	-----	-----	3,384
Lead and tin alloys:					
Antimonial lead	342,475	571	17,948	384	361,378
Common babbitt	12,511	812	1,333	141	14,797
Genuine babbitt	27	103	13	5	148
Solder	31,136	5,202	527	82	36,947
Type metals	28,132	1,677	3,834	15	33,658
Cable lead	18,577	1	164	-----	18,742
Miscellaneous alloys	1,092	210	21	538	1,861
Total	433,950	8,576	23,840	1,165	467,531
Tin content of chemical products	-----	654	-----	-----	654
Grand total	588,260	12,614	23,840	1,165	625,879

[1] Most of the figures herein represent actual reported recovery of metal from scrap.

Table 10.—Secondary lead recovered in the United States

(Short tons)

	1965	1966	1967	1968	1969
As metal:					
At primary plants	13,140	9,004	2,538	2,259	4,966
At other plants	168,774	147,215	147,806	136,607	149,344
Total	181,914	156,219	150,344	138,866	154,310
In antimonial lead:					
At primary plants	19,299	10,758	7,808	6,862	6,409
At other plants	251,354	272,977	280,911	301,701	336,066
Total	270,653	283,735	288,719	308,563	342,475
In other alloys	123,252	132,880	114,709	103,450	107,120
Grand total:					
Quantity	575,819	572,834	553,772	550,879	603,905
Value (thousands) [1]	$184,262	$173,225	$155,056	$145,542	$180,326

[1] Value based on average quoted price, New York.

Table 11.—Lead recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1968	1969	Form of recovery	1968	1969
New scrap:			As soft lead:		
Lead-base	73,845	81,672	At primary plants	2,259	4,966
Copper-base	5,219	5,898	At other plants	136,607	149,344
Tin-base	548	398			
			Total	138,866	154,310
Total	79,612	87,968			
			In antimonial lead [1]	308,563	342,475
Old scrap:			In other lead alloys	87,273	90,582
Battery-lead plates	310,215	349,507	In copper-base alloys	16,142	16,511
All other lead-base	142,963	147,796	In tin-base alloys	35	27
Copper-base	18,085	18,631			
Tin-base	4	3	Total	412,013	449,595
Total	471,267	515,937	Grand total	550,879	603,905
Grand total	550,879	603,905			

[1] Includes 6,862 tons of lead recovered in antimonial lead from secondary sources at primary plants in 1968 and 6,409 in 1969.

Table 12.—Lead consumption in the United States, by products

(Short tons)

Product	1968	1969
Metal products:		
Ammunition	82,193	79,233
Bearing metals	18,441	17,406
Brass and bronze	21,021	21,512
Cable covering	53,456	54,203
Calking lead	49,718	44,857
Casting metals	8,693	9,918
Collapsible tubes	9,310	12,484
Foil	6,114	5,881
Pipes, traps, and bends	21,098	19,407
Sheet lead	28,271	25,818
Solder	74,074	72,626
Storage batteries:		
Battery grids, posts, etc	250,129	280,386
Battery oxides	263,574	302,160
Terne metal	1,427	1,583
Type metal	27,981	25,660
Total	915,500	973,134
Pigments:		
White lead	5,857	6,617
Red lead and litharge	86,480	79,898
Pigment colors	14,163	14,670
Other [1]	3,234	1,201
Total	109,734	102,386
Chemicals:		
Gasoline antiknock additives	261,897	271,128
Miscellaneous chemicals	629	602
Total	262,526	271,730
Miscellaneous uses:		
Annealing	4,194	4,252
Galvanizing	1,755	1,797
Lead plating	389	406
Weights and ballast	16,768	17,366
Total	23,106	23,821
Other, unclassified uses	17,924	18,287
Grand total [2]	1,328,790	1,389,358

[1] Includes lead content of leaded zinc oxide and other pigments.
[2] Includes lead which went directly from scrap to fabricated products.

Table 13.—Lead consumption in the United States, by months

(Short tons)

Month	1968	1969
January	110,608	118,080
February	106,261	105,585
March	106,621	117,508
April	108,113	115,948
May	112,139	117,272
June	104,479	115,780
July	93,301	100,894
August	110,908	112,189
September	114,312	123,941
October	133,133	131,891
November	116,574	112,521
December	112,341	117,749
Total [1]	1,328,790	1,389,358

[1] Includes lead content of leaded zinc oxide and other pigments and lead which went directly from scrap to fabricated products.

Table 14.—Lead consumption in the United States in 1969, by class of products and types of material

(Short tons)

Product	Soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
Metal products	189,558	98,516	50,970	15,367	354,411
Storage batteries	311,987	270,559	-----	-----	582,546
Pigments	101,185	-----	-----	-----	101,185
Chemicals	271,536	194	-----	-----	271,730
Miscellaneous	10,707	13,005	104	-----	23,816
Unclassified	15,885	2,050	352	-----	18,287
Total	900,858	384,324	51,426	15,367	[1] 1,351,975

[1] Excludes 36,182 tons of lead which went directly from scrap to fabricated products and 1,201 tons of lead contained in leaded zinc oxide and other nonspecified pigments.

Table 15.—Lead consumption in the United States in 1969, by States [1]

(Short tons)

State	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
California	92,153	34,898	7,576	741	135,368
Colorado	1,019	2,832	95	-----	3,946
Connecticut	16,465	12,751	94	1,396	30,706
District of Columbia	153	-----	-----	-----	153
Florida	5,913	5,771	-----	-----	11,684
Georgia	41,734	17,615	2,558	-----	61,907
Illinois	80,746	49,306	8,033	2,086	140,171
Indiana	83,705	43,546	1,904	623	129,778
Kansas	12,142	10,489	50	353	23,034
Kentucky	2,912	7,620	1	-----	10,533
Maryland	3,315	15,066	92	-----	18,473
Massachusetts	5,772	893	55	136	6,856
Michigan	17,593	19,446	2,051	462	39,552
Missouri	39,579	14,278	141	446	54,444
Nebraska	3,611	988	27	700	5,326
New Jersey	136,616	21,100	10,090	707	168,513
New York	41,523	1,846	11,201	846	55,416
Ohio	12,954	3,604	3,304	842	20,704
Pennsylvania	55,668	36,625	873	2,846	96,012
Rhode Island	1,557	495	33	-----	2,085
Tennessee	197	13,080	206	168	13,651
Virginia	945	1,541	782	1,293	4,561
Washington	6,958	444	301	-----	7,703
West Virginia	18,077	4,948	-----	-----	23,025
Wisconsin	3,223	3,233	45	239	6,740
Alabama and Mississippi	1,414	2,993	-----	525	4,932
Arkansas and Oklahoma	5,210	4,178	29	-----	9,417
Hawaii and Oregon	872	3,336	-----	-----	4,208
Iowa and Minnesota	3,217	8,360	126	445	12,148
Louisiana and Texas	193,923	31,949	1,725	361	227,958
Montana and Idaho	2,977	-----	-----	-----	2,977
New Hampshire, Maine, Vermont, Delaware	5,682	8,312	34	152	14,180
North and South Carolina	2,945	2,781	-----	-----	5,726
Utah, Nevada, Arizona	88	-----	-----	-----	88
Total	900,858	384,324	51,426	15,367	1,351,975

[1] Excludes 36,182 tons of lead which went directly from scrap to fabricated products and 1,201 tons of lead contained in leaded zinc oxide and other non-specified pigments.

Table 16.—Production and shipments of lead pigments [1] and oxides in the United States

Pigment	1968				1969			
	Production (short tons)	Shipments			Production (short tons)	Shipments		
		Short tons	Value [2]			Short tons	Value [2]	
			Total	Average per ton			Total	Average per ton
White lead:								
Dry	6,614	8,578	$3,514,502	$410	8,551	7,858	$3,357,280	$427
In oil [3]	2,822	3,056	2,087,601	683	1,944	2,501	1,776,903	710
Total	9,436	11,634	5,602,103	482	10,495	10,359	5,134,183	496
Red lead	23,816	23,811	8,458,714	355	23,583	22,177	8,067,711	364
Litharge	114,900	131,178	38,721,968	295	123,395	135,719	44,396,471	327
Black oxide	218,119	-----	-----	---	244,586	-----	-----	---

[1] Except for basic lead sulfate; these figures withheld to avoid disclosing individual company confidential data.
[2] At plant, exclusive of container.
[3] Weight of white lead only, but value of paste.

Table 17.—Lead content of lead and zinc pigments [1] and lead oxides produced by domestic manufacturers, by sources

(Short tons)

Pigment	1968 Lead in pigments produced from— Ore: Domestic	1968 Ore: Foreign	1968 Pig lead	1968 Total lead in pigments	1969 Lead in pigments produced from— Ore: Domestic	1969 Ore: Foreign	1969 Pig lead	1969 Total lead in pigments
White lead	---	---	7,549	7,549	---	---	8,396	8,396
Red lead	---	---	21,589	21,589	---	---	21,378	21,378
Litharge	---	---	106,857	106,857	---	---	114,757	114,757
Black oxide	---	---	208,067	208,067	---	---	233,312	233,312
Leaded zinc oxide	768	706	-----	1,474	367	204	-----	571
Total	768	706	344,062	345,536	367	204	377,843	378,414

[1] Excludes lead in basic lead sulfate; these figures withheld to avoid disclosing individual company confidential data.

Table 18.—Distribution of white lead (dry and in oil) shipments,[1] by industries

(Short tons)

Industry	1965	1966	1967	1968	1969
Paints	9,185	8,260	6,968	6,681	5,969
Ceramics	133	130	96	124	67
Other	5,355	6,486	5,064	4,829	4,323
Total	14,673	14,876	12,128	11,634	10,359

[1] Excludes basic lead sulfate, these figures withheld to avoid disclosing individual company confidential data.

Table 19.—Distribution of red lead shipments, by industries

(Short tons)

Industry	1965	1966	1967	1968	1969
Paints	13,725	14,480	13,318	11,347	9,191
Storage batteries	W	W	W	W	9,302
Other	15,938	16,790	12,423	12,464	3,684
Total	29,663	31,270	25,741	23,811	22,177

W Withheld to avoid disclosing individual company confidential data; included with "Other."

Table 20.—Distribution of litharge shipments, by industries

(Short tons)

Industry	1965	1966	1967	1968	1969
Ceramics	21,013	23,476	19,491	24,123	21,570
Insecticides	1,161	1,166	W	W	W
Oil refining	2,886	1,991	1,835	1,849	1,603
Rubber	2,153	2,296	1,928	1,986	1,794
Varnish	3,763	1,620	1,228	W	W
Other	74,916	79,754	75,500	103,220	110,752
Total	105,892	110,303	99,982	131,178	135,719

W Withheld to avoid disclosing individual company confidential data; included with "Other."

Table 21.—U.S. imports for consumption of lead pigments and compounds

Kind	1968 Short tons	1968 Value (thousands)	1969 Short tons	1969 Value (thousands)
White lead	2,158	$672	1,731	$661
Red lead	4,412	977	5,517	1,365
Litharge	24,829	5,131	23,982	5,542
Other lead pigments	207	54	342	107
Other lead compounds	398	116	901	309
Total	32,004	6,950	32,473	7,984

Table 22.—Stocks of lead at primary smelters and refineries in the United States, Dec. 31

(Short tons)

Stocks	1965	1966	1967	1968	1969
Refined pig lead	17,524	16,175	18,243	11,490	21,283
Lead in antimonial lead	7,680	6,396	5,119	3,852	4,448
Lead in base bullion	10,735	15,606	16,622	11,471	12,726
Lead in ore and matte	47,504	77,296	85,495	63,614	63,403
Total	83,443	115,473	125,479	90,427	101,860

Table 23.—Consumer stocks of lead in the United States, Dec. 31, by types of material

(Short tons, lead content)

Year	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
1965	61,586	36,190	10,406	1,013	109,195
1966	44,490	34,704	10,071	1,041	90,306
1967	59,837	35,879	8,919	1,151	105,786
1968	43,933	35,009	9,184	774	88,900
1969	67,304	79,649	8,506	945	156,404

Table 24.—Average monthly and yearly quoted prices of lead at St. Louis, New York, and London [1]

(Cents per pound)

Month	1968			1969		
	St. Louis	New York	London [2]	St. Louis	New York	London [2]
January	13.80	14.00	9.98	13.24	13.44	11.46
February	13.80	14.00	10.36	13.80	14.00	11.67
March	13.80	14.00	10.61	13.80	14.00	11.80
April	13.80	14.00	10.66	14.22	14.42	12.13
May	12.84	13.04	10.72	14.30	14.50	12.54
June	12.80	13.00	10.74	14.68	14.88	12.89
July	12.50	12.70	11.15	15.25	15.45	14.04
August	12.30	12.50	11.29	15.30	15.50	14.24
September	12.30	12.50	11.34	15.30	15.50	13.62
October	12.61	12.81	11.18	15.30	15.50	13.26
November	12.80	13.00	11.19	15.42	15.62	14.28
December	12.80	13.00	11.27	16.10	16.30	15.12
Average	13.01	13.21	10.88	14.73	14.93	13.09

[1] St. Louis: Metal Statistics, 1970. New York: Metal Statistics, 1970. London: Metals Week.
[2] Based on monthly rates of exchange by Federal Reserve Board.

Table 25.—U.S. exports of lead, by countries [1]

Destination	1967		1968		1969	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
PIGS, BARS, AND ANODES						
Belgium-Luxembourg	13	$22	769	$799	986	$861
Brazil	558	163	504	166	70	34
Canada	353	360	450	372	410	302
Chile	587	205	1,404	521	36	16
Colombia	237	71	37	20	83	44
Italy	42	51	664	266	320	134
Japan	1,402	491	1,145	285	321	314
Korea, South	1	(2)	75	20	129	131
Mexico	200	550	141	90	146	82
Netherlands	156	405	412	343	210	415
Pakistan	4	5	42	20	104	62
Philippines	119	89	287	119	141	71
Spain	1	3	59	36	27	15
Sweden	263	472	187	137	190	143
Taiwan	190	60	31	18	80	47
United Kingdom	321	471	191	284	283	261
Venezuela	206	208	634	222	351	199
Vietnam, South	19	6	99	34	193	69
Other	1,864	1,135	1,150	988	888	713
Total	6,536	4,767	8,281	4,740	4,968	3,913
SCRAP						
Belgium-Luxembourg	35	15	207	50	189	29
Canada	56	34	116	24	492	68
Germany, West	---	---	113	17	259	45
Netherlands	139	55	124	28	252	62
Spain	---	---	---	---	122	36
United Kingdom	120	76	367	95	1,018	262
Other	44	18	10	5	8	3
Total	394	198	937	219	2,340	505
Grand total	6,930	4,965	9,218	4,959	7,308	4,418

[1] In addition foreign lead was reexported as follows: Pigs, bars and anodes: 1967—162 tons ($33,794); 1968—11 tons ($19,211); 1969—3 tons ($1,699). Scrap: 1967—69, none.
[2] Less than ½ unit.

Table 26.—U.S. imports[1] of lead, by countries

Country	1967 Short tons	1967 Value (thousands)	1968 Short tons	1968 Value (thousands)	1969 Short tons	1969 Value (thousands)
Ore, flue dust, and matte (lead content):						
Australia	25,553	$4,708	20,592	$3,772	20,335	$4,556
Bolivia	13,764	2,680	5,718	994	3,605	724
Canada	33,474	6,928	36,815	6,733	48,606	10,299
Chile	159	33	490	89	---	---
Colombia	561	49	1	(2)	345	22
Guatemala	197	33	---	---	---	---
Honduras	6,513	1,367	9,272	1,782	12,988	2,606
Mexico	314	38	303	40	301	46
Peru	36,734	6,963	13,976	2,610	22,582	4,933
Philippines	37	11	1	1	---	---
South Africa, Republic of	359	32	608	97	365	35
Other	6,402	1,108	60	12	125	22
Total	124,067	23,950	87,836	16,130	109,252	23,243
Base bullion (lead content):						
Australia	---	---	---	---	1,979	693
Belgium-Luxembourg	442	118	---	---	---	---
Canada r	r ---	r ---	r 8	r 4	1	2
Mexico r	1	3	r ---	r ---	13	4
United Kingdom	71	16	---	---	---	---
Other	55	12	---	---	---	---
Total	r 569	r 149	r 8	r 4	1,993	699
Pigs and bars (lead content):						
Australia	53,156	11,900	46,919	9,851	60,791	14,417
Belgium-Luxembourg	23,281	5,074	18,649	4,343	1,315	465
Burma	2,548	590	---	---	150	36
Canada	37,238	9,728	60,161	14,637	44,457	11,409
Denmark	423	226	46	41	114	136
France	8,202	1,851	4,604	973	5,627	1,258
Germany, West	49,077	12,726	20,711	7,552	1,289	723
Mexico	57,271	13,019	56,516	12,062	57,451	13,973
Peru	70,377	18,506	75,105	18,896	57,249	15,687
South Africa, Republic of	6,989	1,937	8,298	2,201	12,558	3,706
Sweden	3,308	728	3,868	847	---	---
United Kingdom	17,680	4,344	22,919	5,546	8,664	3,752
Yugoslavia	30,478	6,941	19,775	4,155	27,862	6,272
Other	3,570	1,127	549	368	853	259
Total	363,598	88,697	338,120	81,472	278,380	72,093
Reclaimed scrap, etc. (lead content):						
Australia	1,086	485	2,280	986	36	15
Canada	6,431	1,319	2,834	528	4,866	1,222
Dominican Republic	248	42	292	31	236	29
Germany, West	1,472	333	---	---	---	---
Mexico	278	43	670	111	1,253	191
Netherlands Antilles	187	38	60	11	45	9
New Zealand	77	11	64	11	---	---
Panama	374	56	221	27	420	69
Other	136	31	60	10	106	23
Total	10,289	2,358	6,481	1,715	6,962	1,558
Grand total	r 498,523	r 115,154	r 432,445	r 99,321	396,587	97,593

r Revised. 1967: Canada and Peru revised to none; 1968: Mexico and Peru revised to none.
[1] Data are "general imports", that is, they include lead imported for immediate consumption plus material entering the country under bond.
[2] Less than ½ unit.

Table 27.—U.S. imports for consumption [1] of lead by countries

Country	1967		1968		1969	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Ore, flue dust, and matte, (lead content):						
Australia	37,879	$7,160	12,640	$2,274	24,003	$5,004
Bolivia	14,707	3,020	6,708	1,308	4,308	770
Canada	41,416	8,956	36,912	7,583	44,764	8,967
Chile	---	---	2,440	513	1,679	322
Colombia	892	172	113	17	---	---
Honduras	5,350	1,085	7,730	1,532	13,992	2,871
Mexico	409	50	321	54	555	95
Peru	40,321	8,213	28,999	5,545	21,794	4,023
Philippines	264	73	1	1	---	---
South Africa, Republic of	478	51	836	133	413	43
Sweden	2,377	316	---	---	---	---
Other	63	15	163	30	3,778	602
Total	144,156	29,111	96,863	18,990	115,286	22,697
Base bullion (lead content):						
Australia	---	---	---	---	1,979	693
Belgium-Luxembourg	442	118	---	---	---	---
Canada	r ---	r ---	r 8	r 4	1	2
Mexico	1	3	r ---	r ---	13	4
United Kingdom	71	16	---	---	---	---
Other	55	12	---	---	---	---
Total	r 569	r 149	r 8	r 4	1,993	699
Pigs and bars (lead content):						
Australia	53,156	11,900	46,919	9,851	60,791	14,417
Belgium-Luxembourg	23,281	5,074	19,149	4,354	1,814	476
Burma	2,548	590	---	---	150	36
Canada	37,236	9,728	60,161	14,637	44,457	11,409
Denmark	423	226	46	41	108	136
France	8,202	1,851	4,604	973	5,627	1,258
Germany, West	49,077	12,726	19,711	7,333	1,289	723
Mexico	57,271	13,019	56,516	12,062	57,451	13,973
Peru	70,377	18,506	75,105	18,896	57,249	15,687
South Africa, Republic of	6,989	1,937	8,298	2,201	12,558	3,706
United Kingdom	17,680	4,344	22,919	5,546	8,664	3,752
Yugoslavia	30,478	6,941	19,775	4,155	27,862	6,272
Other	6,878	1,855	4,417	1,215	853	259
Total	363,596	88,697	337,620	81,264	278,873	72,104
Reclaimed scrap, etc. (lead content):						
Australia	67	11	30	14	79	27
Canada	6,340	1,296	2,834	528	4,515	1,147
Dominican Republic	248	42	292	31	236	29
Germany, West	1,568	369	---	---	---	---
Mexico	278	43	670	111	1,253	191
Netherlands Antilles	167	35	60	11	45	9
New Zealand	80	12	64	11	---	---
Panama	374	56	221	27	420	69
Other	246	87	78	15	134	41
Total	9,368	1,951	4,249	748	6,682	1,513
Sheets, pipe, and shot:						
Belgium-Luxembourg	513	129	344	90	121	34
Canada	99	38	182	66	190	79
Germany, West	2	(2)	12	4	7	3
Netherlands	402	105	243	64	49	15
United Kingdom	76	22	112	32	30	10
Yugoslavia	115	27	---	---	121	33
Other	5	1	---	---	---	---
Total	1,212	322	893	256	518	174
Grand total	r 518,901	r 120,230	r 439,633	r 101,262	403,352	97,187

r Revised. 1967—Canada and Peru revised to none; 1968—Mexico and Peru revised to none.
[1] Excludes imports for consumption in bond and export, classified as "imports for consumption" by the Bureau of the Census.
[2] Less than ½ unit.

Table 28.—U.S. imports for consumption of lead, by classes [1]

(Thousand short tons and thousand dollars)

Year	Lead in ore, flue dust or fume, and matte, n.s.p.f. (lead content)		Lead in base bullion (lead content)		Pigs and bars (lead content)		Reclaimed scrap, etc. (lead content)		Sheets, pipe, and shot		Not otherwise specified (value)	Total value
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value		
1967	144	$29,111	1	r $149	364	$88,697	9	$1,951	1	$322	$542	r $120,772
1968	97	18,990	(2)	r 4	338	81,264	4	748	1	256	273	r 101,535
1969	115	22,697	2	699	279	72,104	7	1,513	(2)	174	369	97,556

r Revised.
1 Excludes imports for consumption in bond and export, classified as "imports for consumption" by the Bureau of the Census.
2 Less than ½ unit.

Table 29.—U.S. imports for consumption of miscellaneous products containing lead

Year	Babbitt metal, solder, white metal, and other combinations containing lead		
	Gross weight (short tons)	Lead content (short tons)	Value (thousands)
1967	775	413	$1,423
1968	1,204	566	2,244
1969	2,134	667	3,822

Table 30.—World mine production of lead by countries

(Short tons)

Country	1965	1966	1967	1968	1969 p
North America:					
Canada	302,950	323,175	339,701	360,025	330,781
Guatemala [1]	1,017	993	1,279	520	314
Honduras	10,642	12,207	12,879	14,523	15,255
Mexico	183,843	192,072	188,500	191,988	188,378
United States [1]	301,147	327,368	319,931	359,156	509,013
South America:					
Argentina	35,534	34,884	32,253	34,022	35,000
Bolivia	17,981	21,484	r 22,364	24,609	e 27,819
Brazil	25,000	24,953	25,818	29,782	30,416
Chile	863	912	445	1,091	906
Colombia	507	658	665	816	451
Peru [1]	170,135	159,570	r 176,057	170,333	179,592
Europe:					
Austria [1]	5,553	5,336	r 6,215	7,474	7,500
Bulgaria e	110,200	110,200	r 94,909	95,019	90,940
Czechoslovakia e	15,400	15,400	r 7,500	7,800	8,000
Finland	6,952	5,107	r 5,276	4,987	5,019
France	19,898	29,491	30,155	e 29,100	e 33,400
Germany:					
East e	11,000	13,000	r 13,000	13,000	13,000
West	54,727	61,099	r 65,454	57,867	43,335
Greece	10,626	10,748	9,900	9,900	9,458
Ireland	2,853	44,100	66,000	68,000	e 63,700
Italy	39,098	40,456	42,626	40,207	e 39,700
Norway	3,860	3,887	3,660	3,892	e 3,500
Poland	45,400	49,700	49,300	52,900	54,000
Portugal	168	1,890	1,653	2,123	e 2,170
Rumania e [2]	17,000	44,000	44,000	44,000	44,000
Spain	62,435	69,923	r 70,207	81,621	76,700
Sweden	76,004	78,138	81,130	79,400	e 79,400
U.S.S.R.	386,000	413,000	440,000	460,000	490,000
United Kingdom	101	---	r 3,580	3,580	e 3,300
Yugoslavia	117,122	113,097	r 119,137	123,203	e 135,600
Africa:					
Algeria	11,514	4,398	r 3,946	e 5,950	e 7,200
Congo (Brazzaville) e	3,100	3,900	r 1,552	e 1,000	NA
Morocco	85,000	85,536	57,707	79,787	77,832
Nigeria e	770	1,800	e 900	---	---
South-West Africa [1]	96,789	93,745	r 78,006	61,927	66,634
Tunisia	17,494	17,561	13,720	16,213	e 16,500
Zambia [2]	23,529	20,679	21,055	24,133	25,350
Asia:					
Burma e	21,400	13,200	r 9,900	9,900	9,900
China, mainland e	110,000	110,000	100,000	110,000	110,000
India	4,388	4,116	2,608	2,810	2,239
Iran [3]	12,875	16,182	16,300	e 16,500	e 26,400
Japan	60,550	69,551	69,970	69,306	70,037
Korea:					
North e	66,000	66,000	72,000	77,000	77,000
South	5,367	8,422	10,675	19,031	18,163
Philippines	116	101	105	93	74
Thailand	6,152	7,023	3,833	2,998	2,094
Turkey	1,854	1,030	2,599	2,443	2,440
Oceania: Australia	405,594	408,687	r 420,873	428,712	490,891
Total [4]	2,966,508	3,138,779	3,159,343	3,298,741	3,523,401

e Estimate. p Preliminary. r Revised. NA Not available.
[1] Recoverable.
[2] Smelter production.
[3] Year ended March 21 of year following that stated.
[4] Totals are of listed figures only.

Table 31.—World smelter production of lead by countries [1]

(Short tons)

Country	1965	1966	1967	1968	1969 p
North America:					
Canada (refined)	186,484	184,871	190,279	202,100	187,142
Guatemala	126	237	78	220	248
Mexico	181,117	189,757	r 177,990	189,884	186,308
United States (refined) [2]	418,249	440,726	379,894	467,310	638,655
South America:					
Argentina e	35,300	24,300	24,250	27,550	24,000
Bolivia (refined and solder)	1,032	1,246	261	225	25
Brazil	10,654	10,955	18,997	17,821	20,635
Peru	95,668	97,843	r 90,189	91,900	85,895
Europe:					
Austria	8,481	7,907	8,586	7,779	8,245
Belgium [3]	122,089	102,139	107,696	105,300	107,365
Bulgaria [3]	102,979	102,346	106,500	107,000	104,900
Czechoslovakia [3]	22,000	22,000	19,300	19,300	19,800
France	108,419	119,753	125,674	e 126,800	e 132,300
Germany:					
East e	27,600	27,600	27,600	27,600	27,600
West	114,674	120,841	150,250	132,300	138,680
Greece (base bullion from ores)	5,700	6,060	6,060	9,768	12,800
Italy	50,067	59,269	66,689	63,442	68,700
Poland [3]	45,620	47,936	48,800	46,300	55,900
Portugal (refined) [3]	1,442	1,166	1,183	1,358	e 1,100
Rumania e	17,000	44,000	44,000	44,000	44,000
Spain	59,321	72,643	57,937	70,685	89,458
Sweden (refined)	44,346	48,171	r 46,300	46,187	46,407
U.S.S.R. e	386,000	413,000	r 529,000	556,000	585,000
United Kingdom [4]	25,305	17,796	29,566	35,150	43,052
Yugoslavia [3]	111,889	107,809	r 112,314	104,540	132,300
Africa:					
Morocco	18,995	20,696	23,544	26,638	29,582
South-West Africa	72,791	82,976	81,078	67,454	67,085
Tunisia [5]	15,627	15,403	14,600	15,459	e 15,400
Zambia	23,529	20,679	21,055	26,594	25,400
Asia:					
Burma	17,600	15,400	14,300	9,900	11,000
China, mainland e	110,000	110,000	99,000	110,000	110,000
India	2,628	2,803	2,727	1,653	2,186
Iran e [6]	367	387	386	400	400
Japan	119,433	130,715	165,316	181,410	205,708
Korea:					
North e	55,000	55,000	60,000	60,000	60,000
South	900	1,772	3,293	3,438	3,834
Turkey e	1,012	550	550	550	660
Oceania: Australia (refined and bullion)	291,440	299,514	327,074	326,897	379,078
Total [7]	2,910,884	3,026,266	3,182,316	3,330,912	3,670,848

e Estimate. p Preliminary. r Revised.
[1] Primary, except as noted, or source does not differentiate.
[2] Lead refined from domestic and foreign ores; excludes lead refined from imported base bullion.
[3] Includes recovery from secondary materials.
[4] Lead bullion from imported ores and concentrates.
[5] Lead bars only; does not include lead contained in antimonial lead or solder.
[6] Year ended March 21 of year following that stated.
[7] Totals are of listed figures only.

Lime

By Robert A. Whitman [1]

The use of lime increased 8.4 percent in 1969. Increases of 19 percent in use for soil stabilization in construction work, and of 15 percent in use in steel fluxing were major contributors to the total increase. The encouraging factor was that the increases in usage were general throughout most of the industry. The only decreases reported were in agriculture, finishing lime, and the paper and pulp industry.

Table 1.—Salient lime statistics in the United States

(Thousand short tons and thousand dollars)

	1965	1966	1967	1968	1969
Number of primary plants	212	208	209	206	201
Sold or used by producers:					
Quicklime	12,009	13,195	r 13,449	14,440	15,479
Hydrated lime	2,609	2,669	2,656	2,364	2,864
Dead-burned dolomite	2,176	2,193	1,880	1,833	1,866
Total [1]	16,794	18,057	r 17,985	18,637	20,209
Value [2]	$232,939	$239,588	r $240,216	$249,639	$280,736
Average value per ton	$13.87	$13.27	r $13.36	$13.39	$13.89
Open market	10,449	11,451	11,461	12,054	13,113
Captive	6,345	6,606	r 6,524	6,583	7,096
Exports [3]	40	60	52	69	51
Imports for consumption [3]	276	196	123	106	195

r Revised.
[1] Data may not add to totals shown because of independent rounding.
[2] Selling value, f.o.b. plant, excluding cost of containers.
[3] Bureau of the Census.

DOMESTIC PRODUCTION

Although the number of active, primary lime plants decreased from 206 in 1968 to 201 in 1969, the quantity of lime produced in 1969 was some 1.5 million tons more than in 1968.

A new rotary lime kiln 11 feet in diameter by 310 feet long was projected for the Erie, Pa., plant of the Hammermill Paper Co.

Work on a new calcining plant to produce calcium oxide (CaO) was started at Lorain Ohio, for the United States Steel Corp. The new plant was to include two vertical shaft kilns and serve a new basic oxygen furnace shop under construction. Republic Steel Corp. announced a new limestone-calcining plant on the Grand River in northeastern Ohio. The plant was designed with two rotary kilns to produce 345,000 tons of burnt lime annually for use in Republic's northern Ohio steel mills.

A new mine was opened near Comfort, N.C. on a deposit estimated to contain the equivalent of 22 million tons of lime. It is the first such operation in eastern North Carolina. Delivery by truck and barge was planned.

Ash Grove Cement Co., Kansas City, Mo., modernized its plant at Springfield, Mo., to produce 18 tons per hour of high-purity chemical-grade lime with 99.0 percent passing 200 mesh. Ocean Industries of Fort Lauderdale, Fla., announced construction of a $2 million plant at Brunswick, Ga., to produce lime. It also was to produce aragonite which is mined from the ocean floor south of the island of Bimini in the Bahamas. Aragonite, a high-purity calcium carbonate, was used in the agricultural and chemical process industries. The Texas Lime Co. announced plans to triple the size of its lime plant west of Cleburne, Tex., by installation of a 350-ton-per-day rotary kiln.

[1] Physical scientist.

Table 2.—Lime, primary, sold or used by producers in the United States, by States

(Thousand short tons and thousand dollars)

State	Sold			Used			Total		
	Active plants	Quantity	Value	Active plants	Quantity	Value	Active plants	Quantity	Value
1968									
Alabama	6	W	W	3	W	W	6	773	$8,933
Arizona	3	W	W	4	W	W	7	260	4,561
Arkansas	1	72	$971	4	134	$2,087	5	206	3,058
California	6	210	3,703	11	357	5,598	16	568	9,301
Colorado	2	W	W	12	W	W	13	125	2,375
Florida	3	W	W	1	W	W	3	125	2,059
Hawaii	2	W	W	1	W	W	2	8	268
Louisiana	2	W	W	2	W	W	4	781	10,159
Massachusetts	3	W	W	1	W	W	3	198	3,380
Michigan	4	782	9,469	8	848	10,401	11	1,630	19,870
Montana	---	---	---	4	179	2,005	4	179	2,005
New Mexico	---	---	---	1	27	377	1	27	377
New York	1	W	W	3	W	W	3	1,086	10,154
Ohio	16	W	W	8	W	W	21	3,701	49,367
Oregon	2	W	W	2	W	W	4	120	2,407
Pennsylvania	13	W	W	2	W	W	14	1,702	24,272
Texas	9	828	10,454	6	736	10,701	14	1,564	21,154
Utah	3	W	W	4	W	W	7	174	3,439
Virginia	9	W	W	2	W	W	10	919	11,138
West Virginia	3	W	W	1	W	W	3	207	2,848
Wisconsin	5	224	3,620	---	---	---	5	224	3,620
Connecticut, Maryland, New Jersey, Vermont	6	80	1,360	---	---	---	6	80	1,360
Illinois, Indiana, Iowa, Minnesota, Tennessee, Missouri	15	3,185	39,916	8	87	2,059	20	3,272	41,975
Kansas, Mississippi, Nebraska, North Dakota Oklahoma, South Dakota, Wyoming	3	144	1,847	10	126	2,415	13	270	4,262
Idaho, Nevada, Washington	5	323	5,738	6	116	1,561	11	439	7,298
Undistributed [1]	---	6,206	88,135	---	3,973	47,225	---	---	---
Total [2]	122	12,054	165,212	104	6,583	84,427	206	18,637	249,639
Puerto Rico	1	39	1,187	---	---	---	1	39	1,187
1969									
Alabama	5	W	W	2	W	W	5	747	9,870
Arizona	3	W	W	4	W	W	6	283	5,074
Arkansas	1	W	W	3	W	W	4	184	2,748
California	6	225	3,958	10	360	5,708	15	585	9,666
Colorado	1	W	W	10	W	W	11	127	2,449
Florida	2	W	W	1	W	W	3	182	2,712
Hawaii	2	W	W	1	W	W	2	9	287
Louisiana	2	W	W	2	W	W	4	822	10,750
Massachusetts	3	W	W	1	W	W	3	199	3,718
Michigan	4	W	W	7	W	W	10	1,589	20,372
Montana	---	---	---	4	255	2,737	4	255	2,737
New York	1	W	W	3	W	W	3	1,055	10,224
Ohio	17	2,548	40,035	9	1,611	20,939	23	4,159	60,975
Oregon	2	W	W	2	W	W	4	115	2,337
Pennsylvania	12	W	W	2	W	W	13	2,008	28,952
Texas	10	866	10,155	6	768	11,952	15	1,633	22,107
Utah	3	W	W	4	W	W	7	191	3,947
Vermont	1	2	25	---	---	---	1	2	25
Virginia	7	W	W	2	W	W	8	1,072	13,653
West Virginia	3	W	W	1	W	W	3	269	3,648
Wisconsin	5	W	W	1	W	W	6	244	4,080
Connecticut, Maryland, New Jersey	5	96	1,661	---	---	---	5	96	1,661
Illinois, Indiana, Iowa, Minnesota, Missouri, Tennessee	15	3,459	43,245	8	89	2,018	20	3,547	45,263
Kansas, Mississippi, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Wyoming	3	149	1,672	12	182	3,305	15	331	4,977
Idaho, Nevada, Washington	5	378	6,625	6	126	1,880	11	505	8,504
Undistributed [1]	---	5,391	75,901	---	3,705	48,920	---	---	---
Total [2]	118	13,113	183,277	101	7,096	97,458	201	20,209	280,736
Puerto Rico	1	41	1,505	---	---	---	1	41	1,505

W Withheld to avoid disclosing individual company confidential data.
[1] Includes items indicated by symbol W.
[2] Data may not add to totals shown because of independent rounding.

Table 3.—Number and production of domestic lime plants, by size of operation [1]

Annual production (short tons)	1968 r			1969		
	Number of plants	Production (thousand short tons)	Percent of total	Number of plants	Production (thousand short tons)	Percent of total
Less than 10,000	46	228	1	42	209	1
10,000 to less than 25,000	43	698	4	40	645	3
25,000 to less than 50,000	35	1,261	7	33	1,174	6
50,000 to less than 100,000	25	1,761	9	29	2,024	10
100,000 to less than 200,000	26	3,732	20	22	3,371	17
200,000 and over	31	10,957	59	35	12,787	63
Total	206	18,637	100	201	20,209	100

r Revised.
[1] Includes captive tonnage.

Table 4.—Lime sold or used by producers in the United States, by uses

(Thousand short tons)

Use	1968			1969		
	Open market	Captive	Total	Open market	Captive	Total
Agriculture	213	---	213	180	---	180
Construction:						
Finishing lime	306	(1)	306	278	(1)	278
Mason's lime	446	(1)	446	456	(1)	456
Soil stabilization	658	(1)	658	783	(1)	783
Other	11	(1)	11	15	(1)	15
Total [2]	1,422	(1)	1,422	1,532	(1)	1,532
Chemical and other industrial:						
Alkalies (ammonium, potassium, and sodium compounds)	61	2,940	3,001	75	2,926	3,002
Brick, sand-lime, slag, and silica	18	---	18	24	---	24
Calcium carbide	463	268	731	491	274	765
Glass	383	---	383	390	---	390
Other chemical uses [3]	748	r 1,131	r 1,879	855	1,219	2,074
Metallurgical uses:						
Aluminum	137	W	137	183	W	183
Copper smelting	161	207	368	193	316	509
Ore concentration	73	---	73	W	---	W
Steel flux	4,362	666	5,028	4,785	1,001	5,786
Metallurgy (other) [4]	161	203	r 364	367	232	598
Paper and pulp	893	r 99	991	970	W	970
Sewage and trade-wastes treatment	374	74	448	401	83	484
Sugar	28	682	710	31	702	734
Water softening and treatment	1,039	W	1,039	1,112	W	1,112
Total [2]	8,900	r 6,270	15,170	9,877	6,753	16,630
Refractory lime (dead-burned dolomite) [2]	1,520	313	1,833	1,524	343	1,866
Grand total [2]	12,054	6,583	18,637	13,113	7,096	20,209

r Revised. W Withheld to avoid disclosing individual company confidential data.
[1] Included with "Other chemical uses" to avoid disclosing individual company confidential data.
[2] Data may not add to totals shown because of rounding.
[3] Includes calcium carbonate (precipitated), coke and gas, food and food byproducts, insecticides, magnesia, oil-well drilling, paint, petrochemicals, petroleum refining, rubber, tanning, miscellaneous unspecified uses, mason's lime, and items indicated by symbol W.
[4] Includes various metallurgical uses and items indicated by symbol W.

Table 5.—Destination of shipments of primary open-market lime sold in the United States, by States

(Thousand short tons)

State	1968			1969		
	Quicklime	Hydrated lime	Total	Quicklime	Hydrated lime	Total
Alabama	282	34	316	298	28	326
Alaska	W	W	1	W	W	1
Arizona	W	W	131	W	W	157
Arkansas	34	25	58	36	31	67
California	305	114	419	336	128	464
Colorado	80	19	99	7	13	19
Connecticut	71	25	97	74	26	100
Delaware	32	8	41	34	8	42
District of Columbia	W	W	4	W	W	5
Florida	195	53	249	214	55	269
Georgia	95	20	115	107	21	127
Hawaii	W	W	W	W	W	W
Idaho	W	W	11	W	W	20
Illinois	619	160	780	854	156	1,010
Indiana	1,072	68	1,140	1,211	68	1,280
Iowa	62	30	91	58	22	81
Kansas	42	40	82	72	22	94
Kentucky	571	17	588	599	16	614
Louisiana	165	68	233	195	69	264
Maine	48	12	60	48	12	60
Maryland	346	17	364	426	23	449
Massachusetts	W	W	27	W	W	22
Michigan	849	56	905	915	52	967
Minnesota	110	15	126	129	15	144
Mississippi	84	22	106	75	29	104
Missouri	144	39	183	117	42	158
Montana	4	2	5	11	1	12
Nebraska	10	11	21	12	11	22
Nevada	42	3	45	35	3	39
New Hampshire	8	4	12	W	W	12
New Jersey	73	95	168	91	114	206
New Mexico	39	35	74	1	37	38
New York	218	164	382	253	175	427
North Carolina	87	33	121	104	29	133
North Dakota	10	18	28	11	16	27
Ohio	1,468	137	1,605	1,177	152	1,329
Oklahoma	62	45	107	59	57	116
Oregon	61	19	80	47	18	66
Pennsylvania	1,114	176	1,290	1,493	187	1,680
Rhode Island	W	W	16	9	7	16
South Carolina	49	9	58	40	7	47
South Dakota	12	34	47	12	37	49
Tennessee	95	42	136	104	43	146
Texas	392	444	835	385	510	895
Utah	63	14	77	62	25	87
Vermont	W	W	2	W	W	2
Virginia	84	34	117	173	42	215
Washington	57	20	77	72	24	97
West Virginia	222	20	242	274	23	297
Wisconsin	113	56	169	123	52	175
Wyoming	W	W	W	W	W	W
Undistributed [1]	109	96	13	127	99	6
Total [2]	9,597	2,350	11,947	10,478	2,505	12,983

W Withheld to avoid disclosing individual company confidential data.
[1] Includes States indicated by symbol W.
[2] Data may not add to totals shown because of rounding.

CONSUMPTION AND USES

The use of lime registered gains in nearly all fields of consumption in 1969. Overall the gain was 8.4 percent, while the use of lime for steel fluxing increased about 15 percent and the use for soil stabilization increased 19 percent. The use of lime as a flux in steelmaking has more than doubled from 1965 through 1969. The basic oxygen furnace was the principal reason for the increase. In the same period, the output of steel from the basic oxygen furnace increased 2.6 times.

As the population density forced the use of less desirable land, the need for inexpensive methods of soil stabilization for such projects as roads, airports, buildings, and parking lots accounted for the large increase in the use of lime for this purpose.

One technique of stabilizing a highway grade was outlined in an article in Roads and Streets.[2]

Increases in the consumption of lime for treatment of sewage and industrial wastes, for water softening, and for chemical and industrial uses, also contributed to the 8.4-percent gain in 1969 lime consumption and were expected to be a factor in continued future growth.

PRICES

Price quotations for various commodities are reported in the Engineering News Record each month. Prices for delivered hydrated finishing lime in 1969 ranged from $63.00 per ton in Seattle to $24.50 per ton in Cincinnati. The average price reported for 20 major cities was $43.92 per ton in December. Prices for pulverized quicklime ranged from $64.00 per ton in Seattle to $24.50 per ton in Cincinnati. The price on common lump ranged from $29.76 per ton in San Francisco to $24.50 per ton in Cincinnati.

The average value of lime sold or used by producers, f.o.b. plant, excluding the cost of containers, was reported to the Bureau of Mines at $13.89 per ton. The comparable 1968 price was $13.39 per ton.

FOREIGN TRADE

In 1969, the United States shipped to nearby Canada nearly 70 percent of the total lime exported, with just over 19 percent going to Mexico. Of the remainder, divided among 35 countries, the only countries to take over 1 percent of our export total were the Bahamas, the Philippine Islands, Japan, and Australia. U.S. imports of lime increased nearly 84 percent, practically all from Canada. The average per ton value of lime imported was only two-thirds of that in 1968.

Table 6.—U.S. exports of lime

Year	Short tons	Value (thousands)
1967	52,143	$1,099
1968	68,915	1,437
1969	51,006	1,153

Table 7.—U.S. imports for consumption of lime

Year	Hydrated lime		Other lime		Dead-burned dolomite [1]		Total	
	Short tons [2]	Value (thousands)	Short tons [2]	Value (thousands)	Short tons [2]	Value (thousands)	Short tons [2]	Value (thousands)
1967	545	$12	79,983	$961	42,413	$1,832	122,941	$2,805
1968	873	21	71,632	877	33,498	1,552	106,003	2,450
1969	39,270	542	144,471	1,911	10,780	568	194,521	3,021

[1] Dead-burned basic refractory material consisting chiefly of magnesia and lime.
[2] Includes weight of immediate container.

WORLD REVIEW

Canada.—A new hydrated lime plant was announced for Joliette, Quebec. Plans by Domtar Chemicals, Ltd., Montreal, Quebec, called for a $750,000 plant to replace an outmoded facility which the company planned to demolish.

New Zealand.—New Zealand Steel announced plans to get its burnt lime from the Otorohanga works of McDonald's Lime (New Zealand) Ltd. It was announced that about 4,000 tons would be needed annually as a flux in steelmaking.

United Kingdom.—It was esimated that annual maintenance requirements for liming agricultural land in the United Kingdom were about 4.5 million long tons.

[2] Thompson, M. R. Lime-Soil Stablization: Deep Plow Style. Roads and Streets, v. 112, No. 3, March 1969, pp. 80, 83, 88.

Table 8.—World production of quicklime and hydrated lime, including dead-burned dolomite, sold or used, by countries

(Thousand short tons)

Country [1]	1967	1968	1969 p
North America:			
Canada	1,423	1,440	1,718
Costa Rica e	9	9	9
Guatemala	21	19	19
Puerto Rico	35	39	41
United States (sold or used by producers)	r 17,985	18,637	20,209
South America:			
Brazil	r 1,477	1,669	e 1,764
Colombia	965	1,008	e 1,025
Paraguay e	19	20	20
Uruguay e	77	66	56
Europe: [2]			
Austria	r 764	e 794	680
Belgium	r 2,853	2,872	2,899
Bulgaria	1,069	1,069	e 1,069
Czechoslovakia	2,604	2,524	e 2,535
Denmark	209	e 209	e 209
Finland	254	231	235
France [2]	r 4,388	4,389	e 4,685
Germany:			
East	r 2,762	2,848	e 2,866
West	11,180	11,722	11,758
Hungary	882	808	e 882
Ireland	46	69	57
Italy	e 5,401	e 5,512	6,388
Norway	211	246	e 250
Poland	2,599	2,528	e 2,535
Rumania	1,157	1,157	e 1,157
Spain	337	e 347	e 364
Sweden	r 1,015	e 1,025	e 1,025
Switzerland	169	162	e 165
U.S.S.R.	21,661	22,835	e 23,149
Yugoslavia	r 1,606	e 1,609	1,539
Africa:			
Ethiopia (including Eritrea)	25	25	20
South Africa, Republic of (sales)	964	914	999
Tanzania	6	8	12
Tunisia	187	e 187	e 187
Uganda	204	22	NA
Zambia	77	79	e 77
Asia:			
Cyprus	e 90	e 94	110
India	NA	313	336
Iran e	1,102	1,102	1,102
Japan	3,397	3,996	4,657
Kuwait	1	1	e 1
Lebanon e	55	99	132
Mongolia e	44	44	44
Philippines	93	116	238
Saudi Arabia	7	12	e 10
Taiwan	102	143	122
Oceania:			
Australia [3]	210	237	e 231
Fiji Islands	3	4	5
Total [4]	r 89,746	93,259	97,591

e Estimate. p Preliminary. r Revised. NA Not available.

[1] Lime is produced in many other countries besides those listed. Congo (Kinshasa), Mexico, Nicaragua, Venezuela, and United Kingdom are among the more important countries for which official data are unavailable.

[2] For Europe the data includes lime only, and in the case of France, high-grade lime only. France's total lime production is much larger than that shown.

[3] Year ended June 30 of year stated.

[4] Totals are of listed figures only.

TECHNOLOGY

A technique for preparing sound lime (CaO) specimens with closely controlled properties was described.[3] The procedure involved calcination of the carbonate, followed by compaction and low-temperature sintering of the calcium oxide. Greatest control over water reactivity of the specimens was achieved by variation of the calcining conditions. Compacting the lime at

[3] Schlitt, W. J., and G. W. Healy. Preparations of Lime Specimens With Closely Controlled Properties. Am. Ceram. Soc. Bull., v. 49, No. 2, February 1970, pp. 212–215.

various pressures primarily controlled the bulk density and porosity. Measurements of the apparent specific gravity, percent porosity, bulk density, specific surface area, and average pore size were made on the specimens. Results compared favorably with those obtained on lime produced from natural carbonate materials.

Marketing of a multicolumn vertical lime kiln was announced.[4] The Schmid-Hofer limekiln, developed in Austria, was expected to produce a soft-burned, high-quality lime through the use of a patented regenerative and parallel flow principle.

Precipitation reactions using waste lime for production of various metallic salts were outlined in an article on the recovery of minerals from effluents.[5]

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[4] Pit and Quarry. Vertical Lime Kiln Development Now Marketed in U.S. and Canada. V. 62, No. 7, January 1970, pp. 162–163.

[5] Teworte, Wilhelm. Economic Aspects of Recovery of Minerals From Effluents. Chem. and Ind., No. 18, May 3, 1969, pp. 569–571.

Magnesium

By John R. Lewis [1]

Shortages of magnesium metal which had existed for several years began to ease in 1969. Production, shipments, and productive capacity increased slightly, and deliveries of primary magnesium and alloy ingot from the Government stockpile continued throughout the year. There were, however, indications of oversupply within a year or two. One new plant went into production and a smaller plant was permanently shutdown. In the Great Salt Lake, Utah, area there was considerable construction and other developmental activities aimed at use of the lake's brines as a source of magnesium, while other new magnesium plants were well beyond the talking stage.

Legislation and Government Programs.—The General Services Administration, under a law passed in October 1968, continued active disposal of magnesium from the Government stockpile. A total of 26,480 short tons was committed to sale during 1969. A revised stockpile objective under conventional war conditions was established on December 3, 1969, by the Office of Emergency Preparedness at 78,000 tons. This would leave a surplus of 12,000 tons in the stockpile at termination of the October 1968 program.

[1] Physical scientist, Division of Nonferrous Metals.

Table 1.—Salient magnesium statistics

(Short tons)

	1965	1966	1967	1968	1969
United States:					
Production:					
Primary magnesium	81,361	79,794	97,406	98,375	99,886
Secondary magnesium	13,617	15,129	13,444	15,525	e 12,973
Shipments: Primary	85,796	96,443	100,743	103,671	117,702
Exports	17,836	14,869	11,989	18,364	26,032
Imports for consumption	2,551	3,265	9,235	4,077	3,515
Consumption	69,622	82,678	90,775	86,427	95,057
Price per pound cents	35.25	35.25	35.25	35.25	35.25
World: Primary production	178,318	179,894	208,575	212,663	p 221,649

e Estimate. p Preliminary.

DOMESTIC PRODUCTION

U.S. production of primary magnesium rose a nominal 1.5 percent (1,511 short tons) in 1969, to 99,886 short tons. Secondary magnesium recovery was estimated to be close to 13,000 tons for the year.

For a short period in 1969, almost the entire quantity of primary magnesium metal produced in the Nation for consumption, as opposed to in-plant use, came from the Dow Chemical Co.'s two electrolytic plants in Texas. This production was augmented late in the year by smaller output from the new Snyder, Tex., plant of American Magnesium Co. Plans for new plants, some already begun, will beget great increases in the Nation's primary producing capacity by 1970–71, and some sources indicate that by 1972 the producing capacity in the United States will be nearly 300,000 tons per year, almost double that of 1969.

At Snyder, Tex., in June, American Magnesium Co. began charging cells and preparing to produce magnesium metal from brines from 1,600-foot-deep wells some 23 miles distant. The brine is moved to the plant via an asbestos cement pipeline. The Snyder plant's initial output was slated to be 10,000 tons per year, a rate not achieved at yearend. However, operations were about on schedule toward an ultimate production level of 30,000 tons per year sometime in 1972. Low-cost gas is an important factor in the brine processing. The dehydrated brine is fed into electroytic cells, out of which come 3 pounds of chlorine gas per pound of magnesium produced. In the spring, National Steel Corp., acquired a 30-percent interest in American Magnesium.

Table 2.—Magnesium recovered from scrap processed in the United States, by kinds of scrap and forms of recovery

(Short tons)

	1965	1966	1967	1968	1969 p
Kind of scrap:					
New scrap:					
Magnesium-base	6,306	6,462	5,062	7,006	4,767
Aluminum-base	3,643	4,127	4,266	r 5,050	5,239
Total	9,949	10,589	9,328	r 12,056	10,006
Old scrap:					
Magnesium-base	2,232	3,321	2,973	2,113	1,700
Aluminum-base	1,436	1,219	1,143	r 1,356	1,267
Total	3,668	4,540	4,116	r 3,469	2,967
Grand total	13,617	15,129	13,444	r 15,525	12,973
Form of recovery:					
Magnesium alloy ingot [1]	2,138	5,202	3,760	2,502	3,231
Magnesium alloy castings (gross weight)	14	24	39	15	11
Magnesium alloy shapes	58	70	103	82	149
Aluminum alloys	7,947	6,336	6,157	r 9,900	7,888
Zinc and other alloys	23	17	18	18	6
Chemical and other dissipative uses	542	281	25	64	63
Cathodic protection	2,895	3,199	3,342	2,944	1,625
Total	13,617	15,129	13,444	r 15,525	12,973

p Preliminary. r Revised.
[1] Figures include secondary magnesium content of both secondary and primary magnesium alloy ingot.

Oregon Metallurigical Corp. proceeded with an $8 million expansion program at its Albany, Oreg., plant, where $3.5 million was allocated to a 10,000-ton-per-year plant which will use modified Alcan cells for electrolytic magnesium production. Target for completion was early 1970. Magnesium will be used and reused within the plant in the making of titanium sponge.

National Lead Co. acquired, by an exchange of stock, the minority interest in H-K, Inc., which had conducted pioneer engineering studies and pilot plant investigation on the commercial production of magnesium metal and chlorine from the brines of Great Salt Lake. By mid-1969, National Lead was reported ready to undertake construction and operation of a nearly $70 million single-site electrolytic reduction plant utilizing solar evaporating ponds and auxiliary facilities. Magnesium capacity of the plant was rated at 45,000 tons per year. The site for the plant was the southwest shore of Great Salt Lake near Rowley and Grantsville, Tooele County, Utah. Part of the plant's capacity was to be ready in 1971 and the balance by 1972. Output will be primary magnesium and alloy products, and byproduct possibilities were expected to include gypsum, potash, magnesium oxide, salt cake, potassium sulfate, and lithium compounds. This plant, once fully operational, will increase U.S. magnesium output by slightly more than one-third.

A second Utah magnesium project also moved forward during the year. Known as the Great Salt Lake Minerals & Chemicals Corp., it is situated on the northeast side of the lake in the Bear River basin area west of Ogden. Ownership was 51 percent by Gulf Resources & Chemical Corp. of Houston, Tex., and 49 percent by Salzdetfurth A.G., an important chemical producer in West Germany. A 2 year sequential precipitation cycle was already started at the company's large solar evaporation ponds on the lake flats in the North Arm near the site of the plant. The magnesium chloride brines thus obtained will be processed to purified bulk solids in a two-plant complex being built by Great Salt Lake and The Dow Chemical Co. and shipped to a new 48,000-ton-per-year (magnesium metal) plant which will soon be started by Dow at Dallesport on the Columbia River in Oregon. Completion at Dallesport is scheduled for late 1971.

The 9,200-ton-per-year silicothermic magnesium plant at Selma, Ala., was sold and permanently closed down in the fall of 1969. Operated by the Calumet & Hecla Division of Universal Oil Products Co., the plant produced 99.98-percent primary magnesium from calcined dolomite and 75-percent grade ferrosilicon. Closing was said to have been due to rising costs and competition from metal produced from brines by the electolytic process.

CONSUMPTION AND USES

Consumption of magnesium in the U.S. reversed the previous year's dip and rose to almost 100,000 tons, about 15 percent better than in 1968 and about in line with the development of the market in recent years. Very preliminary data indicate that almost all sectors of the magnesium-using industry were buying more in 1969. There was no group of users where consumption was out of line with previous years.

Primary magnesium is consumed in two broad categories: structural products, such as castings or wrought products, and distributive or sacrifical applications where magnesium's value is its chemical properties. At present the structural applications take about one-third of the output while sacrificial uses take two-thirds of the magnesium.

In the face of some wariness by potential users of the lightest structural metal, magnesium's versatility appeared to be an endorsement. Increasing use of magnesium in automobiles (engines, housings, and particularly wheels) was noted in both the United States and Europe. A wide-ranging series of new applications came to the fore during 1969. One Canadian snowmobile builder was using 20 pounds of magnesium castings in each vehicle. Similar applications were reported by motor scooter, lawn mower and chain saw manufacturers. Even lawn rake and tennis racket makers were looking with favor upon magnesium as a prime constituent. The products seemed to

Table 3.—Consumption of primary magnesium (ingot equivalent and magnesium content of magnesium-base alloys) in the United States, by uses

(Short tons)

	1965	1966	1967	1968	1969 p
For structural products:					
Castings:					
Sand	2,959	3,961	3,848	3,740	2,562
Die [1]	5,599	4,980	8,366	7,337	7,484
Permanent mold	814	632	555	607	404
Wrought products:					
Sheet and plate	4,937	6,075	W	W	W
Extrusions (structural shapes, tubing)	[2] 5,995	[2] 7,100	[3] 10,517	[3] 11,280	[3] 13,110
Forgings	W	W	W	W	W
Total	20,304	22,748	23,286	22,964	23,560
For distributive or sacrificial purposes:					
Powder	W	W	W	W	W
Aluminum alloys	26,266	30,862	31,244	34,484	37,375
Zinc alloys	136	100	53	52	54
Other alloys	2,216	1,975	2,370	W	W
Scavenger and deoxidizer	170	195	W	W	W
Chemical	3,806	4,604	5,214	W	W
Cathodic protection (anodes)	4,597	4,670	4,855	5,714	6,087
Reducing agent for titanium, zirconium, hafnium, uranium, and beryllium	8,467	8,429	6,704	6,209	7,363
Other [4]	3,660	9,095	17,049	17,004	20,618
Total	49,318	59,930	67,489	63,463	71,497
Grand total	69,622	82,678	90,775	86,427	95,057

p Preliminary. W Withheld to avoid disclosing individual company confidential data.
[1] Includes primary metal to produce small quantities of investment castings.
[2] Includes "Forgings."
[3] Includes "Sheet and plate" and "Forgings."
[4] Includes primary metal for experimental purposes, debismuthizing lead, and producing nodular iron, secondary magnesium alloys, other alloys, scavengers and deoxidizers, chemicals and powder.

be competitive economically, and certain long-lasting properties were expected to appeal to buyers.

The big use of magnesium is as an alloy for aluminum, but each year sees more direct applications. Use of magnesium powder to make small parts by compacting and sintering was being critically investigated in 1969, and magnesium die casting was expected to rise as soon as new suppliers become available via new ingot productive capacity.

Magnesium has been used for many years to make special long-life dry batteries. The development was begun and supported by Army research and development programs, which were successful and have since been concluded. The Army spent $12 million in 1969 for these batteries and was estimated to spend $20 million in 1970. To date all output has been used by the military, but the projected future lies in commercial use. Higher voltage, longer shelf life, more uniform output, especially in periods of high power demand, and a more efficient design are claimed for magnesium batteries. Demand has grown from about 1 million pounds of magnesium extrusions in 1969 to about 5 million pounds in 1970.[2]

[2] Modern Metals. Magnesium, Best Metal for Batteries. V. 25, No. 7, August 1969, pp. 79–81.

PRICES

As it has for more than a decade, the quoted base price for primary magnesium ingot, in 10,000-pound lots, f.o.b. plant, remained at 35.25 cents per pound throughout the year. There were selective price hikes during 1969 of 5 to 10 percent for certain magnesium mill products, however, and some die-casting alloy prices rose because of higher production and labor costs.

Depending upon the state of preservation of the metal available from the national stockpile, the General Services Administration accepted bids for primary magnesium and for a small amount of alloy ranging from 37.10 cents to 24.01 cents per pound, f.o.b. storage location; at an average price of 32.12 cents per pound, 26,480 short tons was committed to sale during the year.

Effective March 1, 1969, Magnesium Elektron, the leading seller of magnesium in the United Kingdom, raised its base f.o.b. price to the equivalent of 35.25 cents per pound. Prices for magnesium metal in Europe generally varied and were usually lower than in the United States, even to as much as 10 cents per pound.

STOCKS

A preliminary tally indicated that on December 31, 1969, producer and consumer stocks of primary magnesium were 8,950 short tons, while primary magnesium alloy ingot stocks stood at 3,410 short tons. Stocks a year earlier were 7,735 short tons of primary metal and 2,205 short tons of alloy ingot. The increase in stocks was not unreasonable but may have reflected some increase, late in the year, of productive capacity.

Table 4.—Stocks and consumption of new and old magnesium scrap in the United States in 1969

(Short tons)

Scrap item	Stocks Jan. 1	Receipts	Consumption			Stocks Dec. 31
			New scrap	Old scrap	Total	
Cast scrap	171	2,176	86	2,076	2,162	185
Solid wrought scrap [1]	1,443	5,415	5,736	-----	5,736	1,122
Total	1,614	7,591	5,822	2,076	7,898	1,307

[1] Includes borings, turnings, drosses, etc.

FOREIGN TRADE

The 1960's saw exports of primary magnesium go from 4,467 short tons in 1960 to 26,032 short tons by 1969, an increase of 483 percent. Except for 1966-67, the trend was upward, sometimes sharply. In 1966, magnesium exports fell 17 percent, and in 1967 there was another 19.4 percent cutback. Since then, however, increases of 40 to 50 percent each year have been noted. The Volkswagen automobile uses magnesium alloy and West Germany was the largest customer for U.S. magnesium, taking 61.3 percent of the total exported. Imports by Brazil and Canada, the next largest buyers, remained consistent in 1969. The Netherlands upped U.S. purchases from 57 short tons in 1968 to 1,267 short tons in 1969, while the United Kingdom's take fell about 53 percent, from 1,153 short tons in 1968 to 545 short tons in 1969.

Table 5.—U.S. exports of magnesium, by classes and countries

Destination	1968				1969			
	Primary metals, alloys, and scrap		Semifabricated forms, n.e.c., including powder		Primary metals, alloys, and scrap		Semifabricated forms, n.e.c., including powder	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Argentina	142	$62	------	------	141	$79	3	$5
Australia	160	90	25	$77	867	478	87	272
Belgium-Luxembourg	37	26	45	71	234	166	23	34
Brazil	1,887	958	(1)	(1)	2,663	1,498	------	------
Canada	1,393	818	435	843	2,345	1,421	476	945
Colombia	5	3	22	23	27	28	57	70
France	129	72	12	49	130	93	14	35
Germany, West	12,113	6,797	2	7	15,954	8,982	3	21
India	6	3	1	3	106	71	(1)	1
Israel	13	9	35	55	21	17	103	169
Italy	227	144	24	49	222	131	5	13
Japan	28	16	57	110	227	160	105	263
Mexico	469	339	117	107	305	190	195	195
Netherlands	57	56	131	649	1,267	876	152	625
New Zealand	(1)	(1)	------	------	68	40	3	5
Norway	134	75	2	7	84	48	3	8
Philippines	(1)	(1)	4	3	2	2	42	24
South Africa, Republic of	21	13	------	------	46	26	(1)	(1)
Spain	132	74	1	(1)	441	251	2	4
Surinam	1	1	------	------	54	33	------	------
Sweden	49	26	21	60	44	23	4	20
United Kingdom	1,153	950	21	57	545	338	20	41
Venezuela	177	155	92	78	190	156	7	7
Other	31	32	46	82	49	30	36	67
Total	18,364	10,719	1,093	2,330	26,032	15,137	1,340	2,824

[1] Less than ½ unit.

Imports for consumption of magnesium (all forms combined) continued the downward trend established in 1968 and dropped 16.3 percent in 1969. Canada, by far the largest of U.S. sources, contributed 79 percent of the total; the United Kingdom sent 6 percent; a block of six countries—Denmark, The Netherlands, West Germany, Hong Kong, Australia, and the Republic of South Africa—sent 12 percent; 10 other nations contributed the remaining 3 percent.

Under terms of the "Kennedy round" trade agreements, another series of tariff reductions became effective on January 1, 1969. The import duty on nonalloyed unwrought magnesium dropped to 32 percent from 36 percent ad valorem the previous year; the duty on unwrought alloys was lowered from 14.4 cents per pound on magnesium content plus 7 percent ad valorem to 12.8 cents per pound plus 6 percent ad valorem, while the duty on wrought magnesium was reduced from 12 cents per pound on magnesium content plus 6 percent ad valorem to 10.5 cents per pound plus 5.5 percent ad valorem.

Table 6.—U.S. exports and imports for consumption of magnesium

Year	Exports			
	Metal and alloys in crude form and scrap		Semifabricated forms, n.e.c.	
	Short tons	Value (thousands)	Short tons	Value (thousands)
1967	11,989	$7,132	1,184	$1,983
1968	18,364	10,719	1,093	2,330
1969	26,032	15,137	1,340	2,824

Year	Imports					
	Metallic and scrap		Alloys (magnesium content)		Powder, sheets, tubing, ribbons, wire, and other forms (magnesium content)	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1967	9,235	$4,920	354	$1,529	132	$422
1968 r	4,077	2,203	656	1,228	40	428
1969	3,515	1,913	467	1,175	14	66

r Revised.

WORLD REVIEW

World production of magnesium rose about 3.5 percent in 1969 and totaled 221,649 short tons. The United States produced 46.5 percent of the estimated world total. This was a slight reduction in the U.S. share of world total, indicating proportionally increased output from other nations, including Canada and the U.S.S.R.

Worldwide information covering the production of primary magnesium follows:

Country	Company	Capacity (short tons)	Process	Plant location
Canada	Dominion Magnesium Ltd	11,300	Silicothermic	Haley, Ontario.
France	Compagnie de Produits Chimiques et Electrométallurgiques (Péchiney) - (35 percent), Societé d'Electrochimie, d'Electrométallurgie et des Aciéries Electriques d'Ugine (35 percent), Société des Produits Azotés (SPA) - (30 percent).	3,900	Silicothermic	Marignac.
Italy	Societa Italiana per il Magnesio e Leghe di Magnesio.	7,000	do	Bolzano.
Japan	Furukawa Magnesium Co. Ltd	6,600	do	Koyama
	UBE Industries, Ltd	2,200	do	Yamaguchi.
Norway	Heroya Electrokemiske Fabrikker A/S subsidiary of Norsk Hydro-Elektrisk A/S	37,400	I.G. Farben-industrie	Heroya.
U.S.S.R.	NA	50,000	Electrolytic	NA.
United States	Alamet Division, Calumet & Hecla, Inc.[1]	9,000	Silicothermic	Selma, Ala.
	American Magnesium Co	10,000	Electrolytic	Snyder, Tex.
	The Dow Chemical Co	[2] 90,000	Dow cells	Freeport, Tex.
	Titanium Metals Corporation of America	[3] 12,000	Electrolytic	Henderson, Nev.

NA. Not available
[1] Plant permanently shut down at end of 1969.
[2] Capacity planned for 125,000 by mid-1969 but no announcement made when completed.
[3] Captive use.

West Germany.—The Norweigian magnesium producing firm Norsk Hydro-Elektrisk, A/S, cooperating with the West German chemical firm Salzdetfurth, announced plans during 1969 for construction of a 20,000- to 30,000-metric-ton electrolytic magnesium plant in West Germany, probably in Lower Saxony on the River Elbe. The plant will utilize the chloride salts which are a by-product of the output of the Salzdetfurth factory with possibly some raw materials from the Great Salt Lake area of the United States. The plant, which will also produce from 50,000 to 80,000 metric tons of chlorine annually, was due on stream during 1971. This production may be expected to cut into U.S. exports of magnesium to Germany.

Table 7.—World production of primary magnesium, by countries

(Short tons)

Country	1967	1968	1969 p
Canada	8,887	9,928	10,585
China, mainland e 1	1,102	1,102	1,102
France	4,590	4,938	6,504
Italy	6,963	7,273	7,385
Japan	7,438	6,236	6,900
Norway	r 33,570	34,546	35,274
U.S.S.R. e	44,100	46,297	49,604
United Kingdom 2	4,519	3,968	4,409
United States	97,406	98,375	99,886
Total	208,575	212,663	221,649

e Estimate. p Preliminary. r Revised.
1 Conjectural, denoting an order of magnitude.
2 Primary metal and remelt alloys.

TECHNOLOGY

An announcement by Nalco Chemical Co. of Chicago reported a new and economically advantageous process for magnesium metal production. Although company officials would not disclose further details, educated guesses pointed to electrolysis of magnesium chloride in an organic solvent,[3] a process compatible with Nalco's tetraethyl lead-tetramethyl lead process used in its plant located in the Dow complex at Freeport, Tex. The magnesium produced by Nalco presumably would be for its own use at Freeport.

United States, Canadian, and German patents were issued during 1969 on a process for slurry mining of carnallite, a hydrous magnesium potassium chloride. Water or an unsaturated salt solution is introduced into the mineral deposit, and the more soluble magnesium chloride is leached out while the less soluble potassium chloride remains as solid particles in the saturated leach liquor. The magnesium chloride solution is then pumped out of the upper part of the leached-out cavity, a slurry containing the particles of potassium chloride is withdrawn from the lowermost part of the cavity, and the solids then are separated from the brine.[4]

ZE41A, a magnesium casting alloy which has found favor with European aerospace, military, and commercial industries for years, began to attract favorable attention of the U.S. aerospace industry during 1969. Easily cast, the alloy generally has been used in structural applications, and has recently found favor for use in helicopters, particularly transmission housings.

3 Chemical Week. V. 104, No. 23, June 7, 1968, p. 49.
4 Kutz, K. J. (assigned to Texas Gulf Sulfur Co.). Mining Solution. U.S. Pat. 3,442,553, May 6, 1969; Canadian Pat. 835,708, Mar. 3, 1969; German Pat. 1,288,538, Feb. 6, 1969.

Magnesium Compounds

By John R. Lewis [1] and V. Anthony Cammarota, Jr. [1]

World production of magnesite has risen about 3.5 percent per year since 1967, and in 1969 was slightly over 12 million tons. The Communist Bloc (U.S.S.R., mainland China, North Korea, and Czechoslovakia) was estimated to be the source of 70 percent of the world's magnesite production in 1969. Among free world countries, only Austria was an important producer.

Magnesium compounds sold or used by producers in 1969 were about 20 percent above 1968 production. Value of the 1969 output rose 23 percent.

Imports for consumption of crude and processed magnesite dropped about 24 percent in 1969. Nearly all crude magnesite imported by the United States comes from Greece, and that nation is a big factor in U.S. supplies of the various magnesias as well. The leading Greek producer, Sté Financière de Grece S.A. (Financial Corporation of Greece, Ltd.) accounts for 70 percent of annual exports and has proceeded with expansion and product improvement.

Legislation and Government Programs.—Under terms of the Tax Reform Act of 1969, signed by the President on December 30, 1969, the percentage depletion allowance for magnesium carbonates was reduced from 15 percent to 14 percent. The reduction took effect on taxable years beginning after October 9, 1969. The depletion allowance for magnesium chloride, obtained from brines, from wells, or from saline perennial lakes within the United States, remained at 5 percent.

[1] Physical scientist, Division of Nonferrous Metals.

Table 1.—Salient magnesium compounds statistics

(Thousand short tons and thousand dollars)

	1965	1966	1967	1968	1969
United States:					
Caustic-calcined and specified magnesias:[1]					
Shipments:					
Quantity	90	99	114	135	154
Value	$9,163	$9,686	$11,250	$12,226	$14,698
Exports:[2]					
Value	$1,637	$1,627	$2,095	$2,301	$2,687
Imports for consumption:[2]					
Value	$592	$743	$585	$758	$983
Refractory magnesia:					
Sold and used by producers:					
Quantity	897	852	688	661	737
Value	$56,100	$52,290	$43,148	$44,535	$51,843
Exports:					
Value	$5,912	$6,208	$5,889	$4,706	$4,973
Imports:					
Value	$4,214	$8,139	$5,171	$6,179	$5,449
Dead-burned dolomite:					
Sold and used by producers:					
Quantity	2,176	2,193	1,880	1,833	1,866
Value	$39,606	$39,725	$34,083	$31,627	$33,580
Imports:					
Value	$2,385	$2,038	$1,832	$1,552	$568
World: Crude magnesite production:					
Quantity	11,072	11,106	11,248	11,656	12,027

[1] Excludes caustic-calcined magnesia used in production of refractory magnesia.
[2] Caustic-calcined magnesia only.

DOMESTIC PRODUCTION

With the closing of the Chewelah, Wash., operation of Northwest Magnesite Co. during 1968, only Nevada remained as a producer of crude magnesite in 1969. Brucite was also produced in the United States solely in Nevada. In both instances, production was by Basic Inc., from its Gabbs, Nev., property.

The volume of dead-burned dolomite sold or used by producers in the United States rose almost 2 percent in 1969, and the average value per ton, $17.99, rose slightly over 4 percent. The combined yield from Illinois, Louisiana, Pennsylvania, and Ohio amounted to 82 percent of the Nation's output, with Ohio supplying about half the total. Smaller amounts came from Alabama, California, Colorado, Mississippi, Missouri, Pennsylvania, Utah, and West Virginia. Crude olivine was produced, as in recent years, in North Carolina and Washington. Production rose about 2 percent in 1969.

Refractory magnesia from well brines, sea water, or dolomite increased in 1969, and Michigan again supplied more than any of the other producing States, which were California, Florida, Mississippi, New Jersey, and Texas. Nevada stood alone in the production of refractory magnesia from magnesite and brucite.

Table 2.—Dead-burned dolomite sold in and imported into the United States

(Thousand short tons and thousand dollars)

Year	Sales of domestic product		Imports	
	Quantity	Value	Quantity	Value
1965	2,176	$39,606	55	$2,385
1966	2,193	39,725	44	2,038
1967	1,880	34,083	42	1,832
1968	1,833	31,627	33	1,552
1969	1,866	33,580	11	568

Producers sold 390,371 short tons of refractory magnesia in 1969, up 17 percent over 1968 sales. In addition, they consumed another 346,867 short tons in their own plants, up about 6 percent. Thus, total production was 737,238 short tons valued at $51.8 million, compared with 660,891 short tons in 1968 valued at $44.5 million. The unit value of shipments was applied to producers' consumption to calculate the total values.

Production of hydrous magnesium sulfate was up more than 5 percent in 1969, while production of magnesium trisilicate rose about 30 percent, thus not fully recovering from its decline of 53 percent in 1968. Small volumes of anhydrous magnesium sulfate, magnesium nitrate, magnesium phosphate, and magnesium acetate also were produced in the United States during 1969.

Production of a range of calcined magnesia products started during the summer of 1969 at the expanded Manistee, Mich., plant of Standard Lime and Refractories Co. Standard, a part of the Cement and Lime Division of Martin Marietta Corp., will make a variety of grades to meet specifications of the chemical rubber, petroleum, pulp, paper, glass, and construction industries. The new calcined magnesia facility is part of an $8 million expansion at Manistee, where refractory magnesia also is produced.

CONSUMPTION AND USES

Consumption of refractory magnesia, both single-burned and doubled-burned, increased from 661,000 short tons in 1968 to 737,000 short tons in 1969. More sophisticated refractory products for use in the metals, petroleum, cement and ceramics industries, plus a widening range of specialty and shaped refractories, were thought to be responsible for the improved consumption during the year.

Consumption of caustic-calcined magnesia, excluding that used in the production of refractory magnesia, increased again; in 1969 the consumption rose by 14 percent from 125,400 to 143,000 short tons.

Most of the magnesium hydroxide consumed during the year went into the production of other magnesium compounds, although about 110,000 tons were sold to other industries. Magnesium hydroxide sales of The Dow Chemical Co. rose, for example, as a manufacturer of periclase refractory brick for basic oxygen steel furnaces at Manistee, Mich. became a customer for this item from Dow's Ludington, Mich., plant.

Consumption of hydrous magnesium sulfate increased in 1969, by 6.6 percent. Consumption of magnesium trisilicate increased 15 percent; that of anhydrous magnesium chloride (principally used in making magnesium metal) dropped to about 25 percent of 1968 consumption. Hydrous magnesium chloride consumption rose about 4.5 percent.

Table 3.—Magnesium compounds shipped and used in the United States

Year and product	Plants	Shipped and used: Short tons	Shipped and used: Value (thousands)
1968:			
Refractory magnesia [1]	12	660,891	$44,535
Caustic-calcined [2] and specified (U.S.P. and technical) magnesias	10	135,469	12,226
Magnesium hydroxide (100 percent $Mg(OH)_2$) [2]	9	r 78,241	r 2,888
Magnesium chlorides [3]	6	[3] 394,287	27,147
Precipitated magnesium carbonate [2]	5	8,791	NA
1969:			
Refractory magnesia [1]	10	737,238	$51,843
Caustic-calcined [2] and specified (U.S.P. and technical) magnesias	10	154,303	14,698
Magnesium hydroxide (100 percent $Mg(OH)_2$) [2]	7	89,925	3,392
Magnesium chlorides [3]	7	[3] 408,373	28,230
Precipitated magnesium carbonate [2]	5	7,800	NA

r Revised. NA Not available.
[1] Includes both single-burned and double-burned.
[2] Excludes material produced as an intermediate step in the manufacture of other magnesium compounds.
[3] Production for 1968, 409,795; 1969, 561,108; includes magnesium chloride used in production of magnesium metal.

Table 4.—Domestic consumption of caustic-calcined magnesia and specified magnesias by uses

(Percent)

Use	1968	1969
Chemical processing	11	10
Fertilizer	6	7
85-percent MgO insulation	1	1
Oxychloride and oxysulfate cements	10	10
Pulp and paper	12	11
Rayon	10	6
Rubber	8	8
Other: Electrical, medicinal, flux, ceramic, glass, sugar, animal feed, fuel additive, water treatment, and uranium processing	42	47

Olivine consumed in 1969 was only very slightly more than in the previous year. It continued to be used principally in moldings and mixtures.

Use of magnesium oxide in a new system to recover sulfuric acid from powerplant stack gases was planned. The sulfuric acid plant of the Essex Chemical Corp. of Clifton, N.J., was selected to process the magnesium sulfite washed from stack effluent at the Mystic Electric Generating Station of Boston Edison Co. Cost of the 2-year experimental program was to be shared by Boston Edison and the Department of Health, Education, and Welfare (National Air Pollution Control Administration). However, Boston Edison expected that the system would work so effectively that it would not have to use expensive low-sulfur fuel oils, but could continue to use the lower cost high-sulfur fuels which will soon otherwise be outlawed under new air pollution control regulations.

In the process, magnesium oxide fed through a scrubber will absorb the sulfur dioxide in the stack gases. The resulting magnesium sulfite cake will then be shipped to the Essex sulfuric acid plant, and calcined to obtain sulfur dioxide for making sulfuric acid. Almost all of the magnesium oxide will be recovered so that it can be recycled in the powerplant scrubber. Sulfur dioxide emissions are expected to be well below minimums established under State and Federal standards.

PRICES

Prices for magnesia, calcined, technical, heavy, 90 percent and 93 percent (bags, carlot, f.o.b. Luning, Nev.) showed no change from the preceding year at $53.00 and $56.00 per short ton, respectively, according to the Oil, Paint and Drug Reporter. Magnesia, technical, synthetic rubber grade, light, was quoted at $0.23 to $0.24 per pound (bags, carlot, freight equalized) compared with $0.23 to $0.275 in 1968. Because of the closing of the Chewelah, Wash., plant in mid-1968, no quote was given for dead-burned magnesite.

Prices for magnesium carbonate, technical (bags, carlot, freight equalized) increased from $0.13 to $0.14 per pound, and from $0.135 to $0.14–$0.145 in truckload quantities. For magnesium hydroxide, NF, powder (drums, carlot, and truckload, works) the price range was $0.21 to $0.265 per pound, compared with $0.255 to $0.26 in 1968. No price changes were noted for other magnesium compounds which were quoted as follows: Magnesium bromide, 80-pound drums, f.o.b. works, $1.60 per pound; magnesium chloride, anhydrous, 92 percent, flake or pebble, drums, carlot, works, $0.1275 per pound; magnesium chloride, hydrous, 99 percent, flake, bags, carlot, works, $60.00 per ton; magnesium gluconate, 100-pound drums, f.o.b. works, $1.42 per pound; and magnesium lauryl sulfate, tanks, freight allowed, $0.18 per pound.

FOREIGN TRADE

The decline in exports of dead-burned magnesite and magnesia continued for the fifth consecutive year but at a slower rate. Exports decreased about 2 percent, compared with about 11 percent in 1968 and 12 percent in 1967. Three countries showing the largest decrease in deliveries were Mexico (−41 percent), Venezuela (−26 percent), and Australia, which imported none compared with 1,802 short tons in 1968. Countries showing the largest increase in deliveries were Argentina (+208 percent), Canada (+12 percent), Chile (+29 percent), and Peru (+50 percent). Spain and Costa Rica imported 4,704 tons and 817 tons, respectively, compared with none in 1968. Exports of magnesite, including crude, caustic-calcined, lump or ground, increased about 22 percent to 8,732 tons. Deliveries of about 1,000 tons or more went to Canada, West Germany, and the United Kingdom.

Imports for consumption of lump or ground caustic-calcined magnesia increased about 29 percent to 15,238 tons. For dead-burned and grain magnesia and periclase containing a maximum of 4 percent lime, imports decreased about 7 percent to 80,667 tons. Imports for the same material containing over 4 percent lime decreased 68 percent. Total imports were down about 24 percent in 1969, to 91,447 tons.

Under the "Kennedy round" tariff agreement, tariffs on a number of magnesium compounds were further reduced:

Item	1968	1969
Magnesite:		
Crude	$4.72 per ton	$4.20 per ton
Caustic calcined	$9.45 per ton	$8.40 per ton
Magnesium carbonate:		
Precipitated	0.3¢ per pound	0.25¢ per pound
Not precipitated	7.5 percent ad valorem	6.5 percent ad valorem
Magnesium chloride:		
Anhydrous	0.9¢ per pound	0.8¢ per pound
Other	0.375¢ per pound	0.33¢ per pound
Magnesium oxide:		
Calcined magnesia	1.8¢ per pound	1.6¢ per pound
Magnesium sulfate:		
Epsom salts	0.335¢ per pound	0.3¢ per pound
Kieserite	7.5 percent ad valorem	6.5 percent ad valorem

Table 5.—U.S. exports of magnesite and magnesia, by countries

Destination	Magnesite and magnesia, dead-burned				Magnesite, n.e.c. including crude, caustic-calcined, lump or ground			
	1968		1969		1968		1969	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Argentina	293	$27	902	$36	27	$13	39	$15
Australia	1,802	92	------	------	534	297	390	212
Belgium-Luxembourg	------	------	------	------	92	24	69	30
Canada	25,506	2,329	28,458	2,528	1,666	134	3,259	243
Chile	889	66	1,147	95	40	9	133	35
Colombia	------	------	220	18	159	44	84	21
Costa Rica	------	------	817	163	331	15	275	23
Denmark	2	1	2	1	28	17	51	29
El Salvador	445	27	399	82	------	------	------	------
France	3	1	2	1	155	66	145	49
Germany, West	102	50	114	62	754	423	1,028	614
Honduras	------	------	------	------	------	------	151	19
India	------	------	4	3	7	4	13	8
Israel	------	------	1	(1)	16	10	36	17
Italy	5	1	21	3	286	110	278	118
Japan	30	12	9	1	76	58	427	188
Mexico	19,092	1,276	11,298	845	507	51	237	36
Netherlands	20	3	439	27	192	34	80	34
New Zealand	1	1	------	------	151	94	87	55
Peru	1,102	70	1,653	106	1	1	------	------
Philippines	1	(1)	3	1	214	42	56	9
South Africa, Republic of	86	59	83	54	113	62	150	66
Spain	------	------	4,704	310	93	39	105	44
Sweden	39	25	148	97	171	106	362	254
Switzerland	------	------	------	------	45	19	112	24
United Kingdom	367	184	141	74	969	518	992	481
Venezuela	7,318	471	5,435	443	290	40	34	6
Other	54	11	84	23	267	71	139	57
Total	57,157	4,706	56,084	4,973	7,184	2,301	8,732	2,687

(1) Less than ½ unit.

Table 6.—U.S. imports for consumption of crude and processed magnesite, by countries

Country	1968 Short tons	1968 Value (thousands)	1969 Short tons	1969 Value (thousands)
Crude magnesite:				
Greece	--------	--------	6,666	$464
Venezuela	--------	--------	18	(1)
Total	--------	--------	6,684	464
Lump or ground caustic-calcined magnesia:				
Australia	1,361	$133	2,454	244
Austria	1,082	41	562	21
Belgium-Luxembourg	110	7	10	1
Canada	--------	--------	5	(1)
Greece	1,184	89	3,472	242
India	5,021	319	7,535	397
Israel	--------	--------	16	2
Italy	--------	--------	545	41
Netherlands	130	9	109	7
Tanzania	55	4	--------	--------
Turkey	2,514	141	362	21
Yugoslavia	331	15	168	7
Total	11,788	758	15,238	983
Dead-burned and grain magnesia and periclase:				
Not containing lime or not over 4 percent lime:				
Austria	--------	--------	2,405	153
Canada	82	12	2	6
Germany, West	47	19	3	(1)
Greece	64,189	4,778	61,314	4,525
Italy	12,316	898	--------	--------
Japan	7,554	369	14,722	647
United Kingdom	20	2	(1)	4
Yugoslavia	2,146	101	2,221	114
Total	86,354	6,179	80,667	5,449
Containing over 4 percent lime:				
Canada	793	42	4,141	239
Yugoslavia	32,705	1,510	6,639	329
Total	33,498	1,552	10,780	568
Grand total	119,852	7,731	91,447	6,017

[1] Less than ½ unit.

Table 7.—U.S. imports for consumption of magnesium compounds

Year	Oxide or calcined magnesia		Magnesium carbonate (precipitated)		Magnesium chloride (anhydrous)		Magnesium sulfate (epsom salts and kieserite)		Magnesium salts and compounds n.s.p.f.[1]	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1967	64	$31	900	$173	451	$71	32,274	$404	3,354	$127
1968	535	183	1,269	222	480	92	44,261	644	2,799	185
1969	103	47	836	157	368	70	43,685	605	3,727	372

[1] Includes magnesium silicofluoride or fluosilicate and calcined magnesia.

WORLD REVIEW

Australia.—It was announced late in the year that Norseman Gold Mines NL had ordered a market and feasibility study aimed at possible production of dead-burned magnesite from a deposit in the Ravensthorpe district in the southern sector of the State of Western Australia. Depending upon the studies, the company plans to mine the ore and process it in nearby kilns at a rate of 50,000 tons per year for export. Its proximity to a good road and the established deepwater port of Esperance would make the product competitive in world markets.

India.—Economically recoverable reserves of magnesite occur in three States of India: Tamil Nadu, Uttar Pradesh, and Mysore. Major producers, all in the private sector, are Salem Magnesite Ltd., Salem, Tamil Nadu; Dalmia Magnesite Corporation, Salem; Burn and Co., Suramangalem, Salem; and Tata Iron and Steel Co., Ltd., of Bombay with mines in Mysore. The manufacture of refractories consumes most of India's calcined magnesite, and 90 percent of her magnesite is consumed internally. The bulk of the magnesite comes from the Salem district, and deposits there are nearing exhaustion. New reserves have recently been found in the Almora district, and the mining and calcining of these new deposits is to be undertaken by the Uttar Pradesh Industrial Corp. in collaboration with Tata Iron and Steel Company, Ltd. Production of dead-burned magnesite is expected to begin early in 1971; capacity is planned for 35,000 tons yer year.

Late in 1969 it was also announced that Salem Magnesite Private Ltd. plans to install a rotary kiln to permit production of up to 30,000 tons of dead-burned magnesite. Feed for this installation will come from other installations of Salem's which have been producing caustic-calcined magnesite, mostly for export.

Ireland.—Progress continued on construction of the Dungarvan, County Waterford, sea water magnesite plant of the

Table 8.—World production of magnesite, by countries [1]

(Short tons)

Country	1967	1968	1969 [p]
North America: United States	W	W	W
South America: Brazil	120,430	151,920	NA
Europe:			
Austria	1,692,386	1,704,923	1,763,696
Czechoslovakia	[r] 2,321,465	[e] 2,370,718	2,425,082
Greece	[r] 406,752	486,119	639,340
Italy	[r] 4,952	5,516	4,410
Poland [e]	49,604	49,604	49,604
Spain [2]	121,254	250,224	220,462
U.S.S.R. [e]	3,306,930	3,306,930	3,417,161
Yugoslavia	468,219	441,272	525,802
Africa:			
Kenya	465	75	555
South Africa, Republic of	88,198	65,915	49,604
Sudan	[r] 4,409	7,165	550
Tanzania	2,246	1,595	1,705
Asia:			
China, mainland [e]	881,848	992,079	1,102,310
India	270,893	278,965	286,825
Iran [e]	6,614	7,165	7,165
Korea, North [e]	1,377,887	1,377,887	1,377,887
Pakistan	[r] 2,251	1,798	NA
Turkey	93,651	129,780	130,072
Oceania:			
Australia	26,492	25,923	24,250
New Zealand	636	887	882
Total [3]	[r] 11,247,582	[r] 11,656,460	12,027,362

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available. W Withheld to avoid disclosing individual company confidential data.

[1] Quantities in this table represent crude salable magnesite. Magnesite is also produced in Bulgaria, Canada, Colombia, and Southern Rhodesia, but data on production are not available.

[2] Estimated from data reported as MgO.

[3] Totals are of listed figures only.

Quigley Magnesite Division, Chas. Pfizer and Co. Inc., and production was expected by May 1970. First production was expected to be 94 percent magnesite, but improvement to 96 or 97 percent was foreseen once the plant had a shakedown period. The plant will process sea water at a rate of 12,000 gallons per minute to deal with a dolomite intake of 230,000 tons per year. After satisfying the company's demand in Ireland, the excess output, about 50,000 tons per year, is to go to Quigley Co. Inc. in the United States, to sales outlets in the United Kingdom, and perhaps to the Common Market.

Israel.—A contract calling for the investment of US $11 million to construct a plant in Arad for the production of magnesia from magnesium chloride reserves in the Dead Sea was signed in June 1969 by representatives of the Austrian-American Magnesite Co., and the Dead Sea Works of Israel. The plant, to be built in 2 years, will be owned in equal shares by the two companies, with the Austrians responsible for the chemical functions and the Israelis for the engineering. In addition to a planned annual output of 46,000 metric tons of pure magnesia, the plant will produce 40,000 tons of hydrochloric acid per year (using the Israeli AMAN process) for domestic consumption.

United Kingdom.—The full duty of 7 percent ad valorem on imports of deadburned magnesite and refractory-grade magnesia, which took effect on July 1, 1969 was suspended at least to January 1, 1970.

TECHNOLOGY

The problem of air pollution caused by sulfur dioxide in stack gases may be solved by the use of magnesia. A pilot plant has been operating in Japan using the process of absorbing sulfur dioxide from the flue gas into active magnesia at 200° to 300° F. Magnesia combines with the sulfur dioxide to form magnesium sulfite, which is subsequently decomposed at below 1,400° F to yield reusable magnesia and sulfur dioxide that is suitable for sulfuric acid production.[2] Patents have been applied for in Japan and major foreign countries.

A refractory made from finely ground magnesia and chrome ore has been developed which has properties superior to those of direct-bonded and fused-cast basic refractories.[3] The improved refractory has a higher load-bearing capacity at high temperature, more resistance to slag penetration, and better thermal shock resistance. The improved properties of the fine-grained refractory are a function of the retention of a large volume of closed pores after high-temperature firing. Formation and growth of the closed pores are controlled by reactions between the finely ground material and the amount and distribution of the silicate phase.

Alumina-rich single crystals of magnesium-aluminum spinel with molar ratios of 1.7 to 3.5 (Al_2O_3:M_gO) were grown by flame fusion, and the fracture load of these crystals was measured.[4] It was found that in unannealed crystals the strength increased with increasing alumina content and that strength was influenced by the temperature of heat treatment. The strengthening found in magnesium-aluminum spinels is thought to be age strengthening as is often observed in alloys. The authors stated that to their knowledge, magnesium-aluminum spinel is the first oxide in which age strengthening has been observed.

[2] Chemical & Engineering News. Active Magnesia Method Rids Stack Gas of Sulfur Dioxide in Japanese Process. V. 47, No. 38, September 1969, p. 48.

[3] Herron, R. H., and W. J. Smothers. Fine-Grained Magnesite-Chrome Refractories. Am. Ceramic Soc. J., v. 48, No. 5, May 1969, p. 544.

[4] Grabmaier, J. G., and H. R. Falckenberg. Strength of Flame-Fusion-Grown Magnesium-Aluminum Spinel. Am. Ceramic Soc. J., v. 52, No. 12, December 1969, p. 648.

Manganese

By Gilbert L. DeHuff [1]

A halving of domestic shipments of manganese ore—that is, ore, concentrate, and nodules, containing 35 percent or more manganese—brought a new production low, particularly noteworthy in that for the first time in many years there were neither shipments nor production of natural battery-grade ore. Good quality foreign metallurgical ores continued to be offered in abundance. Their price fell 10 cents per long ton unit during the year, influenced in part by increased Australian production and shipments. Prices for manganese metal and alloys rose. Ferromanganese imports increased 50 percent over those of the previous year to approximately 300,000 short tons.

[1] Physical scientist, Division of Ferrous Metals.

Table 1. Salient manganese statistics in the United States

(Short tons)

	1965	1966	1967	1968	1969
Manganese ore (35 percent or more Mn):					
Production (shipments):					
Metallurgical	22,871	W	W	10,536	5,630
Battery	6,387	W	W	842	---------
Total	29,258	14,406	12,585	11,378	5,630
Imports, general	2,575,229	2,553,704	2,058,691	1,827,626	1,962,166
Consumption	2,872,720	2,370,516	2,382,984	2,228,412	2,181,333
Manganiferous ore (5 to 35 percent Mn):					
Production (shipments)	332,763	324,926	289,160	244,590	430,637
Ferromanganese:					
Production	1,148,011	946,210	940,927	879,962	852,019
Exports	3,273	545	1,861	3,710	1,759
Imports for consumption	257,339	251,972	216,279	203,212	301,956
Consumption	1,040,502	1,048,429	982,130	1,016,559	1,071,042

W Withheld to avoid disclosing individual company confidential data.

Legislation and Government Programs.—On March 27, the Office of Emergency Preparedness (OEP) decreased the conventional war stockpile objective for battery-grade synthetic manganese dioxide to 1,900 short tons from 6,700 tons. On May 13, new conventional war stockpile objectives, and subobjectives, were established for other manganese items as follows in short tons:

	Short tons Old	Short tons New
Objective:		
Battery, natural	80,000	135,000
Chemical, type A	68,500	35,000
Chemical, type B	64,000	35,000
Metallurgical	7,900,000	4,000,000
Subobjective:		
Metallurgical ore	6,647,500	2,605,600
Ferromanganese:		
High carbon[1]	1,000,000	1,200,000
Low carbon [1]	18,000	18,000
Medium carbon[1]	72,000	72,000
Silicomanganese [1]	135,000	81,900
Electrolytic metal [1]	27,500	22,500

[1] Ore equivalent.

On April 23, the General Services Administration (GSA) issued Solicitation of Offers for Metallurgical Grade Manganese, PMDS-ORES-85. Prospective buyers were offered 101 manganese ore items, mostly of domestic origin, in either the national or Defense Production Act stockpiles and located at storage depots in various parts of the country. Contract terms were to be negotiated, and offers received until further notice. Sales for the year totaled 34,536 short tons. In addition, metallurgical ore was withdrawn from the stockpile for upgrading to medium carbon ferromanganese and to silicomanganese under two separate contracts initiated in 1967 and 1968, respectively. As of December 31, 1969, 18,660 tons of medium carbon ferromanganese had been delivered to GSA under the one contract out of 36,000 tons to be delivered by June 30, 1971, and 12,331 tons of silicomanganese had been delivered out of a total of 45,500 tons for the other contract. The final delivery date for the silicomanganese was extended 1 year to June 15, 1971, by a contract amendment dated August 26, 1969. The stockpile inventory for metallurgical manganese ore decreased by 199,720 short tons during the year to 10,186,208 tons as of December 31, 1969. Part of the ore withdrawals represents deliveries under outstanding long-term contracts. The inventory for battery-grade synthetic manganese dioxide decreased 1,122 short tons during the year to 23,553 tons.

DOMESTIC PRODUCTION

Goret and Aguilar, Inc., produced metallurgical manganese ore at the Nancy-Tower mine, Luis Lopez district, Socorro County, N. Mex. The ore was concentrated at the firm's mill at Socorro before shipment; the concentrate averaged 48 percent manganese. Although The Anaconda Company shipped some metallurgical oxide nodules that were made some years ago from Montana carbonate ore, no manganese ore, concentrate, or nodules, of any type were produced in Montana in 1969. For the first time since battery ore production was specifically identified as such in the Bureau's statistical tables—at least 48 years—there were no shipments nor production of domestic natural battery-grade ore.

Ferruginous manganese ores or concentrates containing 10 to 35 percent manganese were produced and shipped from the Cuyuna Range of Minnesota and from New Mexico. In addition, a small quantity of manganiferous iron ore containing 5 to 10 percent manganese was shipped from Cuyuna Range stocks. Manganiferous zinc residuum was produced from New Jersey zinc ores.

Table 2.—Manganese and manganiferous ore shipped[1] in the United States, by States

(Short tons)

Type and State	1968		1969	
	Gross weight	Manganese content	Gross weight	Manganese content
Manganese ore (35 percent or more Mn, natural):				
Montana	4,649	2,434	775	404
New Mexico	6,729	3,133	4,855	2,331
Total	11,378	5,567	5,630	2,735
Manganiferous ore:				
Ferruginous manganese ore (10 to 35 percent Mn, natural):				
Minnesota	190,058	27,037	381,435	54,510
Montana	2,063	423	------	------
New Mexico	50,681	5,504	49,146	5,465
Total	242,802	32,964	430,581	59,975
Manganiferous iron ore (5 to 10 percent Mn, natural):				
Minnesota	1,788	123	56	4
Total manganiferous ore	244,590	33,087	430,637	59,979
Value manganese and manganiferous ore	$2,407,619	------	$3,454,254	------

[1] Shipments are used as the measure of manganese production for compiling U.S. mineral production value. They are taken at the point at which the material is considered to be in marketable form for the consumer. Besides direct-shipping ore, they include, without duplication, concentrate and nodules made from domestic ores.

CONSUMPTION, USES, AND STOCKS

In the production of raw steel (ingots, continous or pressure cast blooms, billets slabs, etc. and including steel castings) consumption of manganese as ferroalloys, metal, and direct-charged ore was 13.0 pounds per short ton of raw steel produced. Of this total, 11.4 pounds was ferromanganese; 1.3 pounds, silicomanganese; 0.05 pounds, spiegeleisen; and 0.25 pounds, manganese metal. The comparable 1968 total, on the same basis, was 13.6 pounds with ferromanganese at 11.7, silicomanganese at 1.6, spiegeleisen at 0.05, and metal at 0.25.

Electrolytic Manganese and Manganese Metal.—It can be assumed that virtually all the manganese metal consumed, produced, and imported in the United States was electrolytic metal. Producers were American Potash & Chemical Corp. (wholly owned subsidiary of Kerr-McGee Corp.), Hamilton (Aberdeen), Miss.; Foote Mineral Co., Knoxville and New Johnsonville, Tenn.; and Union Carbide Corp., Marietta, Ohio.

Table 3.—Consumption and stocks of manganese ore[1] in the United States

(Short tons)

	Consumption 1968	Consumption 1969	Stocks Dec. 31, 1969[2] (including bonded warehouses)
By use:			
Manganese alloys and metal	2,028,567	2,000,735	1,692,934
Pig iron and steel	27,167	50,157	16,455
Dry cells, chemicals and miscellaneous	172,678	130,441	95,674
Total	2,228,412	2,181,333	[3]1,805,063
By origin:			
Domestic	43,251	22,300	22,081
Foreign	2,185,161	2,159,033	1,782,982
Total	2,228,412	2,181,333	[3]1,805,063

[1] Containing 35 percent or more manganese (natural).
[2] Excluding Government stocks.
[3] Excludes small tonnages of dealers' stocks.

Table 4.—Consumption, by end uses, and stocks of manganese ferroalloys and metal in the United States, in 1969

(Short tons, gross weight)

End use	Ferromanganese: High carbon	Ferromanganese: Medium and low carbon	Silico-manganese	Spiegel-eisen	Manganese metal[1]
Steel:					
Carbon	756,718	92,306	96,630	11,788	7,273
Stainless and heat resisting	1,000	4,148	10,599	W	7,939
Alloy (exclude stainless and tool)	114,438	25,924	29,064	1,906	2,885
Tool	472	92	W	------	W
Cast Irons	12,289	2,017	5,991	7,991	W
Superalloys	758	129	W	------	345
Alloys (exclude alloy steels and superalloys)	5,857	1,408	1,860	------	8,098
Miscellaneous and unspecified	51,378	2,108	8,247	91	1,473
Total	942,910	128,132	152,391	21,776	28,013
Stocks December 31[2]	247,827	26,325	33,626	15,116	8,563

W Withheld to avoid disclosing individual company confidential data, included in Miscellaneous and unspecified.
[1] Virtually all electrolytic.
[2] Industry stocks held by producers, consumers, and bonded warehouses.

Table 5.—Ferromanganese produced in the United States and metalliferous materials [1] consumed in its manufacture

Year	Ferromanganese produced			Materials consumed		
	Gross weight (short tons)	Manganese content		Manganese ore (35 percent or more Mn natural) [2]		Manganese ore used per ton of ferromanganese [3] made (short tons)
		Percent	Short tons	Foreign (short tons)	Domestic (short tons)	
1965	1,148,011	77.8	892,725	2,692,290	12,067	2.3
1966	946,210	78.7	744,359	2,133,925	30,043	2.2
1967	940,927	78.2	735,177	2,182,997	4,367	2.3
1968	879,962	78.0	686,370	2,013,360	15,207	2.3
1969	852,019	77.3	658,837	1,992,671	8,064	2.3

[1] Excluding scrap and other secondary materials.
[2] Includes ore used in producing silicomanganese and metal.
[3] Includes ore used in producing silicomanganese.

Table 6.—Manganese ore used in producing ferromanganese, silicomanganese, and manganese metal in the United States, by source of ore

Source	1969	
	Gross weight (short tons)	Mn content, natural (percent)
Domestic	8,064	47.4
Foreign:		
Africa	865,058	46.8
Australia	102,447	46.8
Brazil	579,524	48.4
Chile	27,567	46.5
Guyana	51,037	38.2
India	77,728	41.9
Mexico	29,344	35.6
Other or unidentified	259,966	----
Total	2,000,735	46.7

Ferromanganese.—With the shut down of its Sheridan, Pa., blast furnace in the second quarter of the year, the Lavino Division, International Minerals & Chemical Corp., stopped production of ferromanganese entirely. Large inventories in the face of high imports of both ferromanganese and steel were given as the reason for this action. U.S. shipments of ferromanganese totaled 837,000 short tons compared with 833,000 tons in 1968. The quantity of ferromanganese made in blast furnaces was 1½ times that made in electric furnaces.

Silicomanganese.—Production of silicomanganese in the United States was 223,000 short tons, compared with 284,000 tons in 1968. Shipments from furnaces were 218,000 tons compared with 262,000 tons in 1968. The ratio of consumption of silicomanganese to consumption of ferromanganese dropped to 14 percent from 16 percent registered in the 2 previous years.

Spiegeleisen.—The New Jersey Zinc Co. continued to produce spiegeleisen solely by electric furnaces at Palmerton, Pa.

Pig Iron.—In producing pig iron, 748,000 short tons of manganese-bearing ores containing over 5 percent manganese (natural) were consumed. Domestic sources supplied 635,000 tons, of which 519,000 tons were manganiferous iron ore containing 5 to 10 percent manganese, and 116,000 tons were ferruginous manganese ore containing 10 to 35 percent manganese. Foreign sources supplied 113,000 tons, of which 56,000 tons were manganiferous iron ore, 7,000 tons were ferruginous manganese ore, and 50,000 tons contained more than 35 percent manganese.

Battery and Miscellaneous Industries.—The ore reported in table 3 includes that consumed in making synthetic manganese dioxide, but does not include consumption of the synthetic dioxide. Although some synthetic dioxide is used for chemical purposes, most of it is used in the manufacture of dry cell batteries.

The domestic ore and much of the foreign ore used for chemical and miscellaneous purposes did not meet national stockpile specification P-81-R for chemical-grade ore.

Early in 1969, Pickands Mather & Co. together with its Manganese Chemicals Co. Division were merged into Diamond Shamrock Corp.

PRICES

Manganese Ore.—All manganese ore prices are negotiated, being dependent in part on the characteristics and quantity of ore offered, delivery terms, and fluctuating shipping rates. Prices were weak throughout the year, and no quotations were published for ore containing 46 to 48 percent manganese until after the middle of January. The American Metal Market then quoted this grade at 54 to 58 cents, nominal, per long ton unit, c.i.f. eastern seaboard and Gulf ports, down 5 cents from the prices quoted at the end of 1968. In August, the quotation was lowered another 5 cents to 49 to 53 cents, nominal, at which it continued to the end of the year. Metals Week quoted this grade at 50 cents, nominal, throughout the year, except at times in the first 2 months when only "nominal" was ventured.

Manganese Alloys.—Major producers of standard high-carbon ferromanganese went in April from a "price on request" basis to firm published prices. For the 74 to 76 percent grade this was $164.50 per long ton, f.o.b. plant. This price carried to the end of the year. Metals Week's quotation for imported standard ferromanganese containing 74 to 76 percent manganese had risen by year end to $160 to $164 per long ton, delivered in Pittsburgh or Chicago.

Manganese Metal.—Effective July 1, the price of standard electrolytic manganese metal was increased 2 cents to 29 cents per pound, f.o.b. producer plant. This base price continued to apply to shipments of 30,000 pounds or more, but was now for packaging in pallet boxes instead of for bulk shipments as quoted in 1968 and earlier. A bulk price no longer was quoted. Earlier in the year an upward adjustment of 0.4 cent was made for the packaging change. Effective October 1, the price was increased to 30.25 cents per pound. Here it remained through the last quarter of the year, but a 1-cent increase was announced for the beginning of the new year.

FOREIGN TRADE

Ferromanganese exports totaled 1,759 short tons valued at $482,684, compared with 3,710 tons valued at $645,057 in 1968. Canada took two-thirds of the quantity in 1969. Exports classified as "manganese and manganese alloys, wrought or unwrought, and waste and scrap" were 2,470 tons valued at $1,410,437 in 1969, and 2,118 tons valued at $1,119,127 in 1968. Exports of ore and concentrate containing more than 10 percent manganese totaled 19,231 tons at a value of $1,627,324 in 1969, compared with 18,500 tons at $2,042,305 in 1968. These were believed to consist almost entirely of imported manganese dioxide ore exported after grinding, blending, or otherwise classifying.

The average grade of imported manganese ore increased notably to 50.6 percent manganese from the 47.5 percent and 47.3 percent manganese average grades of 1968 and 1967. Brazil and Gabon continued to supply more than half of the total. General imports of manganiferous ores containing more than 10 but less than 35 percent manganese totaled 6,238 short tons in 1969. Of this quantity, 6,181 tons averaged 11.3 percent manganese and came from Canada. The balance of 57 tons averaged 34.97 percent manganese and came from Mexico.

Table 7.—U.S. imports of manganese ore (35 percent or more Mn), by countries

Country	General imports [1] (short tons)						Imports for consumption [2] (short tons)					
	1968			1969			1968			1969		
	Gross weight	Mn content	Value (thousands)	Gross weight	Mn content	Value (thousands)	Gross weight	Mn content	Value (thousands)	Gross weight	Mn content	Value (thousands)
Angola	77,017	36,838	$1,839	29,762	14,356	$419	77,017	36,838	$1,839	29,762	14,356	$419
Australia	76,097	36,634	1,928	154,774	75,887	3,105	76,097	36,634	1,928	154,774	75,887	3,105
Brazil	538,166	254,521	12,718	693,802	353,557	13,509	538,166	254,521	12,718	670,316	342,284	13,069
British West Africa [3]	----	----	----	101	38	2	----	----	----	101	38	2
Canada	27	18	2	444	213	13	27	18	2	444	213	13
Congo [4]	117,695	59,856	3,113	190,488	105,636	4,436	118,602	60,332	3,135	190,488	105,636	4,436
Gabon [5]	526,227	260,617	14,265	508,436	255,369	10,124	526,227	260,617	14,265	508,436	255,369	10,124
Ghana	58,871	30,290	1,360	95,202	46,835	1,946	58,871	30,290	1,360	95,202	46,835	1,946
Guyana [6]	108,200	43,246	2,731	17,196	6,707	353	108,200	43,246	2,731	17,196	6,707	353
India	97,305	47,671	1,861	65,040	30,508	1,081	97,305	47,671	1,861	65,040	30,508	1,081
Ivory Coast	45,441	20,562	977	7,194	3,218	119	45,441	20,562	977	7,194	3,218	119
Japan	17	7	2	39	16	5	17	7	2	39	16	5
Mexico	8,124	3,450	276	5,249	2,376	229	8,124	3,450	276	5,249	2,376	229
Morocco	32,720	16,789	1,552	23,939	12,799	1,372	32,720	16,789	1,552	23,939	12,799	1,372
Philippines	----	----	----	4,744	2,540	147	----	----	----	4,744	2,540	147
South Africa, Republic of	131,313	54,037	2,334	59,228	29,018	904	133,990	55,096	2,374	59,228	29,018	904
Turkey	6,455	2,657	130	----	----	----	6,455	2,657	130	----	----	----
Venezuela [7]	2,846	1,110	58	216	104	4	2,846	1,110	58	216	104	4
Western Africa, n.e.c. [8]	----	----	----	106,312	53,057	1,850	----	----	----	106,312	53,057	1,850
Zambia	1,105	552	56	----	----	----	1,105	552	56	----	----	----
Total	1,827,626	868,855	45,202	1,962,166	992,234	39,618	1,831,210	870,390	45,264	1,938,680	980,961	39,178

[1] Comprises ore received in the United States; part went into consumption during the year and the remainder entered bonded warehouses.
[2] Comprises ore received during the year for immediate consumption and ore withdrawn from bonded warehouses.
[3] Probably from Ghana or Guyana.
[4] In 1969, actual imports originating in Congo (Kinshasa) were approximately 118,000 tons (gross weight); see note 5.
[5] In addition for 1969: Gabon imports reported as Congo (Kinshasa) were approximately 72,000 tons (gross weight); those reported as Western Africa, n.e.c. were approximately 106,000 tons (gross weight).
[6] All reported from Trinidad and Tobago (country of transshipment). In addition Guyana imports, reported as Venezuela (country of transshipment) appear to have been 2,846 tons (gross weight) in 1968 and 216 tons (gross weight) in 1969.
[7] Apparently no imports originated in Venezuela; see note 6.
[8] Actually from Gabon.

Table 8.—U.S. imports for consumption of ferromanganese, by countries

Country r	1968 Gross weight (short tons)	1968 Mn content (short tons)	1968 Value (thousands)	1969 Gross weight (short tons)	1969 Mn content (short tons)	1969 Value (thousands)
Belgium-Luxembourg	8,905	6,947	$846	4,464	3,365	$445
Canada	1,166	906	136	4,483	3,514	557
Chile	356	307	58	390	341	65
France	r 48,385	r 37,267	r 5,053	64,421	49,476	5,571
Gabon [1]	11,216	8,636	527	------	------	------
Germany, West	r 37,132	r 29,764	r 4,333	33,904	25,828	3,966
India	17,244	12,991	1,300	42,188	32,241	3,118
Italy	1,051	841	203	2,169	1,782	442
Japan	904	723	178	6,436	5,063	1,153
Netherlands	3,874	2,874	359	------	------	------
Norway	2,394	1,888	290	2,339	1,830	217
South Africa, Republic of	r 42,946	r 33,314	r 4,119	113,846	88,972	12,096
Spain	5,747	4,480	646	------	------	------
Sweden	10,493	8,802	2,120	14,341	12,031	2,916
United Kingdom	11,399	8,564	1,010	------	------	------
Western Africa, n.e.c. [1]	------	------	------	12,975	10,120	1,162
Total	r 203,212	r 158,304	r 21,178	301,956	234,563	31,708

r Revised. Yugoslavia revised to none.
[1] Probably originated in Republic of South Africa.

Silicomanganese imports for consumption were 32,040 short tons containing 21,337 tons of manganese. Sources and tonnage (gross weight) were as follows: Norway, 20,782; Yugoslavia, 4,385; Mexico, 2,755; Canada 2,616; Republic of South Africa, 1,118; and France, 384. Imports for consumption classified as unwrought manganese metal, except alloys, and waste and scrap of such metal, totaled 1,371 short tons, compared with 3,183 tons in 1968. In 1969, the Republic of South Africa supplied 1,271 tons and Japan supplied 10 tons of manganese metal. Except for less than a half ton of high unit value from the United Kingdom, the remaining 90 tons was from Canada with a unit value somewhat more than half that of the South African and Japanese metal.

Imports for consumption classified as "manganese compounds, other" totaled 2,160 tons in 1969, compared with 3,059 tons in 1968. The sources, gross weights, and values per pound in 1969 were as follows: Japan, 1,778 tons (15.1 cents); United Kingdom, 342 tons (6.4 cents); and Belgium-Luxembourg, 40 tons (14.4 cents). The imports from Japan and Belgium-Luxembourg appear to have consisted largely, if not entirely, of synthetic manganese dioxide.

WORLD REVIEW

Argentina.—Approximately 10 short tons of rhodochrosite having a value of $27,616 were exported in 1968, compared with approximately 15 tons valued at $30,619 in 1967. The United States took 1 ton in 1968 and 5½ tons in 1967.

Belgium.—Soc. Europeene des Derives du Manganese (SEDEMA) announced plans for expansion that should bring its production of synthetic manganese dioxide at Tertre to 12,500 tons per year by 1970 from a current rate of approximately 10,000 tons. SEDEMA's operation is based on the chemical process of Manganese Chemicals Corp., Baltimore, Md. The later's one-third interest in SEDEMA was sold in 1967 to Belgian partners. Various oxides of manganese, manganese sulfate, and various carbonates of manganese are produced in addition to the synthetic manganese dioxide, which is marketed under the trade name Faradiser M.

Table 9.—World production of manganese ore by countries [1]

(Short tons)

Country	Percent Mn [e]	1967	1968	1969 [p]
North America:				
Mexico [2]	35+	75,444	65,420	158,252
United States	35+	12,585	11,378	5,630
South America:				
Argentina	30−	[r] 11,220	4,344	NA
Do	30–40	[r] 29,052	29,829	NA
Brazil	38–50	[r] 1,325,260	1,852,195	[e] 2,166,260
Chile	41–47	16,356	26,283	26,124
Guyana	36–42	196,820	144,138	----------
Peru	34–42	[r] 1,284	7,885	8,022
Europe:				
Bulgaria	30+	[r] 48,500	45,000	[e] 45,000
Greece	50	8,501	[e] 9,000	7,037
Hungary	30−	[r] 230,000	172,000	[e] 172,000
Italy	30−	51,917	56,020	58,385
Portugal	38–42	10,838	10,652	[e] 8,300
Rumania [e]	35	88,000	88,000	88,000
Spain	30+	[r] 9,332	14,248	25,302
U.S.S.R. [3]	NA	7,909,000	7,236,000	[e] 7,700,000
Yugoslavia	30+	10,826	[e] 15,750	13,593
Africa:				
Angola	35+	36,575	10,086	32,044
Botswana	30+	----------	4,282	24,769
Congo (Kinshasa)	42+	299,427	354,735	343,291
Gabon	50–53	1,264,350	1,381,819	1,502,449
Ghana [4]	48+	549,379	455,617	385,476
Ivory Coast	32–47	164,721	128,685	140,036
Morocco	35–53	315,413	176,602	143,935
South Africa, Republic of	30+	2,002,513	2,173,438	2,429,599
Sudan	36–44	2,750	[e] 5,500	940
United Arab Republic	30−	83,000	4,361	NA
Zambia	35+	27,522	27,962	[e] 27,500
Asia:				
China, mainland [e]	30+	770,000	990,000	1,100,000
India	32–53	1,752,000	1,766,000	1,769,000
Indonesia	35–49	[e] 11,000	[e] 11,000	NA
Iran [5]	35+	46,000	13,000	39,000
Japan	30–43	373,672	344,247	332,606
Korea, South	35+	7,982	4,653	3,199
Malaysia	30–40	93,812	49,737	NA
Philippines	30+	95,331	72,800	22,048
Thailand	40+	86,603	45,270	32,872
Turkey	30–50	[r] 19,078	27,944	14,582
Oceania:				
Australia	46	[r] 627,164	822,177	1,016,185
Fiji	40–50	4,883	9,429	22,917
New Hebrides	49–55	80,189	[e] 60,000	----------
Total [6]		[r] 18,748,299	18,727,486	19,864,353

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.
[1] Czechoslovakia and Sweden produce about 90,000 and 13,000 tons annually of lowgrade ore (13-17 percent Mn). Cuba and South West Africa also produce manganese ore but quantities are not available.
[2] Estimated on basis of reported contained manganese.
[3] Grade unreported. Source: The National Economy of the U.S.S.R., Central Statistical Administration (Moscow).
[4] Dry weight.
[5] Iranian calendar year beginning April 1; 1967 and 1969 mine run, 1968 concentrated ore.
[6] Totals are of listed figures only.

Brazil.—Termoligas-Metalúrgicas S.A., a joint venture of Brasimet-Comércio e Indústria S.A. and Cia. de Ferro-Ligas da Bahia S.A., started production at its new ferroalloy plant. Refined ferromanganese was among the alloys to be included in the output of the plant, which has a capacity of 1,550 tons. Electro-Siderúrgica Brasileira S.A. was erecting a ferroalloy plant at Aratu, Bahia, which was expected to be the largest in Latin America. Scheduled for completion in September, it was to have an initial capacity of 40,000 to 45,000 tons per year of ferromanganese and ferrosilicon, with plans for later expansion.[2]

Indústria e Comércio de Minerios S.A. (ICOMI) awarded a $5 million contract in August to Arthur G. McKee & Co., Cleveland, Ohio, for construction of a plant to

[2] Metal Bulletin (London). No. 5421, Aug. 5, 1969, p. 18.

produce 259,000 short tons of manganese ore pellets annually at Santana, Amapá Territory, from Serra do Navio ore fines. Roasting and concentrating units will be included in the facility, which will be the world's first commerical pellet plant for manganese ore. Work was to begin immediately with completion expected within 2 years. ICOMI is owned 51 percent by Cia. Auxiliar de Empresas de Mineração (one of the Antunes mining interests of Brazil) and 49 percent by Bethlehem Steel Corp.

On October 21, a new sole tax on minerals became effective. For manganese ores this was 7 percent of the base value or cost. Proceeds from the tax will have the following distribution: 10 percent to the Union, 70 percent to the State or Federal District from which the mineral was mined, and 20 percent to the municipality of origin.

In 1969, Amapá produced 2,103,000 short tons of mine run ore; the manganese content averaged less than 40 percent manganese. The washed ore product was 1,597,700 tons of ore averaging approximately 48 percent manganese. At the Urucum mine in Mato Grosso, production was 83,600 tons averaging 45.38 percent manganese; the Meridional mine in Minas Gerais produced 138,534 tons having an average grade of 38.27 percent manganese.

Chile.—Manganese ore produced in 1969 averaged 41.75 percent manganese.

Congo (Kinshasa).—Production of manganese ore in 1969 averaged 50.8 percent manganese.

Fiji.—Southland Mining Ltd., an Australian company, was raising $1 million to finance a manganese mining operation in Fiji having 100,000 tons per year production as its objective. Part of the funds will be used to improve ship loading facilities at Lautoka. Measured reserves in the western part of Viti Levu were estimated to consist of 115,000 short tons of dioxide ore containing 72 to 95 percent manganese dioxide and 645,000 tons of siliceous ore; inferred reserves were estimated at 230,000 tons of dioxide ore and 860,000 tons of siliceous ore. The only present operator in Fiji, Akhil Holdings Ltd., has produced more than 135,000 tons of ore since 1955. Of this quantity, 35,000 tons were of the 80-percent-manganese-dioxide grade.[3] In 1968, Fiji exports of manganese ore totaled 12,146 short tons consisting partly of 80-percent-manganese-dioxide ore and partly of 50-percent-manganese ore. These ores were exported to Japan.

Germany, West.—Knapsack A.G., a subsidiary of Farbwerke Hoechst A.G. and one of two European sources, reportedly had capacity to produce approximately 10,000 tons of synthetic manganese dioxide per year. An electrolytic process was employed.[4]

India.—It was reported that nine Japanese steel mills had agreed to buy 270,000 tons (presumably metric) of ferruginous manganese ore during 1969 at an f.o.b. price of $10.57 per ton.[5] Much of the manganese ore reported as exported in 1968 and 1969 was ferruginous manganese ore, or manganiferous iron ore containing only 10 percent manganese. Reported exports of manganese ore in 1969 were 1,305,000 short tons compared with 1,317,000 tons in 1968. Of the ore exported in 1969, Japan took 71 percent. Belgium was next in size of receipts at 6 percent, followed in decreasing order by the United States, Czechoslovakia, Norway, France, Netherlands, Rumania, Spain, and the United Kingdom. The continued closure of the Suez Canal with resulting high ocean freight rates, as much as 50 percent above those of 1967, low market prices, high port charges, inadequate port facilities, continuing export duties, and problems in transporting the ore long distances from mine to port, all contributed to difficulties in meeting competition in world markets. Domestic consumption of manganese ore in 1969 totaled 815,000 tons, of which 365,000 tons was used for the production of ferromanganese, 440,000 tons by the iron and steel industry, and 10,000 tons for the production of dry cell batteries.

Seven companies produced ferromanganese in 1969 as follows (short tons):

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[3] Mining Journal (London). V. 272, No. 6962, Jan. 24, 1969, p. 81.
World Mining. V. 5, No. 3, March 1969, p. 49.

[4] Industrial Minerals (London). No. 17, February 1969, p. 22.

[5] Mining Journal (London). V. 272, No. 6966, Feb. 21, 1969, p. 167.

Producer	Location	Capacity	Production
Ferro-Alloys Corp. Ltd	Andhra Pradesh	48,000	47,634
Khandelwal Ferro-Alloys Ltd	Maharashtra	40,000	39,430
Universal Ferro and Allied Chemicals, Ltd	do	40,000	35,712
Tata Iron & Steel Co., Ltd	Orissa	33,000	29,112
Jeypore Sugar Co., Ltd	do	26,500	20,970
Electro Metallurgical Works (P) Ltd	Mysore	13,500	9,967
Mysore Iron & Steel, Ltd	do	3,000	1,944
Total		204,000	184,769

Total production in 1968 was 161,819 short tons. Most of the ferromanganese produced was the standard high-carbon grade. Of the producers, all were private sector companies except Mysore Iron & Steel, Ltd., which is owned by the state of Mysore. Domestic ferromanganese consumption was approximately 80,000 tons. Exports totaled 101,422 tons with the United States taking 35,600 tons, Japan 26,300 tons, Sweden 17,600 tons, Yugoslavia 10,750 tons, and 11 other countries receiving smaller quantities. Exports in 1968 totaled 80,821 short tons. With production costs reportedly exceeding the world market price of ferromanganese, the Government of India for the past 2 years has granted a cash subsidy of $20 per metric ton on all ferromanganese exported through its Minerals and Metals Trading Corp., the agency through which virtually all of the manganese ore continues to be exported. The result has been a significant increase in ferromanganese exports. In addition, plant expansions were under way to meet an expected domestic consumption of approximately 165,000 tons by 1975, and to permit additional exports.

Italy.—Manganese ore production in 1969 had an average manganese content of 28 percent.

Japan.—Production of dioxide ore concentrates was 2,448 short tons in 1969 averaging 77.6 percent manganese dioxide, and 3,515 tons in 1968 averaging 68.0 percent manganese dioxide. Metallurgical ore concentrates produced in those 2 years averaged 29.8 and 30.0 percent manganese, respectively. Production of ferromanganese for the 2 years was, respectively, 421,000 tons and 380,000 tons; electrolytic manganese metal, 7,956 tons and 7,756 tons; and synthetic manganese dioxide, 41,800 tons and 35,800 tons. Most of the synthetic manganese dioxide was produced for export.

Morocco.—Soc. Anonyme Chérifienne d'Etudes Minierès (SACEM) planned to build a new beneficiation plant at the Imini mine with the objective of increasing production of chemical grades of ore and possibly eventually discontinuing the production of metallurgical ore.[6] Moroccan production of chemical-grade ore, probably all from Imini, was 132,000 short tons in 1969 at an average grade of 82 percent manganese dioxide, compared with 81,000 tons of the same grade in 1968. This was a drop in grade from the 84 percent reported for 1967. Sinter produced in 1969 totaled 34,000 tons made from 43,000 tons of metallurgical ore, most of which apparently came from stocks. In 1968, there were 68,000 tons of sinter produced from 85,000 tons of metallurgical ore. This quantity of ore is included in the 1968 data shown on table 9. Poland received 58,000 tons of the 67,000 tons of sinter exported in 1968, with most of the remainder going to France. In the first 9 months of 1969, Czechoslovakia took more than half of the 24,000 tons exported. Of total chemical-grade manganese ore exports amounting to 87,000 tons in 1968, the United States took 29,000 tons, France took 21,000 tons, and the remainder was divided among more than 15 other countries. In 1967, the United States took 36,000 tons out of a total of 77,000 tons of chemical-grade ore exported.

Manganese ore production at Tiouine was virtually at a halt in 1969, apparently awaiting completion of a beneficiation plant to be built there by the Hungarian organization, NIKEX, under an agreement signed in October 1967 with the Bureau de Recherches et de Participations Minières (BRPM). In June 1969, it was reported that materials and equipment for the project were being delivered.

New Hebrides.—The only manganese producer, the Forari mine of Cie. Française des Phosphates de l'Oceanie ceased operations in December 1968. In subsequent developments leading to reopening the mine,

[6] Industrial Minerals (London). No. 23, August 1969, pp. 32–33.

Southland Mining Ltd., an Australian company interested in mining manganese ore in Fiji, acquired a 50-percent interest in Le Manganese de Vaté, a company or syndicate which had acquired the mine early in 1969. After modernization of the existing beneficiation plant, it was expected that production would be resumed in the first half of 1970 at a rate of 60,000 tons per year in order to supply a contract with Japanese buyers. Ore reserves were estimated to be 300,000 tons containing 42 percent manganese.[7]

Peru.—Manganese ore produced in 1969 averaged 36.5 percent manganese. The Gran Bretaña mine, owned by the San Martin family and M.A. Cavagnaro but working under the supervision of the Banco Minero del Peru, probably continued to be the only producer. It is located at an elevation of 13,500 feet in the Province of Jauja, Department of Junin, in the central region of the country. The Toho Zinc Co., Japan, has taken a 1-year option to buy a 70-percent interest in the mine as a source of zinc and lead concentrates. Although operated historically as a manganese mine, zinc concentrates have occasionally been produced in the past 2 years.

Philippines.—Of the manganese ore produced in 1969, 14,000 short tons averaged 48 percent manganese; the remainder had an average grade of 34 percent manganese. Gregorio T. Lluch Co. produced 4,700 short tons, and the Sierra Madre project of Acoje Mining Co., Inc., provided the balance. Lluch's production was 23 percent less than that reported for 1968, and Acoje's production dropped in the course of phasing out its operation. Philippine production of ferromanganese was 40 tons in 1969; silico-manganese production was 97 tons.

South Africa, Republic of.—Exports of metallurgical ore in 1969 were 1,917,000 short tons, compared with 1,579,000 tons in 1968, and 1,442,000 tons in 1967; chemcial ore exports in 1969, 1968, and 1967 were 11,650, 14,500, and 15,500 tons, respectively; manganiferous ore exports (containing 15 to 30 percent manganese and 20 to 35 percent iron) in 1969, 1968, and 1967 were 179,000, 329,000 and 140,000 tons, respectively. Of the chemical ore produced in 1969, 54,000 tons contained 35 to 65 percent manganese dioxide, 15,700 tons contained 65 to 75 percent manganese dioxide, and none was produced of the 75 to 85 percent grade. Local sales were 74,600 tons of the 35 to 65 percent grade, and 2,590 tons of the 65 to 75 percent grade. Production of metallurgical ore in 1969 was as follows: 30 to 40 percent manganese, 1,466,000 tons; 40 to 45 percent manganese, 172,400 tons; 45 to 48 percent manganese, 146,000 tons; and over 48 percent manganese, 571,000 tons. Local sales of metallurgical ore by the various grades respectively were 606,000, 1,260, 121,000, and 117,000 tons Manganiferous ore production was 484,000 tons in 1969; 502,000 tons in 1968; and 313,000 tons in 1967. Respective local sales were 12,100, 5,460, and 420 tons.

Spain.—The manganese ore produced in 1969 had an average manganese content of 32.7 percent.

Thailand.—After investigation of the manganese deposits of northeastern Thailand in the period of 1963–66, the conclusion was reached that it was improbable that a large deposit would be found, although the possibility could not be entirely eliminated. Small-scale mining of chemical-grade ore has been done in the region, but these mines have now been worked out or otherwise abandoned. Mining of this type could be resumed at a favorable price for chemical ore. Manganese occurs as oxides, and at some localities as veins of rhodochrosite. The oxides occur principally as pods and fracture coatings in porous, or weathered-brecciated, sediments and metasediments to depths of 15 feet, but oxide veins are also found.[8] Production of battery-grade manganese ore (75 percent manganese dioxide) in Thailand was 4,700 short tons in 1969, compared with 6,500 tons in 1968, and 10,000 tons in 1967. In 1969, Thailand also produced 127 tons of chemical-grade ore containing 75 percent or more manganese dioxide. None of this grade was produced in the previous 2 years. Exports of battery-grade ore were 2,400 tons in 1969 and 4,100 tons in 1968; metallurgical ore exports were 10,000 tons and 44,400 tons in 1969 and 1968, respectively. Japan has accounted for most of Thailand's sales of manganese ore. The metallurgical ore produced in 1969 contained 46 to 50 percent manganese.

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[7] Mining Journal (London). V. 273, No. 6998, Oct. 3, 1969, p. 303.

[8] Jacobson, Herbert S., Charles T. Pierson, and others. Mineral Investigations in Northeastern Thailand. U.S. Geol. Survey Prof. Paper 618, 1969, pp. 58–63.

United Kingdom.—British Steel Corp. (BSC) will double its capacity to produce standard high-carbon ferromanganese at its Cleveland Works by converting the No. 5 blast furnace from one designed for production of pig iron to one for production of ferromanganese. This will be done primarily by improving the furnace's gas-cleaning equipment so that the very fine dust generated in producing ferromanganese can be handled satisfactorily. The general ancillary services for the furnace will be improved as well. At present, only the No. 1 furnace produces ferromanganese. Its output is 2,000 tons per week. Workington is the only other BSC works producing the alloy. When the change over at Cleveland is completed by September 1970, Cleveland will be ready to produce the bulk of the Corporation's ferromanganese.[9]

[9] Metal Bulletin (London). No. 5443, Oct. 24, 1969, p. 21.

TECHNOLOGY

Deepsea Ventures Inc., a subsidiary of Tenneco Inc., was formed in October 1968 to assume and pursue the deep sea mineral interests of Newport News Shipbuilding and Dry Dock Co., acquired by Tenneco in September of that year. From $5 million to $10 million was being invested for the exploration and development of mining and processing technology with the objective of an economical operation for the recovery of manganese and associated nickel, cobalt, and copper. In carrying on this work, Deepsea Ventures collected more than 40 tons of manganese nodules from the Blake Plateau, off the Georgia and Florida coasts, for metallurgical pilot-plant tests. Development of a hydraulic suction dredging system capable of working to depths of 18,000 feet was well advanced, with its prototype scheduled for tests off the Florida coast in mid-1970 at a projected recovery rate of 350 to 400 tons of nodules per day from a 3,000-foot depth of water. Tests of the suction dredging system were conducted sucessully in 1969 from a depth of 750 feet in a flooded mineshaft. During the year, the company's research vessel "Prospector" was engaged in extensive exploration and evaluation of deposits lying on both the Atlantic and Pacific sea floors, surveying in detail to establish continuity and concentrations that might be suggestive of possible commerical mining sites. A 1973 target was tentatively set for recovery of nodules commerically from the Pacific floor where they are of higher tenor than are those of the Atlantic. A consortium capable of investing $100 million to $200 million has been visualized as the requirement for accomplishing this objective.

Other companies that continued to be seriously interested in investigating the possibilities for deep sea mining of manganese nodules included Bethlehem Steel Corp., The International Nickel Co., Kennecott Copper Corp., Union Carbide Corp., and United States Steel Corp.

Mercury

By J. M. West [1]

The price of mercury (New York) dipped below $500 per flask [2] in the first part of the year, and although it rebounded above this mark several times during the year, the trend was clearly downward. U.S. production of mercury increased only 2 percent in 1969; imports for consumption jumped 37 percent. Actual releases from Government stocks were much lower than in 1968, but large quantities either were made available through interagency transfer for gradual sale or were under consideration for future release from the Government's strategic stockpiles as a result of changed objectives. Secondary mercury provided a lesser share of the total supply—about 17 percent in 1969 compared with 46 percent in 1968, chiefly as a result of decreased sales by the General Services Administration (GSA). World supplies of new mercury were higher, with significant increases in Spanish, Canadian, and Mexican production.

Table 1.—Salient mercury statistics

	1965	1966	1967	1968	1969
United States:					
Producing mines	149	130	122	87	109
Production flasks	19,582	22,008	23,784	28,874	29,360
Value thousands	$11,176	$ 9,722	$11,639	$15,464	$14,828
Exports flasks	7,543	357	2,627	7,496	507
Reexports do	494	476	475	103	108
Imports:					
For consumption do	16,238	31,364	24,348	23,246	31,924
General do	17,838	34,757	23,899	23,956	30,848
Stocks Dec. 31 do	20,386	20,076	18,277	22,907	20,390
Consumption do	73,560	71,509	69,517	75,422	79,104
Price: New York, average per flask	$570.75	$441.72	$489.36	$535.56	$505.04
World:					
Production flasks	267,873	264,994	232,073	258,051	285,343
Price: London, average per flask	$607.85	$447.68	$499.36	$546.80	$536.41

Questions about mercury pollution of the environment were raised, and instances of mercury poisoning of domesticated animals, of fish and of wildlife were under investigation. In Sweden, mercury contamination was considered to be one of the leading pollution issues.[3]

Treasure hunters were at work in 1969 attempting to recover a sizable cache of mercury believed to have sunk with a river boat many years ago in the Missouri River.[4] Several flasks were reported recovered after extensive search.

Legislation and Government Programs.—Government financial assistance on a participatory basis was available, as before, for mercury exploration projects to the extent of 75 percent of the acceptable costs. Repayment was to be made at the annual rate of 5 percent royalty on production from the property. Such aid was available through the Office of Minerals Exploration, U.S. Geological Survey. Projects were limited during the year by a shortage of available funds, but several contracts and new applications were under review or being implemented.

[1] Physical scientist, Bureau of Mines, San Francisco, Calif.

[2] Flask as used throughout this chapter refers to the 76-pound flask.

[3] U.S. Embassy, Stockholm. State Department Airgram A-691, Oct. 31, 1969, 3 pp.

[4] San Francisco Chronicle. Missouri Discovery: Mercury Fortune From Lost Boat. July 15, 1969. p. 30.

Although Government stockpile objectives for mercury were dropped to 126,500 flasks in 1969, no disposal sales of surplus stockpile supplies were initiated and a new review of requirements was anticipated. The previous objective had been 200,000 flasks. Total stockpile accumulations from all programs stood at 200,093 flasks as of June 30, 1969.

Sales by the GSA of surplus mercury stocks obtained from the Atomic Energy Commission were resumed again in October 1969 after closing out earlier supplies in February. A total of 15,000 flasks was to be sold at maximum monthly offerings of 1,500 flasks. Actual sales from the new supplies totaled only 806 flasks as most bids during the remaining months of 1969 were rejected as too low. Total surplus sales for the year amounted to 3,077 flasks. Unsold stocks were carried over for sale in future months. Awards were made at prices per flask averaging $524.05 in January, $534.94 in February, $480.48 in October, $497.52 in November, and $510.00 in December.

Effective in taxable years beginning after October 9, 1969, the depletion allowance for mercury was cut from 23 to 22 percent for domestic deposits and 15 to 14 percent for foreign deposits, in accordance with the Tax Reform Act of 1969.

DOMESTIC PRODUCTION

First-year production from the Ruja mine, located adjacent to the Quinn River (Cordero) mine in Humboldt County, Nev., was largely responsible for a sharp increase in production from Nevada. Production of primary mercury from California declined, with the Nation's leading source, the New Idria mine, supplying significantly less than in 1968. Outputs of several other California mines, including the Gibraltar, Guadalupe, Abbott, and Culver-Baer, were higher, but increases failed to offset decreases at other mines. The El Capitan mine, in the Last Chance Range of eastern California, supplied much less mercury than in 1968, its first full year of operation, when it was one of the country's leading producers.

Output from Oregon was sharply lower because the Black Butte mine had ceased operations. In Texas, although production in 1969 was higher, the main source, the Study Butte mine, was expected to close about yearend because of the marginal ore grade, averaging 3.4 pounds of mercury per ton. Arizona production remained small and came from two mines.

In Idaho, the Idaho-Almaden mine continued operations with low-grade ore, averaging only about 1.25 pounds per ton in 1969. Alaskan mercury production rose; three mines were reported active in the Kuskokwim River region and one in the Bristol Bay region. The Red Devil mine remained under development, and facilities were scheduled for reactivation in early 1970, with forthcoming concentrate to be shipped in that form to a Japanese buyer. No production was reported in Washington, although there had been some in 1968.

The total number of operating mines in 1969 rose to 109, with most of the increase accountable to California and Nevada producers of less than 100 flasks. The number of producers reporting outputs of 1,000 flasks or more rose to 11; those reporting 500 to 1,000 flasks declined to 3; and those reporting 100 to 500 flasks declined to 15. Of the total production, 76.5 percent came from producers of 1,000 flasks or more, 6.5 percent from producers of 500 to 1,000 flasks, and 12.7 percent from producers of 100 to 500 flasks. Principal mines in 1969 were as follows:

State	County	Mine
Properties Producing 1,000 Flasks or More		
California	San Luis Obispo	Buena Vista.
Do	Marin	Gambonini.
Do	Santa Barbara	Gibraltar.
Do	Santa Clara	Guadalupe.
Do	Sonoma	Mt. Jackson.
Do	San Benito	New Idria.
Idaho	Washington	Idaho-Almaden.
Nevada	Esmeralda	B & B.
Do	Humboldt	Quinn River (Cordero).
Do	Do	Ruja.
Texas	Brewster	Study Butte.

State	County	Mine
Properties Producing 500 to 1,000 Flasks		
California	Lake	Abbott.
Do	Sonoma	Culver-Baer.
Nevada	Pershing	Goldbank.
Properties Producing 100 to 500 Flasks		
Alaska	Kuskokwim River Region	Cinnabar Creek.
Do	Kuskokwim River Region	White Mountain.
California	Trinity	Altoona.
Do	Marin	Chileno Valley.
Do	Napa	Corona.
Do	Inyo	El Capitan.
Do	Colusa	Juniper.
Do	San Luis Obispo	Klau.
Do	Napa	Knoxville.
Do	Santa Clara	New Almaden.
Do	Napa	Oat Hill.
Do	Colusa	Petray.
Nevada	Humboldt	Cahill.
Do	Pershing	Horton's Mercury.
Do	Nye	Ione Mercury.

Table 2.—Mercury produced in the United States, by States

Year and State	Producing mines	Flasks	Value [1] (thousands)
1968			
Arizona	3	192	$103
California	53	21,417	11,470
Nevada	17	4,780	2,560
Oregon	6	938	502
Alaska, Idaho, Texas, Washington	8	1,547	829
Total	87	28,874	15,464
1969			
California	72	18,480	9,333
Idaho	1	1,012	511
Nevada	24	8,165	4,124
Oregon	4	43	22
Alaska, Arizona, Texas	8	1,660	838
Total	109	29,360	14,828

[1] Value calculated at average New York price.

Table 3.—Mercury ore treated and mercury produced in the United States [1]

Year	Ore treated (short tons)	Mercury produced	
		Flasks	Pounds per ton of ore
1965	339,124	19,353	4.3
1966	321,080	21,993	5.2
1967	439,753	23,767	4.1
1968	r 434,193	28,857	5.1
1969	432,591	28,552	5.0

r Revised.
[1] Excludes mercury produced from old surface ores, dumps, and placers.

Secondary production of mercury declined in consonance with lower Government releases, which were included as part of the figures. Other sources, such as battery scrap, dental amalgams, and various types of sludges contributed to the secondary recoveries.

Table 4.—Production of secondary mercury in the United States

Year	Flasks [1]
1965	46,670
1966	16,400
1967	22,150
1968	34,380
1969	13,650

[1] Includes GSA releases.

CONSUMPTION AND USES

Electrolytic preparation of chlorine and caustic soda continued to require increasing quantities of mercury, both for that lost in processing and that going into initial startup requirements of new plants. According to the Chlorine Institute, Inc., mercury cells in the United States accounted for 27.9 percent of the total installed chlorine capacity in 1969. This was low compared with the Canadian ratio of

56.8 percent in mercury cells. The total U.S. chlorine capacity in 1969 was 25,124 short tons per day, according to preliminary figures, representing an 8-percent increase over the 1968 capacity. Thus, about 7,000 tons of chlorine capacity per day was available in plants using mercury cells. In a technical development that might alter the trend toward increased mercury consumption for the previously stated purposes, it was announced that a new dimensionably stable anode made of specially coated titanium had been devised that would make the use of diaphragm-type cells more attractive again.[5] In addition to lasting longer, the anode was expected to increase capacity when placed in existing cells, was reported to be applicable to both mercury and diaphragm-type cells, and to reduce power requirements by several percent.

A unique use for mercury featured an 11-ton (about 290 flasks) pool of the metal to provide frictionless support for floating the optical assembly of a telescope.[6] A mercury-fueled ion engine, providing thrust of about six thousandths of a pound, was scheduled for testing in an earth-orbiting spacecraft.[7] Consumption of mercury for such propulsion was expected to be minimal. Technical details were reported elsewhere.[8] A study was completed on uses and projected consumption of mercury through 1975, when annual consumption was expected to have grown to about 83,500 flasks.[9] Battery and other applications of mercury were discussed and a "Buyers' Guide to Suppliers of Mercury," arranged by products sold and including scrap mercury buyers, was published.[10]

Consumers were told of the availability of a new type of plastic container that could substitute for traditional metal flasks.[11] Weight savings of about 5 pounds per flask were estimated, but the cost could be two to three times that of the metal flask, depending upon volume ordered.

[5] Chemical Week. The Challenge to Graphite Anodes, V. 104, No. 7, Feb. 15, 1969, pp. 40–46.

[6] Government Executive. Big Eye: Closer Look at Old Sol. November 1969, p. 16.

[7] American Metal Market. Mercury Ion Engine Will Be Tested on Lockheed Agena. Mar. 26, 1969, p. 22.

[8] Byers, David C. An Experimental Investigation of a High Voltage Electron-Bombardment Ion Thruster. J. of the Electrochem. Soc., v. 116, No. 1, January 1969, pp. 9–17.

[9] National Materials Advisory Board. Trends in Usage of Mercury. NMAB-258, September 1969, 37 pp.

[10] American Metal Market. Mercury Supplement, Section 2, July 28, 1969, pp. 1A–8A.

[11] Metals Week. More On the 2-lb Surlyn Flask. V. 40, No. 29, July 28, 1969, p. 23.

Table 5.—Mercury consumed in the United States by uses

(Flasks)

Use	1965	1966	1967	1968	1969
Agriculture (includes fungicides and bactericides for industrial purposes)	3,116	2,374	3,732	3,430	2,689
Amalgamation	268	248	219	267	195
Catalysts	924	1,932	2,489	1,914	2,958
Dental preparations [1]	1,619	1,334	1,359	2,089	3,053
Electrical apparatus [1]	16,097	16,257	14,610	17,484	18,650
Electrolytic preparation of chlorine and caustic soda	8,753	11,541	14,306	17,453	20,720
General laboratory use:					
Commercial	1,119	1,563	1,133	1,246	2,041
Industrial and control instruments [1]	4,628	4,097	3,865	3,935	6,981
Paint:					
Antifouling	255	140	152	392	244
Mildew proofing	8,211	8,280	7,026	10,174	9,486
Paper and pulp manufacture	619	612	446	417	558
Pharmaceuticals	418	232	283	424	724
Redistilled [1]	12,131	7,267	7,334	8,252	(2)
Other [3]	15,402	15,632	12,563	7,945	9,689
Total known uses	73,560	71,509	69,517	75,422	77,988
Total uses unknown	------	------	------	------	1,116
Grand total	73,560	71,509	69,517	75,422	79,104

[1] A breakdown of the "redistilled" classification showed averages of 47 percent for instruments, 13 percent for dental preparations, 23 percent for electrical apparatus, 10 percent for general laboratory, and 7 percent for all other uses in 1965–68.

[2] In 1969 "redistilled" mercury is broken down and included in the categories for which it is used.

[3] Includes mercury used for installation and expansion of chlorine caustic soda plants.

Table 6.—Mercury consumed in the United States in 1969
(Flasks)

	Primary	Redistilled	Secondary	Total
Agriculture [1]	2,689	-----	-----	2,689
Amalgamation	194	1	-----	195
Catalysts	2,235	144	579	2,958
Dental preparations	214	1,422	1,417	3,053
Electrical apparatus	13,260	3,855	1,535	18,650
Electrolytic preparation of chlorine and caustic soda	19,263	-----	1,457	20,720
General laboratory use	1,232	555	254	2,041
Industrial and control instruments	2,832	3,484	665	6,981
Paint:				
Antifouling	244	-----	-----	244
Mildew proofing	9,486	-----	-----	9,486
Paper and pulp manufacture	558	-----	-----	558
Pharmaceuticals	360	364	-----	724
Other	8,427	81	1,181	9,689
Total known uses	60,994	9,906	7,088	77,988
Total uses unknown	134	107	875	1,116
Grand total	61,128	10,013	7,963	79,104

[1] Includes fungicides and bactericides for industrial purposes.

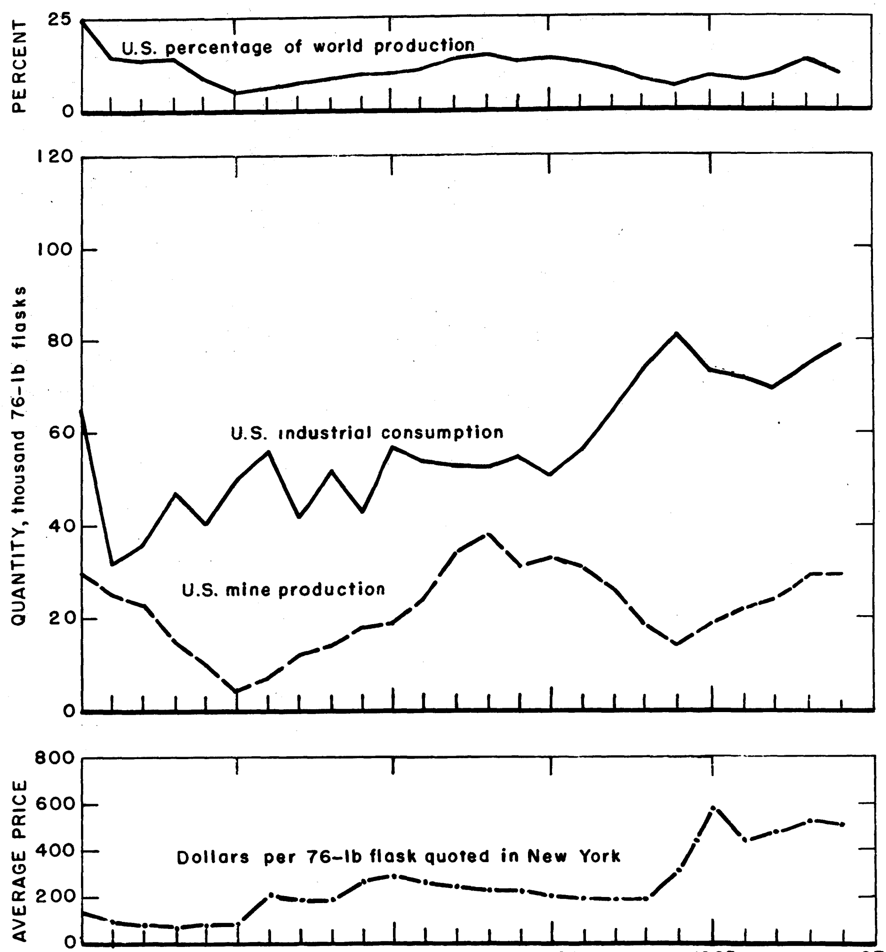

Figure 1.—Trends in production, consumption, and price of mercury.

Table 7.—Stocks of mercury, December 31
(Flasks)

Year	Producer	Consumer and Dealer	Total
1965	1,432	18,954	20,386
1966	1,976	18,100	20,076
1967	757	17,520	18,277
1968	1,059	r 21,848	r 22,907
1969	2,640	17,750	20,390

r Revised.

PRICES

Mercury prices declined during 1969, averaging $505.04 per 76-pound flask on the New York market. Despite the drop, this average ranked as the third highest of record. Only the averages for 1965 and 1968 were higher. Monthly price averages ranged from $483.91 to $537.26 per flask, New York. The annual average on the London market was $31.37 higher.

Table 8.—Average monthly prices of mercury at New York and London
(Per flask)

Month	1968		1969	
	New York [1]	London [2]	New York [1]	London [2]
January	528.32	536.02	528.18	532.29
February	571.70	597.49	537.26	533.28
March	571.33	587.93	520.48	533.34
April	555.57	566.82	500.95	533.67
May	536.91	561.47	516.24	532.19
June	510.00	524.62	495.00	532.87
July	502.64	518.63	499.32	533.05
August	517.14	523.66	485.24	531.92
September	541.85	540.75	491.10	524.47
October	539.74	545.34	483.91	526.32
November	520.42	532.63	506.89	560.13
December	531.05	526.90	495.95	563.36
Average	535.56	546.80	505.04	536.41

1 Metals Week, New York.
2 Mining Journal (London) and Metal Bulletin (January–July) prices in terms of pounds sterling were converted to U.S. dollars by using average rates of exchange recorded by Federal Reserve Board.

FOREIGN TRADE

Exports of mercury fell sharply from those in 1968 when the U.S. Agency for International Development was a factor in export sales. Shipments in 1969 went to the Republic of Korea (229 flasks), Canada (99 flasks), and to 32 other countries. Reexports from bonded U.S. warehouses remained small.

Table 9.—U.S. exports and reexports of mercury

Year	Exports		Reexports	
	Flasks	Value (thousands)	Flasks	Value (thousands)
1967	2,627	$1,281	475	$193
1968	7,496	3,951	103	54
1969	507	294	108	57

Imports for consumption rose 37 percent, an increase of 8,678 flasks, with Canada replacing Spain as the principal source. The Mexican and Italian shares of total imports rose sharply from those in 1968; imports from Yugoslavia continued to decline. Ghana was listed as the source of 107 flasks, although that country had not been known as a producer before. Peru dropped from the list of U.S. suppliers, shipping mostly to Japan instead.

Included in imports were waste and scrap mercury coming principally from Canada but also from Ghana, the United Kingdom, and Mexico. Waste and scrap imports totaled 23 short tons valued at $101,170. Based on dollar values, it was estimated these imports probably contained about 200 flasks of mercury. Also, mercury ore was imported from Bolivia, Peru, and Mexico. The ore, totaling 36 short tons, was valued at $13,600 and probably contained about 30 flasks of mercury.

The U.S. rate of duty on mercury imports dropped from $15.20 per flask during the year to $12.92 per flask as of January 1, 1970, in accordance with provisions of the General Agreement on Tariffs and Trade.

Table 10.—U.S. imports for consumption [1] of mercury, by countries

Country	1967		1968		1969	
	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)
Argentina	------	------	142	$69	------	------
Bolivia	40	$18	20	10	11	$6
Canada	391	97	5,626	2,829	15,546	7,455
Chile	------	------	40	19	------	------
France	250	80	------	------	------	------
Ghana	------	------	------	------	107	4
Italy	r 4,091	r 1,831	r 252	r 119	5,041	2,520
Mexico	r 1,234	r 533	r 1,928	r 877	7,398	3,409
Netherlands	200	84	------	------	------	------
Peru	1,037	427	1,161	463	------	------
Philippines	550	238	------	------	------	------
Spain	r 13,470	r 5,837	12,900	6,218	2,602	1,216
Sweden	------	------	6	2	------	------
United Kingdom	------	------	------	------	388	186
Yugoslavia	3,085	1,408	1,171	558	831	411
Total	r 24,348	r 10,553	r 23,246	r 11,164	31,924	15,207

r Revised.
[1] Data include mercury imported for immediate consumption plus material withdrawn from bonded warehouses.

Table 11.—U.S. imports [1] of mercury, by countries

Country	1967		1968		1969	
	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)
Argentina	------	------	142	$69	------	------
Bolivia	40	$18	20	10	11	$6
Canada	391	97	5,626	2,829	15,546	7,455
Chile	------	------	40	19	------	------
France	250	80	------	------	------	------
Ghana	------	------	------	------	107	4
Italy	r 5,117	r 2,308	r 551	r 261	3,665	1,873
Mexico	r 1,260	r 546	r 2,339	r 1,076	7,398	3,409
Netherlands	200	84	------	------	------	------
Peru	1,037	427	1,161	463	------	------
Philippines	550	238	------	------	------	------
Spain	r 11,969	r 5,103	12,900	6,218	2,902	1,355
Sweden	------	------	6	2	------	------
United Kingdom	------	------	------	------	388	186
Yugoslavia	3,085	1,408	1,171	558	831	411
Total	r 23,899	r 10,309	r 23,956	r 11,505	30,848	14,699

r Revised.
[1] Data are "general" imports, that is, they include mercury imported for immediate consumption plus material entering the country under bond.

WORLD REVIEW

Algeria.—A reported 125-ton-per-day furnacing plant was scheduled to be in full production in early 1970 at the Ismail mercury deposit near Annaba. Ore reserves in the deposit were said to total 300,000 tons. Russian equipment was incorporated in the plant.

Canada.—Events leading to recent development of the Pinchi Lake mercury deposit in British Columbia were reviewed.[12] Operated by Cominco Ltd., the mine in

[12] Lang, A. H. Discovery of the Pinchi Lake Mercury Deposit. Can. Min. J., v. 90, No. 11, November 1969, pp. 45–46.

1969 was supplying near capacity requirements of the 800-ton-per-day flotation mill. About three-fourths of the mercury produced was destined for export to the United States. Silverquick Development Co., Ltd. continued to develop its open pit mercury mine near Gold Bridge, B.C., and expected to begin production at its 500-ton-per-day mill in early 1970. A large tonnage of low-grade ore was said to exist. Empire Mercury Corp., Ltd., also was developing a large, mainly low-grade, deposit in the same mining district and initiated a drilling program to explore below the 250-foot depth already probed. Highland Mercury Mines, Ltd., pursued plans to diamond drill its mercury property adjacent to the Pinchi Lake mine after intersecting what was considered a favorable showing of cinnabar in the Cache Creek formation.

Table 12.—World production of mercury, by countries
(Flasks)

Country	1967	1968	1969 p
Bolivia (exports)	r 100	134	68
Canada	------	e 5,000	e 20,000
Chile	184	513	275
China, mainland e	20,000	20,000	20,000
Colombia	210	362	344
Czechoslovakia	r 203	116	e 150
Ireland	------	------	420
Italy	48,066	52,215	48,733
Japan	4,617	5,084	5,599
Mexico [1]	r 14,417	17,202	22,500
Peru	r 3,135	3,119	3,360
Philippines	2,611	3,544	3,478
Rumania	190	e 203	e 200
Spain	49,227	57,262	64,406
Tunisia	292	309	e 320
Turkey	r 4,147	4,320	e 4,800
U.S.S.R. e	45,000	45,000	47,000
United States	23,784	28,874	29,360
Yugoslavia	15,890	14,794	14,330
Total [2]	r 232,073	258,051	285,343

e Estimate. p Preliminary. r Revised.
[1] Official figures as reported by Statistical Office, Secretary of Industry and Commerce, Mexico; overall production of mercury believed to be much higher.
[2] Total is of listed figures only.

A base-metal sulfide prospect in Southeastern Ontario, on the boundary of Frontenac and Lanark Counties about 50 miles Southwest of Ottawa, was reported to contain anomalous and possibly significant amounts of mercury occurring in tetrahedrite. The property was under development by Carndesson Mines, Ltd.

Chile.—The principal Chilean mercury producer, Compania Minera Tamaya, continued development at its several small mines.

Colombia.—Cia Minera Nueva operated its furnacing plant far below the 300-flask-per-month reported capacity in 1969. Company officials discussed with Nomura Mining Co. of Japan, a plan under which the latter would provide financing to develop Minera Nueva's deposits at Aranzazu, in Caldas Province, with repayment to be made in concentrates over a 10-year period.

Czechoslovakia.—The first mercury recovery plant in Czechoslovakia for processing mercury-bearing copper sulfide concentrates was scheduled to go into production in 1969. Capacity of the plant was believed to be about 1,000 flasks per year.

Ghana.—Cinnabar was identified in sulfide ores discovered in 1967 or 1968 in the Sampa area of Ghana. The country apparently became a small producer of mercury in 1969, as indicated by U.S. import statistics.

India.—Minerals & Metals Trading Corp. sought tenders for prompt shipment of 2,700 flasks of mercury for the Indian Government, mainly for use in chlorine and caustic soda manufacture and also in the drug industry.

Indonesia.—Nomura Mining Co. of Japan sent a survey mission to Indonesia to study a new discovery in Puruacarta and possible rehabilitation of the Tegoro mercury mines in nearby Sarawak (Malaysia). Recent mercury discoveries near the Sankaropi copper deposit in central Sulawesi were investigated by a U.S. firm.

Ireland.—From July through September 1969, the new distillation plant of Gortdrum Mines (Ireland) Ltd. treated 404 tons of mercury-bearing copper concentrate, producing 149 flasks of byproduct mercury. About 775 additional tons of concentrate was scheduled for treatment before yearend. The extraction plant and facilities were built at a cost of $1.5 million.

Italy.—The average grade of ore mined continued to decline, approaching 10 pounds of mercury per ton. Italian exports of mercury in the first 10 months of 1969 totaled 29,150 flasks, compared with 29,510 flasks during the same period of 1968. Italy imported about 340 flasks in the first 10 months of 1969. Late in the year the Italian Government concern, Instituto per la Recostruzione Industriale (IRI), purchased an approximate one-third interest in the country's leading mercury producer. Società Minerariá Monte Amiata, from the holding company, Sta. Finanziara di Participazioni Azionarie. Mercury producers maintained firm resistance throughout the year to lower sales prices, according to market reports.

Table 13.—Italy: Exports of mercury [1] by countries

(Flasks)

Destination	1967	1968	1969
Australia	745	508	(2)
Austria	---	15	(2)
Belgium-Luxembourg	100	(2)	(2)
Bulgaria	58	(2)	(2)
Denmark	90	(2)	(2)
France	1,303	51	1,410
Germany:			
East	2,502	2,883	6,393
West	3,706	2,602	4,908
Hungary	300	400	(2)
Israel	90	(2)	(2)
India	3,126	1,813	2,852
Japan	5,835	6,153	4,403
Netherlands	260	45	148
Poland	658	1,435	1,801
Rumania	301	189	348
South Africa, Republic of	101	31	(2)
Sweden	80	(2)	(2)
Switzerland	52	(2)	(2)
United Kingdom	8,792	7,133	5,883
United States	8,791	2,753	4,102
Other countries	41	8,662	1,813
Total	36,931	34,673	34,061

[1] Calculated from quantities reported in kilograms.
[2] Not reported; may be included under "Other countries."

Japan.—Japan supplemented its limited domestic supplies and continued to purchase mercury and cinnabar concentrates from a number of sources abroad. In 1968 metal imports totaled about 26,100 flasks and for the first 6 months of 1969, about 11,140 flasks. Domestic production for the fiscal year ending March 31, 1969 was 22 percent below that of the preceding year.

Mexico.—Confusion and uncertainty continued over the question of how much mercury is produced in Mexico. Official statistics provided only data on those portions that were taxed and for which export licenses had been granted. It was widely held, however, that sizable quantities were produced in addition to what was officially acknowledged. Gambosinos, or small independent producers, generally in remote areas away from close scrutiny, were considered a significant source of mercury bypassing official channels. Despite easing of regulations and reduced taxes, the trade in mercury from these sources appeared undiminished in 1969. Under rules that had been adopted in late 1968, the Mexicań producer was required to have a notice of shipment from a numbered series issued by the Government in order to store his mercury or move it to the nearest point of sale. The dealer purchasing the mercury had to pay the applicable tax, which then permitted him to obtain a transit invoice. Production and export taxes, which were cut in half at the beginning of 1968, constituted about 14 percent of the official mercury price.

The largest source of mercury was Queretaro State, followed by Durango, San Luis Potosi, and about 12 other States. Big Chief Mining Co., probably the largest single Mexican producer, considered a major expansion which would include a large flotation plant. Although estimates of overall Mexican production varied widely, it appeared that a figure somewhere between 30,000 and 35,000 flasks might find a consensus for the total output in 1969.

Philippines.—Palawan Quicksilver Mines, Inc. expanded operations, adding a fifth kiln to its furnace plant. Plant capacity reached 475 tons per day with the addition; ore treated was averaging from 2.75 to 3.00 pounds a ton, and ore reserves were revised upward to 1 million tons.

Spain.—Spain overcame some of its problems in mercury production and boosted output about 12 percent in 1969. Although less mercury was shipped to the United States, more went to European countries, and net shipments increased. Spain continued to supply East European countries, specifically Czechoslovakia, East Germany, Hungary, Poland, and Rumania.

Table 14.—Spain and Yugoslavia: Exports of Mercury,[1] by countries
(Flasks)

Destination	From Spain			From Yugoslavia		
	1967	1968	1969	1967	1968	1969
Australia	621	71	232	------	------	
Austria	------	------	------	------	11	
Belgium-Luxembourg	217	100	1,276	------	------	
Bulgaria	------	39	174			
Canada	951	400	261	------	------	
Czechoslovakia	2,852	4,253	3,480	------	290	
Finland	300	101	------	------	------	
France	4,266	3,151	1,915	------	------	
Germany:						
East	1,001	1,001	377	------	------	
West	10,220	11,709	13,865	2,089	2,077	
Hungary	901	901	986	------	------	
India	2,252	------	------	783	101	NA
Japan	4,180	5,284	783	------	------	
Netherlands	857	801	1,160	------	------	
Norway	------	50	------			
Poland	1,401	------	1,740	------	290	
Portugal	202	172	638	------	------	
Rumania	2,173	400	2,437	------	------	
South Africa, Republic of	NA	460	261	------	------	
Sweden	676	2,052	1,189	------	200	
Switzerland	25	20	58	------	210	
United Kingdom	2,502	1,621	7,716	3,132	3,301	
United States	14,536	10,336	2,900	5,716	5,646	
U.S.S.R	NA	------	145	2,900	2,030	
Other countries	390	53	352	58	16	
Total	50,523	42,975	41,945	14,678	14,172	NA

NA Not available.
[1] Calculated from quantities reported in kilograms.

Turkey.—About half of Turkish production in 1969 was from Etibank's Halikoys mine; the rest was produced by about eight private firms. Plans were underway to expand production, with construction of several new distillation plants in progress, but it appeared that output would fail to match previously announced growth projections.

United Kingdom.—During the first 9 months of 1969, imports of mercury into the United Kingdom amounted to 18,630 flasks compared with 13,950 flasks for the comparable period of 1968.

U.S.S.R.—Mercury was produced from the Shorbulakh mine in the Caucasus Mountains by underground methods. A second distillation complex was planned as a result of three new mercury discoveries in the nearby area. Capacity of the Kombinat mercury plant at Nikitovsk, in the Ukraine, was expanded.

Yugoslavia.—Mechanization of Yugoslavia's principal mercury mine, the Idria (Idrija) continued. Discovery of a promising new orebody at depth was reported and a long crosscut was said to have been driven to intersect it from lower workings of the Idria mine.

TECHNOLOGY

Further progress was made in geochemical exploration techniques for mercury deposits and for the trace mercury often associated with base-metal deposits. Two similar portable instruments were investigated: One measuring ultraviolet absorption directly, and the other modified with gold wool to remove interfering substances.[13] Tested on soil samples, the first instrument appeared satisfactory when the organic content of soils was low; the second was satisfactory for soils of varying organic content but gave results slower. Precision of mercury analyses with the

[13] Azzaria, L. M., and G. R. Webber. Mercury Analysis in Geochemical Exploration. Canadian Min. and Met. Bull., v. 62, No. 685, May 1969, pp. 521–530.

atomic absorption spectrophotometer was the subject of one paper.[14] The lower limit of detection by this technique was 0.05 micrograms of mercury. Using a 1 gram sample, a content as low as 50 parts per billion was detectable. The process was considered simple enough that two men could prepare and analyze several hundred samples per day. A U.S. Geological Survey report was released describing a new technique of detecting the presence of mercury in vapors either in the soil or in the atmosphere above a deposit.[15] Mercury content of 12 parts per billion was detectable in airborne tests. Research was conducted in a test area north of San Francisco by the California Division of Mines and Geology on mercury vapor sampling of soil using cardboard fitted over shallow holes for collecting the gas. Results were inconclusive. A process for assaying mercury at very low concentrations in soil was reported, using the reaction of mercury and iodine tribromide to form an iodide, followed by addition of crystal violet and a colorimetric test.[16] A bromine solution was used to trap mercury vapor from heated samples, which then was analyzed by treating with nitrosobenzene and ferryocyanide to form a purple test solution. The solution was then compared with a standard using a spectrophotometer.[17]

Genetic relationships of mercury deposits were studied and deposits classified by type according to the host rocks and other features.[18]

Assaying of mercury by the thiocyanate method was reviewed and step by step procedures given.[19] The use of an electric furnace having space for a number of sample tubes for simultaneous assay preparation also was described.

A hydrometallurgical extraction method was devised for treating mercury ores wherein a sodium hypochlorite solution at a pH between 4.5 and 9.5 is used to leach and dissolve the mercury; then the metal is adsorbed on activated carbon, followed by stripping and distillation.[20]

Chemical leaching research on mercury ores was conducted at several locations. At the Federal Bureau of Mines Reno (Nev.) Metallurgy Research Center, excellent recoveries were obtained in preliminary tests on mercury ores using chlorine and a weak acid leach followed by precipitation on iron filings and electrolysis. The possibility of applying the method to heap leaching processes recently developed for gold was under consideration.

In a new technique for purifying aluminum, mercury was added to form aluminum-mercury crystals which were melted in a molten salt bath, the mercury vaporized and condensed, and the purified aluminum separated from the bath for further cleansing.[21]

[14] Pyrih, Roman Z., and Ramon E. Bisque. Determination of Trace Mercury in Soil and Rock Media. Econ. Geol., v. 64, No. 7, November 1969, pp. 825–827.

[15] McCarthy, J. H., Jr. and Others. Mercury in Soil Gas and Air—A Potential Tool in Mineral Exploration. U.S. Geol. Survey Circ. 609, 1969, 16 pp.

[16] Chemical Engineering. Research. V. 47, No. 16, Apr. 14, 1969, p. 37.

[17] Ward, F. N. (assigned to Secretary of the Interior), Method for Analyzing Minerals, Soils, Or Rocks To Determine the Presence and Amount of Mercury Therein. U.S. Pat. 3,434,800, Mar. 25, 1969.

[18] Henderson, F. B. III. Hydrothermal Alteration and Ore Deposition in Serpentinite-Type Mercury Deposits. Econ. Geol., v. 64, No. 5, August 1969, pp. 489–499.

[19] Kenneston, Robert. Assaying Mercury Ore Today. Calif. Div. Mines and Geol. Min. Inf. Serv., v. 22, No. 11, November 1969, pp. 179–182.

[20] Parks, G. A., R. E. Baker (assigned to Mountain Copper Co. of California) Mercury Process. U.S. Pat. 3,476,552, Nov. 4, 1969.

[21] Schmidt, W., and J. W. Carson (assigned to Reynolds Metals Co.). Distillation Purification of Aluminum Containing Mercury Added as a Purge for Iron, Silicon, Titanium, and Like Impurities. Canadian Pat. 813,276, May 20, 1969.

Mica

By Charles L. Readling [1]

Domestically produced sheet mica sold or used by producers dropped substantially in 1969 and was at the lowest level since 1966. Scrap and flake mica registered a strong increase over the previous year although the average value declined. Ground mica produced from scrap and flake mica gained substantially in both quantity and value. Imports of uncut sheet and punch mica increased; imports of scrap mica declined. Exports of mica, other than manufactured, totaled less than half that of 1968; exports of manufactured mica increased.

Table 1.—Salient mica statistics

	1965	1966	1967	1968	1969
United States:					
Sold or used by producers:					
Sheet mica____thousand pounds__	716	4	20	15	W
Value____thousands__	$185	$1	W	W	$3
Scrap and flake mica____thousand short tons__	120	113	119	125	133
Value____thousands__	$3,468	$3,732	$2,876	$3,014	$2,893
Ground mica____thousand short tons__	127	103	97	111	125
Value____thousands__	$7,615	$6,247	$5,756	$7,072	$8,058
Consumption, block and film____thousand pounds__	2,659	2,813	1,972	1,628	1,498
Value____thousands__	$3,188	$3,642	$2,757	$2,591	$2,595
Consumption, splittings____thousand pounds__	8,260	7,100	6,188	4,785	5,077
Value____thousands__	$3,701	$3,221	$2,759	$2,010	$2,196
Exports____thousand short tons__	4	6	7	14	6
Imports for consumption____do____	9	7	4	5	5
World: Production____thousand pounds__	345,457	323,411	317,381	343,468	p 363,358

p Preliminary. W Withheld to avoid disclosing individual company confidential data.

DOMESTIC PRODUCTION

Sheet Mica.—No uncut mica larger than punch and circle was produced in 1969. Only a small quantity of uncut punch and circle, valued at $3,244, was produced from North Carolina, the only producing State in 1969.

[1] Mineral specialist, Bureau of Mines, Minneapolis, Minn.

Table 2.—Mica sold or used by producers in the United States

Year and State	Sheet mica: Uncut punch and circle mica, Pounds	Value	Uncut mica larger than punch and circle, Pounds	Value	Total sheet mica, Pounds	Value	Scrap and flake mica [1], Short tons	Value
1965____	670,506	$139,844	45,580	$45,142	716,086	$184,986	120,255	$3,467,701
1966____	4,500	905	-----	-----	4,500	905	113,133	3,732,242
1967____	-----	-----	20,500	W	20,500	W	118,503	2,876,149
1968____	-----	-----	15,000	W	15,000	W	125,323	3,013,855
1969:								
North Carolina____	W	3,244	-----	-----	W	3,244	67,214	1,513,024
South Dakota____	-----	-----	-----	-----	-----	-----	423	20,290
Other____	-----	-----	-----	-----	-----	-----	[2] 65,421	[2] 1,359,869
Total____	W	3,244	-----	-----	W	3,244	133,058	2,893,183

W Withheld to avoid disclosing individual company confidential data.
[1] Includes finely divided mica recovered from mica and sericite schist, and mica that is a byproduct of feldspar and kaolin beneficiation.
[2] Alabama, Arizona, Connecticut, Georgia, New Hampshire, New Mexico, Pennsylvania, and South Carolina.

Scrap and Flake Mica.—Output of scrap and flake mica increased 6 percent in quantity but declined 4 percent in value. Although output in the State declined 3 percent, North Carolina was again the major producer accounting for 51 percent of the total domestic production. The remainder was produced in nine other States.

Ground Mica.—Sales of ground mica increased 12 percent over 1968 to nearly 125,000 tons, the highest level since 1965. The value of ground mica sales increased 14 percent over 1968. Dry-ground material accounted for 87 percent of the total production, the same proportion as 1968. Reports were received from 20 grinders operating 16 dry and four wet grinding plants.

Table 3.—Ground mica sold by producers in the United States by methods of grinding [1]

Year	Dry-ground		Wet-ground		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1965	110,600	$5,316	15,997	$2,299	126,597	$7,615
1966	87,361	4,110	16,089	2,137	103,450	6,247
1967	82,849	3,842	14,204	1,915	97,053	5,756
1968	96,410	4,862	14,979	2,210	111,389	7,072
1969	109,152	5,486	15,704	2,572	124,856	8,058

[1] Domestic and some imported scrap.

CONSUMPTION AND USES

Sheet Mica.—Consumption of sheet mica consisting of block, film, and splittings, reached 6.6 million pounds, an increase of 3 percent from that of 1968.

About 1.4 million pounds of muscovite block and film were used in 1969, of which approximately 83 percent was consumed in electronic and electrical uses. The manufacture of vacuum tubes required 53 percent; the manufacture of capacitors accounted for 16 percent of the total block and film consumed. Approximately 2 percent of the material consumed was classified as Good Stained or better; 42 percent Stained; and 56 percent Lower than Stained.

Table 4.—Fabrication of muscovite ruby and nonruby block and film mica and phlogopite block mica, by qualities and end-product uses in the United States in 1969

(Pounds)

Variety, form, and quality	Electronic uses: Capacitors	Electronic uses: Tubes	Electronic uses: Other	Electronic uses: Total	Nonelectronic uses: Gage glass and diaphragms	Nonelectronic uses: Other	Nonelectronic uses: Total	Grand total
Muscovite:								
Block:								
Good Stained or better	1,092	4,034	2,898	8,024	4,660	-----	4,660	12,684
Stained	44,736	499,263	39,944	583,943	2,698	162	2,860	586,803
Lower than Stained [1]	155,002	249,510	156,616	561,128	13,594	213,790	227,384	788,512
Total	200,830	752,807	199,458	1,153,095	20,952	213,952	234,904	1,387,999
Film:								
First quality	5,605	-----	-----	5,605	-----	275	275	5,880
Second quality	20,149	-----	-----	20,149	-----	-----	-----	20,149
Other quality	4,025	-----	-----	4,025	-----	-----	-----	4,025
Total	29,779	-----	-----	29,779	-----	275	275	30,054
Block and film:								
Good Stained or better [2]	26,846	4,034	2,898	33,778	4,660	275	4,935	38,713
Stained [3]	48,761	499,263	39,944	587,968	2,698	162	2,860	590,828
Lower than Stained	155,002	249,510	156,616	561,128	13,594	213,790	227,384	788,512
Total	230,609	752,807	199,458	1,182,874	20,952	214,227	235,179	1,418,053
Phlogopite: Block (all qualities)	-----	-----	7,090	7,090	-----	72,726	72,726	79,816

[1] Includes punch mica.
[2] Includes first- and second-quality film.
[3] Includes other-quality film.

Table 5.—Fabrication of muscovite ruby and nonruby block and film mica in the United States in 1969 by qualities and grades

(Pounds)

Form, variety, and quality	Grade: No. 4 and larger	No. 5	No. 5½	No. 6	Other [1]	Total
Block:						
Ruby:						
Good Stained or better	4,870	1,170	679	1,804	-----	8,523
Stained	12,188	50,803	54,840	421,473	20,324	559,628
Lower than Stained	36,468	112,512	81,767	248,481	198,210	677,438
Total	53,526	164,485	137,286	671,758	218,534	1,245,589
Nonruby:						
Good Stained or better	1,682	291	1,638	550	-----	4,161
Stained	601	7,905	5,709	12,960	-----	27,175
Lower than Stained	29,972	13,902	1,300	5,200	60,700	111,074
Total	32,255	22,098	8,647	18,710	60,700	142,410
Film:						
Ruby:						
First quality	1,080	750	600	625	-----	3,055
Second quality	7,682	3,121	5,071	2,650	-----	18,524
Other quality	-----	-----	-----	-----	4,025	4,025
Total	8,762	3,871	5,671	3,275	4,025	25,604
Nonruby:						
First quality	-----	-----	1,575	1,250	-----	2,825
Second quality	-----	-----	1,625	-----	-----	1,625
Other quality	-----	-----	-----	-----	-----	-----
Total	-----	-----	3,200	1,250	-----	4,450

[1] Figures for block mica include all smaller than No. 6 grade and "punch" mica.

Muscovite block and film was used by 16 companies in eight States. North Carolina with four consuming plants, and New Jersey and New York with three each, consumed 62 percent of the domestically fabricated block and film mica. The consumption of phlogopite block increased 13 percent to 79,800 pounds.

Total consumption of mica splittings increased 6 percent over that of 1968, reversing the downward trend begun in 1966. India and the Malagasy Republic provided most of the splittings consumed. Splittings were fabricated into end products by 13 companies in nine States. Six companies, two in New York, two in Pennsylvania, and one each in Massachusetts and New Hampshire, consumed slightly more than 3.8 million pounds of splittings or 76 percent of the total consumption.

Table 6.—Consumption and stocks of mica splittings in the United States, by sources

(Thousand pounds and thousand dollars)

	India		Malagasy		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
Consumption:						
1965	7,948	$3,513	312	$188	8,260	$3,701
1966	6,749	3,005	351	216	7,100	3,221
1967	5,857	2,566	331	193	6,188	2,759
1968	4,579	1,874	206	136	4,785	2,010
1969	4,799	2,005	278	191	5,077	2,196
Stocks Dec. 31:						
1965	3,912	NA	210	NA	4,122	NA
1966	3,669	NA	206	NA	3,875	NA
1967	2,737	NA	159	NA	2,896	NA
1968	2,469	NA	149	NA	2,618	NA
1969	2,415	NA	145	NA	2,560	NA

NA Not available.

Built-Up Mica.—This material was fabricated in various forms primarily for use as an electrical insulator. Output of built-up mica had been declining from 1965–68, but in 1969 output was about 2 percent greater than the previous year. The form in greatest demand was segment plate (32 percent) followed by tape (28 percent) and molding plate (22 percent).

Table 7.—Built-up mica [1] sold or used in the United States, by products

(Thousand pounds and thousand dollars)

Product	1968		1969	
	Quantity	Value	Quantity	Value
Molding plate	929	$2,733	947	$2,706
Segment plate	1,292	2,709	1,376	2,453
Heater plate	34	71	[2] 407	123
Flexible (cold)	347	894	403	856
Tape	1,225	4,270	1,208	4,529
Other	435	1,186	(2)	1,034
Total [3]	4,264	11,863	4,341	11,701

[1] Consists of alternate layers of binder and irregularly arranged and partly overlapped splittings.
[2] "Other" combined with Heater Plate for 1969 to avoid disclosing individual company confidential data.
[3] Data may not add to totals shown because of independent rounding.

Table 8.—Ground mica sold by producers in the United States, by uses

Use	1968		1969	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Roofing	28,413	$909	41,095	$1,198
Wallpaper	1,049	90	600	79
Rubber	6,962	779	7,348	885
Paint	24,146	2,295	29,081	2,818
Plastics	903	125	684	133
Welding rods	738	35	W	W
Joint cement	30,953	2,227	30,031	2,106
Other uses [1]	18,225	611	16,017	838
Total [2]	111,389	7,072	124,856	8,058

W Withheld to avoid disclosing individual company confidential data, included with "Other uses."
[1] Includes mica used for molded electric insulation, house insulation, Christmas tree snow, annealing, well drilling, other purposes and uses indicated by symbol W.
[2] Data may not add to totals shown because of independent rounding.

Reconstituted Mica.—This form of mica was fabricated by the General Electric Co. at Schenectady, N.Y., the Samica Corp. at Rutland, Vt., and the Acim Paper Corp. at New Hyde Park, N.Y., from mica scrap specially delaminated by paper-making techniques. According to the National Electrical Manufacturers Association, net domestic sales of mica-paper products rose 14 percent, from $4.4 million in 1968 to $5.0 million in 1969.

PRICES

Prices quoted in the Engineering and Mining Journal were unchanged from the previous year. North Carolina district, clear sheet mica ranged from $.70 to $1.10 per pound for 1½- by 2-inch sheets to $4 to $8 for 6- by 8-inch sheets. Punch mica, the smallest size, ranged from 7 to 12 cents. Stained or electric mica was quoted 10 to 20 percent lower than the clear sheet mica. Scrap and flake mica was quoted at $30 to $40 per ton. First-quality sheet mica from the Malagasy Republic ranged from 50 cents per pound below one-square inch to $3.25 per pound for that averaging 10 to 14 square inches.

Yearend prices quoted in the Oil, Paint and Drug Reporter are shown in table 9. Dry-ground mica prices were the same as the previous year; yearend prices for all categories of wet-ground mica were ½ cent per pound (6 to 7 percent) higher than the previous year.

Table 9.—Price of dry- or wet-ground mica in the United States in 1969 [1]

	Cents per pound
Dry-ground:	
Paint, 100 mesh	3¾
Plastic, 100 mesh	3¾
Roofing, 20 to 80 mesh	2–3
Wet-ground: [2]	
Biotite	7½
Biotite, less than carlots [3]	8½
Paint or lacquer, 325 mesh	8½
Paint or lacquer, 325 mesh, less than carlots [3]	9½
Rubber	8½
Rubber, less than carlots [3]	9½
Wallpaper	9½

[1] In bags at works, carlots, unless otherwise noted.
[2] Freight allowed east of the Mississippi River, ½ cent higher west of the Mississippi River, 1 cent higher west of the Rockies.
[3] Ex-warehouse or freight allowed east of the Mississippi River.

Source: Oil, Paint and Drug Reporter. V. 196, No. 26, Dec. 29, 1969.

FOREIGN TRADE

Total exports of all classes of mica declined 55 percent from the unusual high of 27.5 million pounds in 1968 to 12.4 million pounds in 1969, but rose 12 percent in value for the same period. Canada received the largest share of the total exports, 37 percent, followed by Jamaica with 22 percent.

Table 10.—U.S. exports of mica and manufactures of mica, 1969 by countries

Destination	Mica, including sheet, waste and scrap and ground: Pounds	Mica, including sheet, waste and scrap and ground: Value (thousands)	Manufactured: Pounds	Manufactured: Value (thousands)
Algeria	40,000	$3	152	(1)
Argentina	28,600	3	11,291	$31
Australia	59,106	7	3,100	16
Belgium-Luxembourg	125,765	9	767	3
Brazil	211,050	19	4,836	13
Canada	4,364,052	281	250,685	739
Chile	50,000	4	1,870	14
Colombia	50,321	4	1,408	7
Ecuador	106,000	9	784	2
France	796,365	39	11,292	27
Germany, West	401,057	103	3,496	14
India	64,257	5	490	4
Italy	385,269	23	87,372	290
Jamaica	2,770,655	387	6,189	55
Japan	455,363	53	4,480	11
Mexico	38,931	11	136,695	308
Netherlands	395,959	33	2,799	13
Nicaragua	30,000	3	---	---
Peru	137,500	8	2,040	7
Philippines	78,980	11	332	2
Singapore	45,000	1	---	---
South Africa, Republic of	126,265	4	9,921	17
Spain	15,000	1	9,334	27
Sweden	2,079	6	31,621	47
Switzerland	59,529	31	1,407	4
Taiwan	153,541	11	5,057	52
Trinidad and Tobago	79,882	7	---	---
United Kingdom	107,031	152	21,833	55
Venezuela	474,994	30	3,555	7
Other countries	157,457	16	26,024	69
Total	11,810,008	1,274	638,830	1,834

1 Less than ½ unit.

Table 11.—U.S. exports and imports of mica

(Thousand pounds and thousand dollars)

Year	Exports, All classes: Quantity	Exports, All classes: Value	Imports for consumption, Uncut sheet and punch: Quantity	Uncut sheet and punch: Value	Scrap: Quantity	Scrap: Value	Manufactured: Quantity	Manufactured: Value
1967	14,829	$2,534	1,733	r $1,989	1,016	r $24	5,440	$3,373
1968	27,489	2,766	1,491	1,539	r 3,157	77	5,293	3,373
1969	12,449	3,108	1,601	1,695	3,078	74	5,520	3,060

r Revised.

Imports of uncut sheet and punch mica in 1969 increased 7 percent in quantity and 10 percent in value over 1968. Scrap mica imports declined in both quantity and value. Imports of manufactured mica increased in quantity but declined in value.

Table 12.—U.S. imports for consumption of mica by kinds and countries

Year and country	Unmanufactured [1]									
	Waste and scrap				Block mica		Other			
	Phlogopite		Other				Muscovite		Other, n.e.c.	
	Pounds	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)
1967	119,920	$2	896,177	$22	1,141,038	$1,320	312,022	$364	280,321	$305
1968	93,069	5	[r]3,064,096	72	1,128,661	1,041	186,426	298	175,526	200
1969:										
Brazil	---	---	51,066	2	893,043	902	116,812	163	129,990	51
Canada	---	---	---	---	---	---	---	---	200	(2)
Ceylon	---	---	200,019	3	---	---	---	---	77	1
India	---	---	2,200,623	50	347,176	279	1,539	59	11,725	44
Jamaica	---	---	---	---	745	7	---	---	550	3
Japan	---	---	---	---	---	---	190	7	---	---
Malagasy Republic	99,207	5	---	---	5,162	8	---	---	46,744	56
Mexico	---	---	64,935	1	---	---	---	---	---	---
Nepal	---	---	---	---	---	---	633	13	35	4
South Africa, Republic of	36,000	5	426,000	8	3,000	2	2,413	(2)	24,558	18
Tanzania	---	---	---	---	3,594	3	11,687	43	731	10
United Kingdom	---	---	---	---	372	3	---	---	531	19
Total	135,207	10	2,942,643	64	1,253,092	1,204	133,274	285	215,141	206

Year and country	Manufactured							
	Splittings		Not cut or stamped not over 0.006 inch in thickness		Cut or stamped			
					Not over 0.006 inch in thickness		Over 0.006 inch in thickness	
	Pounds	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)
1967	4,884,508	$1,700	111,856	$300	66,493	$1,049	92,755	$167
1968	4,808,447	1,339	97,997	233	98,594	1,444	120,339	191
1969:								
Austria	---	---	---	---	198	4	---	---
Brazil	---	---	9,453	26	1,284	11	7,791	25
Canada	6,250	2	---	---	---	---	---	---
Czechoslovakia	---	---	600	4	---	---	---	---
Germany, West	---	---	---	---	29	1	---	---
India	4,840,523	1,008	68,014	68	76,891	1,121	64,801	88
Jamaica	---	---	2,761	14	---	---	---	---
Japan	---	---	---	---	326	8	---	---
Laos	---	---	---	---	596	4	---	---
Leeward and Windward Islands	---	---	778	5	336	1	---	---
Malagasy Republic	195,332	102	154	1	3,857	16	---	---
Mexico	---	---	174	1	5,716	168	252	1
Nepal	---	---	2,000	14	246	2	---	---
Netherlands	---	---	---	---	30	1	153	4
Pakistan	---	---	200	2	---	---	---	---
South Africa, Republic of	51,587	26	---	---	---	---	35,860	40
Southern Africa, n.e.c	---	---	---	---	117	1	---	---
Tanzania	---	---	805	1	---	---	---	---
United Kingdom	300	1	---	---	1,358	34	886	7
Total	5,093,992	1,139	84,939	136	90,984	1,372	109,743	165

Table 12.—U.S. imports for consumption of mica by kinds and countries—Continued

Year and country	Manufactured					
	Mica plates and built-up mica		Ground or pulverized		Articles not especially provided for of mica	
	Pounds	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)
1967	42,172	$57	226,501	$21	15,185	$79
1968	45,860	77	113,616	13	8,039	76
1969:						
Belgium-Luxembourg	23,810	33	---	---	5,914	6
Brazil	---	---	---	---	83	2
Canada	2,650	10	---	---	---	---
France	---	---	44,092	5	30	1
Germany, West	39,643	47	---	---	357	2
India	300	1	11,023	(2)	4,889	92
Japan	4,654	5	---	---	---	---
Netherlands	---	---	---	---	255	10
Taiwan	---	---	---	---	428	10
United Kingdom	400	1	---	---	1,942	23
Total	71,457	97	55,115	5	13,898	146

r Revised.

1 In addition to classes shown for 1968, of untrimmed phlogopite from which no piece over 2 by 1 inch may be cut was r62,200 pounds (r$700) from Brazil and Other waste and scrap from Mexico, r60,000 pounds.

2 Less than ½ unit.

WORLD REVIEW

Afghanistan.—The Ministry of Mines and Industries has investigated two mica occurrences south of Kabul in Logar Province that it hopes may be developed for both domestic consumption and export within the next few years. Selected samples were reported to vary from a clear, nearly flat muscovite of excellent quality to a marginal brown-stained muscovite-phlogopite.[2]

India.—Crude mica production increased 5 percent from 23,339 tons (revised) in 1967 to 24,440 tons in 1968. Value, however, declined from $19.9 million (revised) to $18.9 million during the same period. Total exports declined from 46.9 million pounds in 1967 to 46.7 million pounds in 1968 although all mica categories increased over 1967, except scrap or waste and film, which declined. The U.S.S.R. and other Eastern European countries received 14 percent of the total mica exports in 1968. Effective July 1968, the ad valorem duty of 40 percent on mica exports was reduced to 20 percent for processed mica powder. The same action applied to loose splittings (grades 5½ and 6) effective March 1, 1969.[3]

2 Bureau of Mines. Mineral Trade Notes. V. 66, No. 6, June 1969, p. 19.

3 Bureau of Mines. Mineral Trade Notes. V. 66, No. 10, October 1969, pp. 26–32.

Table 13.—World production of mica by countries
(Thousand pounds)

Country [1]	1967	1968	1969 p
North America:			
Mexico	1,949	1,625	1,426
United States (sold or used by producers):			
Sheet	20	15	W
Scrap	237,006	250,646	266,115
South America:			
Argentina:			
Sheet	300	207	e 1,500
Waste, scrap, etc	2,211	1,316	
Brazil [2]	2,295	3,677	e 3,000
Colombia	NA	57	37
Europe:			
France	631	e 551	e 500
Norway, including scrap [2]	9,885	10,613	8,393
Portugal	3,653	4,665	e 4,409
Yugoslavia	260	315	e 300
Africa:			
Malagasy Republic (phlogopite):			
Block	119	172	137
Splittings	1,063	1,598	2,218
Scrap	452	227	251
Mozambique, including scrap	220	741	e 741
South Africa, Republic of:			
Sheet	9	20	220
Scrap	10,181	17,456	13,997
Tanzania:			
Sheet	r 170	159	214
Scrap	278	527	254
Asia:			
India: [2]			
Block	3,543	3,816	3,944
Splittings [3]	12,388	13,790	14,976
Scrap	30,748	31,275	40,726
Total [4]	r 317,381	343,468	363,358

e Estimate. p Preliminary. r Revised. NA Not available. W Withheld to avoid disclosing individual company confidential data.
[1] Mica is also produced in China (mainland), Rumania, Southern Rhodesia, South-West Africa, Sweden, and the U.S.S.R., but data on production are not available.
[2] Exports.
[3] Includes condenser film as follows: 1967, 203,000 pounds; 1968, 189,000 pounds; and 1969, 237,000 pounds.
[4] Totals are of listed figures only.

TECHNOLOGY

Mica research continued at the Bureau of Mines Tuscaloosa Metallurgy Research Laboratory. A paper describing mica research at the laboratory over the past 5 years was presented at the annual meeting of the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME) in Washington, D.C. in February 1969.[4]

A report was published describing Bureau of Mines laboratory and continuous pilot plant flotation tests which demonstrated the feasibility of recovering high-grade mica concentrates from Alabama graphitic-mica schists.[5] Results were also published on tests conducted by the Bureau which demonstrated the feasibility of recovering a salable mica product, removing heavy minerals, and recovering a high-grade potash feldspar product and a high-quality glass sand from a mica waste tailing.[6]

A froth flotation process useful for beneficiation of phosphate rock, mica, and feldspar was developed whereby the silica is practically completely removed in the froth.[7]

A composition was developed for forming water-resistant, incombustible insulation on air conditioning ducts, vessels, etc., which consists of micronized mica, chryso-

[4] Browning, James S. Mica Process Development. Society of Mining Engineers of AIME. Preprint No. 69-H-34, 1969, 15 pp.
[5] Adair, Ralph B. and James S. Browning. Flotation of Muscovite from Alabama Graphitic-Mica Schist Ore. BuMines Rept. of Inv. 7263, June 1969, 7 pp.
[6] Eddy, W. H., James S. Browning, and James E. Hardemon. Selective Flotation of Minerals From North Carolina Mica Tailing. BuMines Rept. of Inv. 7319, November 1969, 10 pp.
[7] Dickson, W. J. and F. W. Jenkins (assigned to Petrolite Corp., Wilmington, Del.). Flotation Process. U.S. Pat. 3,425,549, Feb. 4, 1969.

tile asbestos, a silicate binder, silica, and suspending and chelating agents.[8]

The Wet Ground Mica Association announced publication of a new paint formulary listing 90 paint formulas using wet-ground mica.

Something new in shaving was developed in a molded or stick form preshaving cosmetic composition comprised of 30 to 80 parts by weight of micronized mica, 10 to 55 parts of talc, and 10 to 25 parts of fillers and excipients.[9]

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[8] Rolland, G. F. and J. J. Seipel (assigned to Benjamin Foster Co., Philadelphia, Pa.). Coating Composition and Process. U.S. Pat. 3,442,671, May 6, 1969.

[9] Rieger, M. M. Cosmetic Stick Composition. U.S. Pat. 3,429,964, Feb. 25, 1969.

Molybdenum

By John L. Morning [1]

Record production and exports marked the year as domestic production reached nearly 100 million pounds, Canadian output rose to 30 million pounds, and domestic exports were at an alltime high. New capacity scheduled for operation in 1970, both in the United States and Canada, should continue the adequate supply and allow for the continued growth of the industry.

Table 1.—Salient molybdenum statistics

(Thousand pounds of contained molybdenum and thousand dollars)

	1965	1966	1967	1968	1969
United States:					
Concentrate:					
Production	77,372	90,532	90,097	r 93,447	99,807
Shipments	77,310	91,670	81,596	93,245	103,009
Value	$120,801	$144,327	$133,604	$151,000	$173,819
Consumption	68,112	75,476	58,967	75,647	73,275
Imports for consumption	142	5	1,179	1	(1)
Stocks, Dec. 31: Mine and plant	4,208	3,433	9,919	12,208	8,398
Primary products:					
Production	66,616	74,392	54,922	69,675	68,526
Shipments	71,718	78,811	57,231	63,761	77,726
Consumption	48,621	52,324	49,506	49,271	51,622
Stocks, Dec. 31: Producers	3,839	5,945	7,156	18,170	17,844
Free world: Production	98,531	124,988	126,273	125,735	142,802

r Revised.
1 Less than 1 unit.

Legislation and Government Programs.—On July 30 the Office of Emergency Preparedness established a revised conventional-war stockpile objective for molybdenum in concentrate at 36.5 million pounds. The accompanying table indicates the new subobjectives and quantities of molybdenum in Government inventory at yearend.

During the year, the General Services Administration sold 12.5 million pounds of molybdenum of which 12.3 million pounds was purchased on long-term delivery contracts. Actual deliveries for the year totaled 2.8 million pounds of molybdenum. At yearend nearly 2.9 million pounds was available for sale on a shelf-item basis to domestic producers, processors, and consumers only.

The Tax Reform Act of 1969, signed by the President on December 30, 1969, authorized changes in certain mineral and metal percentage depletion rates effective with taxable years beginning after October 9, 1969. For molybdenum, the new rates were 22 percent for domestic and 14 percent for foreign.

1 Physical scientist, Division of Ferrous Metals.

Table 2.—Molybdenum material in Government inventories on December 31, 1969

(Thousand pounds molybdenum)

Type material	Stockpile objective	National (strategic) stockpile
Concentrate	17,115	32,794
Ferromolybdenum	7,500	7,501
Molybdic oxide	10,600	11,584
Total	35,215	51,879

DOMESTIC PRODUCTION

The molybdenum industry operated at near capacity throughout the year as production nearly topped 100 million pounds. Of the total output, about 71 percent was produced from primary mines, and the balance was recovered as a byproduct or coproduct from copper, tungsten, and uranium operations.

According to the American Metal Climax, Inc. (AMAX) annual report, production of molybdenum at company mines totaled about 60 million pounds, which was the same quantity produced in 1968. Planning for future production, the AMAX subsidiary, Climax Molybdenum Co. completed excavation and concreting of an underground crusher facility on the 600 level of its Climax mine. Ore production is expected to begin in 1972 and will be coordinated with the phasing out of production from the Phillipson level. Development work progressed according to plan at its new Henderson mine where mine site preparation and the No. 1 shaft were virtually completed in 1969. Plans call for initial production in 1975.

AMAX received two awards for its environmental activities in the mining industry. The first was presented by Sports Foundation Inc. for environmental control programs at the Urad molybdenum mine; the second was awarded by Business Week for the preservation of our natural environment. The Business Week award recognized environmental control activities in the development of the Urad mine and the related Henderson project, which is under development.

A record output, according to the company's annual report, of 10.9 million pounds of molybdenum by Molybdenum Corporation of America (Molycorp) was achieved as new production facilities were placed in operation in November. Capacity is now considered as 14 million pounds annually as the milling rate reached 16,500 tons per day at yearend. Proven and probable ore reserves were increased from 276 million pounds to 333 million pounds of molybdenum within the main orebody.

Operating at full capacity, Kennecott Copper Corp. announced in its annual report production of 15.9 million pounds of molybdenum domestically and a total of 25 million pounds worldwide during the year.

Duval Corp. reported sales of 5.7 million pounds of molybdenum (Penzoil United Inc. Annual Report). Duval operates two properties in Arizona, Esperanza at Sauharita and Ithica Peak at Mineral Park, near Kingman. Ore reserve in 1968 at Esperanza was reported to total 41 million tons grading 0.45 percent copper and 0.032 percent molybdenum, whereas ore reserve at Ithica Peak was 54.5 million tons grading 0.49 percent copper and 0.044 percent molybdenum. Duval's subsidiary, Duval Sierrita Corp., continued to develop an ore deposit adjacent to the Esperanza mine. Startup of the new facility has been deferred until mid-1970.

The Mission and Silver Bell mines of American Smelting and Refining Company (ASARCO), according to its annual report, operated at capacity in producing nearly 1.2 million pounds of byproduct molybdenum. ASARCO also announced that two years of exploration development partially delineated a molybdenum deposit in the White Cloud area of Idaho. The mining industry's awareness of our environment was indicated as the firm continued to work with governmental agencies and other groups in developing plans which would impose the least practical impact of mine development on the natural characteristics and ecology of the area. During 1969, progress was made in studying the ecology of the area for access, plant site, and waste disposal.

Operating at a record level, the Pima Mining Co., produced 1.7 million pounds of molybdenum during the year (Cypress Mines Corp. Annual Report). Consideration at yearend was being given to expansion of the 39,000-ton-per-day facility to 53,000 tons per day. Completion of the proposed expansion would require 1 year.

Bagdad Copper Corp. molybdenum shipments decreased to 408,000 pounds compared to 599,000 pounds in 1968. The reduction was caused by less molybdenum in the ore and decreased mill recovery, according to Bagdad's Annual Report.

By yearend, The Anaconda Company's Twin Butts molybdenum plant was substantially complete. When placed in operation, a production rate of 1.4 million pounds of molybdenum annually was forecast. Anaconda continued to conduct development work at the Hall molybdenum property in Nevada and a copper-molybdenum property at Heddleston, Mont.

Cities Service Co. (Tennessee Corp.) planned to conduct a feasibility study for open pit mining and surface facilities to process 40,000 tons of molybdenum containing copper ore daily at its Pinto Valley, Ariz. deposit. The estimated ore reserve of 350 million tons was reported to contain 0.45 percent copper and some molybdenum.

The Phelps Dodge Corp. placed in operation a new facility at Tyrone, N. Mex. for copper recovery. Full operation was achieved by October. Incorporated in the design of the 25,000-ton-per-day mill was sufficient space to allow for a 50-percent increase in capacity. Future plans call for recovery of molybdenum.

Other copper ventures now under development that may have potential molybdenum values are those of Ranchers Exploration & Development Corp. at Winnemucca, Nev., and Earth Resources Co. near Cuba, N. Mex.

Table 3.—Production, shipments, and stocks of molybdenum products in the United States

(Thousand pounds of contained molybdenum)

	1968	1969	1968	1969	1968	1969
	Molybdic oxide [1]		Metal powder		Ammonium molybdate	
Received from other producers	4,497	6,021	65	250	184	570
Gross production during year	68,793	68,655	2,615	3,243	1,835	2,393
Used to make other products listed here	17,289	17,140	625	929	1,279	1,273
Net production	51,504	51,515	1,990	2,314	556	1,120
Shipments	47,972	58,042	1,897	2,642	730	1,674
Producer stocks, Dec. 31	11,385	12,547	509	427	210	227
	Sodium molybdate		Other [2]		Total [3]	
Received from other producers	62	85	146	221	4,954	7,146
Gross production during year	989	617	14,702	13,161	88,934	88,068
Used to make other products listed here	25	14	42	188	19,259	19,543
Net production	965	603	14,660	12,973	69,675	68,525
Shipments	864	837	12,298	14,531	63,761	77,726
Producer stocks, Dec. 31	261	162	5,805	4,481	18,170	17,844

[1] Includes molybdic oxide, briquets, molybdic acid, and molybdenum trioxide.
[2] Includes ferromolybdenum, calcium molybdate, phosphomolybdic acid, molybdenum disulfide, pellets, molybdenum pentachloride, and molybdenum hexacarbonyl.
[3] Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Domestic consumption of molybdenum in concentrate decreased 3 percent compared with consumption in 1968 despite the record mine production. Exports of concentrate accounted for the decreased consumption. Except for quantities used as lubricant-grade molybdenum disulfide and other direct uses, molybdenum concentrate was converted to molybdic oxide, the raw material used in production of virtually all other molybdenum primary products. Some molybdic oxide was exported. Consumption of molybdenum by end uses reached 51.6 million pounds as steel producers had a banner year. Nearly 67 percent was used as the oxide, 22 percent as ferromolybdenum, and the balance was used as other primary products or directly as the sulfide. Alloy steels accounted for 41 percent of the annual usage, and the iron and steel industry accounted for about 80 percent of total reported consumption.

Molybdenum was used in a wide variety of products in addition to those quantities used in the iron and steel industry. Substantial quantities of molybdenum were used in the preparation of pigments and catalysts, in lubricants as the disulfide, and for the manufacture of pure-metal mill products.

Table 4.—Consumption of molybdenum materials by end uses in 1969

(Thousand pounds contained molybdenum)

End uses	Molybdic oxides	Ferromolybdenum [1]	Ammonium and sodium molybdate	Other molybdenum materials [2]	Total [3]
Steel:					
Carbon	3,068	468	—	W	3,536
Stainless and heat-resisting	4,259	1,883	—	117	6,259
Alloy (excludes stainless and heat-resisting)	18,768	2,309	—	28	21,105
Tool	2,045	1,204	—	237	3,486
Cast irons	1,050	3,140	—	84	4,274
Superalloys	338	597	—	1,581	2,516
Alloys (excludes alloy steels and superalloys):					
Cutting and wear-resistant materials	W	W	—	3	3
Welding and alloy hard-facing rods and materials	—	383	—	29	412
Magnetic alloys	(4)	W	—	W	W
Other alloys [5]	W	87	—	109	196
Mill products made from metal powder	412	W	—	1,899	1,311
Chemical and ceramic uses:					
Pigments	731	—	371	W	1,102
Catalysts	1,514	(4)	W	—	1,514
Other	35	W	W	785	820
Miscellaneous and unspecified	2,128	1,065	418	478	4,089
Total [3]	34,349	11,135	789	5,348	51,622
Consumer stocks Dec. 31	2,966	1,591	246	671	5,474

W Withheld to avoid disclosing individual company confidential data; included in "Miscellaneous and unspecified."

[1] Includes calcium molybdate.

[2] Includes purified molybdenum disulfide, molybdenite concentrate added directly to steel, molybdenum metal powder, molybdenum metal pellets, and other molybdenum materials.

[3] Data may not add to totals shown because of independent rounding.

[4] Less than ½ unit.

[5] Includes nonferrous alloys.

STOCKS

Despite a record production year and Government stock pile sales of nearly 3 million pounds, the industrial inventory of molybdenum decreased 16 percent owing to an extraordinarily high level of exports. Most of the decrease in stocks occurred in producer inventories of concentrate; however, consumer stocks decreased substantially owing to the plentiful supply.

PRICES

Early in May producers raised the price of most molybdenum products 10 cents per pound of contained molybdenum. The price advance was the first since January 1967 and came despite an apparent oversupply situation as reflected by the large industrial stocks. Justification for the price advance was related to increased costs of labor, capital goods, and materials. The old and new prices per pound of contained molybdenum are as follows:

	Jan. 11, 1967	May 5, 1970
Molybdenum concentrate f.o.b. Climax, Colo	$1.62	$1.72
Bagged molybdic oxide [1]	1.82	1.92
Technical molybdic oxide [1]	1.82	1.92
Molybdic oxide briquettes [1]	1.85	1.95
Ferromolybdenum [1]	2.11	2.21

[1] Molybdenum products, f.o.b. Langeloth, Pa.

In addition, pure molybdic oxide was increased from $1.40 to $1.47 per pound of product. Following the increase in prices of raw materials, molybdenum wire, rod, and sheet producers increased the price of molybdenum mill products.

Prices published by Metals Week for export of molybdenum products ranged from premiums to discounts. Prices at U.S. shipping ports were as follows:

	January 1969	December 1969
Dealer concentrate	$1.55–1.65	$1.72–1.75
Dealer molybdic oxide	1.75–1.85	1.92–1.95
Dealer ferromolybdenum	2.05–2.15	2.18–2.21

Table 5.—Molybdenum reported by producers as shipments for exports from the United States

(Thousand pounds contained molybdenum)

Product	1968	1969
Molybdenite concentrate	19,790	29,528
Molybdic oxide	8,683	18,295
All other primary products	1,617	1,484

FOREIGN TRADE

Exports.—Owing to the large available domestic supply and to accelerated world wide demand, exports of molybdenum concentrate, including roasted concentrate, jumped to an unprecedented 57.5 million pounds of contained molybdenum. Exports of ferromolybdenum were also strong and returned to about the same level as that of 1967. Exports of molybdenum metal powder increased substantially compared to those of 1968. However, most of the total was shipped to Canada and the low value of these shipments ($0.60 per pound) indicates that the material was not pure metal powder. The material was either of lower grade or misclassified.

Imports.—Owing to relatively high tariff rates, imports of molybdenum are generally small. In 1969 imports of molybdenum ore and concentrate totaled 161 pounds valued at $265. Molybdenum oxide imported from Chile totaled 848 pounds of molybdenum valued at $1,318. Molybdenum content of waste and scrap imported from four countries totaled 78,471 pounds valued at $101,337; Canada and West Germany were the principal suppliers. Imports of unwrought molybdenum totaled 1,209 pounds of contained molybdenum valued at $7,421. Six countries supplied wrought molybdenum products totaling 23,557 pounds, gross weight, valued at $220,771.

Table 6.—U.S. exports of molybdenum ore and concentrates (including roasted concentrates), by countries

(Thousand pounds and thousand dollars)

Destination	1968		1969	
	Molybdenum (content)	Value	Molybdenum (content)	Value
Australia	147	$268	396	$677
Austria	27	50	794	1,345
Belgium-Luxembourg	2,330	4,007	1,379	2,465
Brazil	111	111	64	112
Canada	1,394	1,497	464	768
Czechoslovakia	153	232	630	1,033
France	1,117	1,840	2,170	3,687
Germany:				
East	------	------	628	1,235
West	1,989	3,063	7,346	11,962
India	57	106	38	43
Italy	2	4	1,487	2,508
Japan	5,088	9,100	11,446	20,002
Mexico	192	373	207	370
Netherlands	14,652	24,671	24,634	43,087
New Zealand	2	5	5	10
Philippines	41	79	22	36
South Africa, Republic of	62	116	86	141
Spain	1	1	------	------
Sweden	788	1,172	1,950	3,079
United Kingdom	719	1,153	3,654	6,157
Venezuela	119	190	157	290
Other	15	32	27	48
Total	29,006	48,070	57,584	99,055

Table 7.—U.S. exports of molybdenum products

(Thousand pounds, gross weight, and thousand dollars)

Product and country	1968 Quantity	1968 Value	1969 Quantity	1969 Value
Ferromolybdenum:[1]				
Argentina	5	$8	32	$43
Australia	11	21	144	204
Brazil	108	145	55	78
Canada	285	367	483	1,036
Finland	-----	-----	51	71
India	120	189	51	67
Japan	-----	-----	44	66
Mexico	88	128	46	62
Netherlands	120	159	-----	-----
Rumania	-----	-----	110	135
South Africa, Republic of	55	73	57	76
Sweden	-----	-----	239	332
Taiwan	7	11	36	49
Yugoslavia	45	63	100	151
Other	19	30	7	11
Total	863	1,194	1,455	2,381
Metal and alloys in crude form and scrap:				
France	3	12	3	12
Germany, West	9	16	11	42
Japan	145	156	1	1
Mexico	-----	-----	3	11
United Kingdom	128	16	2	2
Other	8	17	1	2
Total	293	217	21	70
Wire:				
Brazil	5	65	10	127
Canada	9	200	15	343
India	1	14	4	43
Japan	(2)	12	9	74
Mexico	3	56	3	72
Netherlands	4	69	11	202
Other	4	135	9	222
Total	26	551	61	1,083
Powder:				
Canada	9	29	750	329
Japan	-----	5	6	44
Mexico	10	14	(2)	1
Netherlands	3	6	-----	-----
Sweden	24	90	19	73
Other	7	26	7	22
Total	53	170	782	469
Semifabricated forms, n.e.c.:				
Australia	(2)	4	11	14
Canada	5	55	26	92
France	3	23	3	29
Germany, West	3	30	3	21
India	1	3	3	23
Italy	2	14	1	17
Japan	84	181	123	235
Mexico	3	19	7	43
Netherlands	3	39	33	108
South Africa, Republic of	5	31	7	39
United Kingdom	2	23	2	28
Other	7	65	10	33
Total	118	487	229	682

[1] Ferromolybdenum contains about 60 to 65 percent molybdenum.
[2] Less than ½ unit.

Molybdenum chemicals and related products imported included ammonium molybdate containing 11,224 pounds of molybdenum valued at $28,489; molybdenum compounds containing 347 pounds molybdenum valued at $1,672; mixtures of inorganic compounds with molybdenum as the chief mineral value containing 10,630 pounds molybdenum valued at $52,694; sodium molybdate containing 1,102 pounds molybdenum valued at $400; and molybdenum orange totaling 128,984 pounds, gross weight, valued at $44,315.

No import transactions were reported for calcium molybdate, potassium molybdate, or ferromolybdenum. At yearend, the third stage of tariff reductions became effective under the 1967 "Kennedy round" of Tariff Negotiations.

Table 8.—U.S. import duties

Item	Articles	Rate of duty, Jan. 1, 1970 [1]
601.33	Molybdenum ore	16.5 cents per pound on molybdenum content.
603.40	Material in chief value molybdenum	14 cents per pound on molybdenum content plus 4 percent ad valorem.
607.40	Ferromolybdenum	Do.
	Molybdenum:	
628.70	Waste and scrap	14.5 percent ad valorem.
628.72	Unwrought	14 cents per pound on molybdenum content plus 4 percent ad valorem.
628.74	Wrought	17.5 percent ad valorem.
	Molybdenum chemicals:	
417.28	Ammonium molybdate	14 cents per pound on molybdenum content plus 4 percent ad valorem.
418.26	Calcium molybdate	Do.
419.60	Molybdenum compounds	Do.
420.22	Potassium molybdate	Do.
421.10	Sodium molybdate	Do.
423.88	Mixtures of inorganic compounds, chief value molybdenum	Do.
473.18	Molybdenum orange	7 percent ad valorem.

[1] Not applicable to Communist countries.

WORLD REVIEW

Argentina.—The Government of Argentina announced a call for tenders for the exploration of a large area of western Argentina believed to contain deposits of copper and molybdenum. United Nations survey teams in cooperation with the Argentine Government conducted a 2-year study that indicated a highly mineralized area similar in geology to that of the Chilean copper deposits. Successful bidders on 54 areas fronting the Chilean border must complete the exploration work within a 5-year period at which time they will be given an option for a 50-year concession to exploit the deposits.

Australia.—Metal Exploration N.L. reported production of 47 tons of molybdenite from its Wolfram Camp mine in Queensland.

Canada.—Canadian molybdenum production rose to 30.3 million pounds compared to 22.5 million pounds in 1968 when work stoppages in the industry and a fire destroyed the mill of a small producer. Four mines in British Columbia accounted for 90 percent of the output. The balance was produced at four small operations in Quebec.

Endako Mines Ltd. (N.P.L.), Canada's largest producer, operated at near capacity in producing 18.8 million pounds of molybdenum. Mill recovery for the year averaged 86 percent in treating 9.6 million tons of ore grading 0.189 percent molybdenite. A new roaster placed in operation in May was operating at capacity of 9 million pounds annually by yearend. Endako planned to expand its line of primary products in mid-1970 with the startup of a new molybdenum oxide briquette plant capable of producing 1,200 pounds of contained molybdenum in briquettes per hour. Exploration drilling continued to define the ore zone, and as a result the ore reserve was increased slightly.

Table 9.—Free world production of molybdenum in ores and concentrates, by countries

(Thousand pounds contained molybdenum)

Country [1]	1967	1968	1969 p
Canada (shipments)	21,377	20,007	30,292
Chile	10,752	8,521	10,675
Japan	558	622	593
Korea, South	613	423	220
Mexico	r 140	176	150
Norway	r 644	660	660
Peru	2,037	1,784	370
Philippines	55	95	35
United States	90,097	93,447	99,807
Total	126,273	125,735	142,802

p Preliminary. r Revised.
[1] Small quantities are also produced in Argentina, Australia, Nigeria, South-West Africa, and Spain.

British Columbia Molybdenum Ltd., a subsidiary of Kennecott Copper Corp., operated at capacity in producing 5.6 million pounds of molybdenum despite poor weather conditions and high employee turnover.

Production of molybdenum at the Boss Mountain mine of Brynnor Mines Ltd. continued to decrease; 2.3 million pounds was recovered. Although the tonnage treated daily has steadily increased, the grade of ore treated has declined. During the mine's first full year of operation in 1966, nearly 3.6 million pounds was produced. The ore reserve above the adit level was maintained, but the estimated average grade was reduced owing to dilution.

Red Mountain Mines Ltd. increased its milling capacity about 15 percent to over 600 tons daily. In 1968 molybdenum output was 550,000 pounds from ore grading 0.28 percent molybdenite.

New capacity was expected in 1970 with the startup of Brenda Mines Ltd., British Columbia. Tuneup operations were initiated in December and the 24,000-ton-per-day mill was expected to reach capacity operation during the first part of 1970. Copper concentrate will be sold to Japanese interests, while the molybdenum output will be sold to European buyers. The ore reserve remained at 177 million tons averaging 0.049 percent molybdenum and 0.183 percent copper.

Lornex Mining Corporation Ltd. continued to develop its large low-grade molybdenum-copper deposit. The reported ore reserve totals 293 million tons averaging 0.427 percent copper and 0.014 percent molybdenum.

Other interesting molybdenum properties that are being considered for possible exploitation include those of Bell Molybdenum Mines Ltd., adjoining British Columbia Molybdenum Ltd.; Highmont Mining Corp. Ltd., adjoining Lornex; the Mount Copeland property of King Resources Company; Silurean Chieftain Mining Company Ltd., in the Alice Arms area; and Utah Construction & Mining Co. on Vancouver Island.

Chile.—Despite short-term work stoppages, drought conditions, and a landslide at the Chuquicamata mine (Anaconda), molybdenum production in Chile of 10.6 million pounds increased 19-percent over that of 1968. Chilean molybdenum concentrate deliveries for the year were as follow: Chile, 30 percent; West Germany, 20 percent; Sweden 13 percent; Netherlands, 14 percent; United Kingdom, 11 percent; Japan, 7 percent; and France, 5 percent.

The Anaconda Company announced that an agreement reached between the Government of Chile and Anaconda's subsidiaries, Chile Exploration Co. and Andes Copper Mining Co., was being implemented at yearend. Two new corporations were formed, Compañía De Cobre Chuquicamata S.A. and Compañía De Cobre Salvator S.A. Assets and liabilities of Chile Exploration Co. and Andes Copper Mining Co. were transferred to the new corporations. Fifty-one percent of the stock of the new corporations was acquired by the Corporacíon del Cobre (CODELCO), an agency of the Republic of Chile, with the Anaconda subsidiaries retaining a 49-percent interest.

Greece.—A geological report describes a complex molybdenum-tungsten-copper deposit in Kimmeria near Xanthi.[2] The report recommended that a more detailed mining survey be made.

Japan.—Japanese interests continued to investigate a project to establish a molybdenum roaster in Japan. As part of the investigation, a mission visited the Climax roaster at Rotterdam, Netherlands, to study its operation. Interest was also shown in a new process being developed by Molycorp, which produces molybdic oxide while avoiding air pollution.

Malaysia.—The Mamut Copper mine was scheduled for operation by mid-1972. The deposit was discovered in 1965 near Mount Kinabalu on the island of Borneo during a United Nations survey and later drilled by the Geological Survey of North Borneo. The deposit is a porphyritic, disseminated-copper deposit with estimated ore reserve of 76 million tons grading 0.66 percent copper. Small quantities of molybdenum, gold, and silver are also present. From the size of operation planned, Borneo could become a molybdenum producer.

Mexico.—The San Judas Molybdenum Corp. acquired a 49-percent interest in Compañía Minera de Hermosillo, S.A., which holds mining claims in the State of Somora. Exploration outlined an orebody of 250,000 tons grading 1 percent molybdenum. A 250-ton-per-day mill was planned for operation in mid-1971.

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[2] Walenta, K., and P. Pantzartzis. Mining Magazine. V. 121, No. 3, Sept. 1969, p. E 267.

Norway.—The Swedish-owned A/S Knaben Molybaengruber, Norway's only producer of molybdenum concentrate has been a producer of molybdenum since the start of the industry, but only in 1938 did production exceed 1 million pounds. In recent years, production has averaged about 600,000 pounds. Since 1965 there have been numerous accounts of expected expanded capacity.

Panama.—A copper-molybdenum, porphyry-type mineralization discovered by a United Nation mineral survey team continued to hold the interest of international mining concerns. As a result of mineralization discovered in three locations in Colón Province, the Panamanian Government set aside 100,000 acres in the Donoso District for mining concessions. In August, the Minister of Commerce and Industry published an official call for bids for exploitation of the area embracing Petaquilla, Botya, and Rio del Medio. Results of the bidding were not expected until sometime in 1970. Seven to 10 years would be required to develop the area owing to dense jungle where rainfall averaged 200 inches per year.

Peru.—Production of molybdenum dropped substantially at Southern Peru Copper Corp.'s (SPCC) Toquepala mine owing to a mineralogic change in ore mined. A 40-day work stoppage also helped to limit production. SPCC signed a contract with the Peruvian Government to develop the Cuajone copper deposit, which is located about 17 miles northwest of the Toquepala mine. Reported ore reserves total 468 million tons containing 1 percent copper. Presumably, molybdenum would be recovered if present in commercial quantities.

Continental Molybdenum Peru S.A, subsidiary of Mineral Investment Corp., planned to conduct a feasibility study in 1970 for a molybdenum mine at Cerro de Chaco, Apurimax, Peru. Indications of a substantial deposit containing 1 percent molybdenum with byproduct copper values were reported by the new concern.

South Africa, Republic of.—Rand Mines Ltd. was granted an exclusive prospecting license for molybdenum covering an area of about 26 square miles in the Salisbury mining district.

TECHNOLOGY

Laboratory tests by the British Columbia Research Council (Canada) indicate that a two-stage rougher flotation process resulted in increased molybdenum recoveries of up to 5 percent. In ores containing lead sulfide as an impurity, the first flotation stage could recover a concentrate essentially lead free. Further processing would yield a penalty-free, marketable product.

Although no details have been revealed, Molycorp continued to develop a new process for converting molybdenum concentrate to molybdic oxide. Principal advantages claimed for the process are the use of lowgrade and less costly raw materials, production of high-purity molybdenum oxide, recovery of valuable byproducts, and avoidance of air pollution.

For a large segment of end-use consumption, molybdenum oxide is added to steel baths in cans. For some applications however, molybdenum oxide in briquette form is preferred, despite a higher cost of 3 cents per pound of contained molybdenum. A new, fully automated briquetting facility at the Rotterdam, Netherlands, plant of Climax Molybdenum Co. was described.[3] The new facility has an annual capacity of 6.5 million pounds of contained molybdenum.

The more important physical and chemical properties of molybdic oxide were compiled.[4] A research investigation indicated that additions of molybdenum to 3 percent carbon, 4 percent silicon ductile iron contributed significantly to its elevated temperature strength owing to retention of finely dispersed carbides during the elevated temperature exposure.[5]

The National Bureau of Standards made available a new standard reference material containing 21.5 percent molybdenum and 78.5 percent tungsten. The new standard was prepared for use in calibrating microprobe microanalyzers and should

[3] Metallurgia. Automated Briquetting for Molybdenum. V. 79, No. 472, February 1969, pp. 53–57.

[4] Properties of Molybdic Oxide. Molybdenum Chemicals, Bulletin Cdb–1, Climax Molybdenum Company, August 1969, 10 pp.

[5] Sponseller, D. L., W. G. Sholz, and F. D. Rundle. Development of Low-Alloy Ductile Irons For Service at 1,200°–1,500° F. American Foundrymen's Soc. Trans., v. 76, 1968, pp. 353–368.

prove valuable to microprobe laboratories doing qualitative analyses.

Smooth, adherent, consolidated coatings of molybdenum were electrodeposited from a sodium lithium metaborate-molybdenum oxide fused-salt system.[6] Coatings were deposited on various types of materials under an argon atmosphere. Composition of the electrolyte was critical. Deposits were obtained only when the electrolyte contained between 1.0 and 3.3 percent molybdenum.

Patent activity mainly concerned the recovery of molybdenum values by solvent extraction,[7] chlorination, acid or basic leaching,[8] and froth flotation.[9]

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[6] McCawley, Frank X., Charles Wyche, and David Schlain. Electrodeposition of Molybdenum Coatings. J. Electrochem. Soc. V. 116, No. 7, July 1969, pp. 1028–1034.

[7] Platzke, R. N., and J. D. Prater (asssigned to Kennecott Copper Corp.). Process For the Recovery of Molybdenum Values as High Purity Ammonium Paramolybdate From Impure Molybdenum Bearing Solutions, With Optional Recovery of Rhenium Values If Present. U.S. Pat. 3,458,277, July 29, 1969.

Swanson, R. R. (assigned to General Mills, Inc.). Recovery of Molybdenum Values from Aqueous Solutions Using α-hydroxy Oximes. U.S. Pat. 3,449,066, June 10, 1969.

[8] Booker, J. L., and R. E. Fredrickson (assigned to Dow Chemical Co.). Recovery of Oxides of Molybdenum From the Oxychloride. U.S. Pat. 3,420,619, Jan. 7, 1969.

Long, R. S., and E. C. Tveter (assigned to Dow Chemical Co.). Hydrochlorination Process For Recovery of Metal Values. U.S. Pat. 3,432,255, Mar. 11, 1969.

[9] Baarson, R. E., and C. L. Ray (assigned to Armour Industrial Chemical Co.). Flotation of Bulk Concentrates of Molybdenum and Copper Sulfide Minerals and Separation Thereof. U.S. Pat. 3,426,896, Feb. 11, 1969.

Bauer, W. C., and C. K. Amano (assigned to FMC Corp.). Extraction of Metals. U.S. Pat. 3,429,693, Feb. 25, 1969.

Corbett, B. (assigned to Miami Copper Co.). Process and Reagent for Recovery of Molybdenite From Copper Sulfide—Molybdenite Flotation Concentrates. U.S. Pat. 3,435,952), Apr. 1, 1969.

Falvey, J. J. (assigned to American Cyanamid Co.). Dialkyl Dithiocarbamates as Collectors in Froth Flotation. U.S. Pat. 3,464,551, Sept. 2, 1969.

Litz, J. E. (assigned to Union Carbide Corp.). Process for Recovering Copper and Molybdenum From Ore Concentrates. U.S. Pat. 3,455,677, July 15, 1969.

Sebba, F., C. W. Jonaitis, C. L. Ray, and R. E. Baarson (assigned to Armour and Company). Precipitate Flotation Process. U. S. Pat. 3,476,553, Nov. 4, 1969.

Natural Gas

By William B. Harper [1] and Leonard L. Fanelli [2]

The marketed production of natural gas totaled 20,698 billion cubic feet in 1969. This volume was 1,376 billion cubic feet above the 1968 levels. Texas accounted for nearly 38 percent of the marketed production of natural gas and is still the leading producer. Louisiana production has been growing steadily. In 1969, for example, Louisiana accounted for 35 percent of production, whereas 5 years earlier (1964) that State's contribution was 27 percent. In 1964 Texas produced 42 percent of the marketed natural gas.

The average wellhead price of natural gas in 1969 advanced 0.3 cent to 16.7 cents per mcf, which is a new high. There were more gas and condensate wells completed in 1969; 4,083 as compared with 3,456 in 1968. At the same time, there were fewer gas and condensate wells operating in States such as California as indicated in table 11. California reported 897 wells producing at year end, which was 97 less than a year earlier. The shutdown of these wells also coincided with the drop in production. Marketed production of natural gas in California was 37.2 billion cubic feet less in 1969 than in 1968.

The industrial consumption of natural gas for fuel, including the utilities, overshadowed all other uses. In 1969, industrial fuel use accounted for two-thirds of the total consumption. Within this grouping, natural gas consumed by utilities is the largest industrial use, and that market for natural gas has been expanding vigorously. Over the 5-year period 1965–69, the use of natural gas as fuel for steam generation by utilities has increased from 2,318 billion cubic feet in 1965 to 3,486 billion in 1969, a rise of 50 percent. Half of the increase was in the West South Central area of the United States. This growth is readily understandable because of the proximity of markets to supply.

Shipments of natural gas interstate have not increased as rapidly as intrastate shipments. Intrastate gas is exempt from the

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Table 1.—Salient statistics of natural gas in the United States

	1965	1966	1967	1968	1969
Supply:					
Marketed production [1] million cubic feet	16,039.753	17,206,628	18,171,325	19,322,400	20,698,240
Withdrawn from storage do	959,865	1,141,614	1,132,534	1,329,536	1,379,488
Imports do	456,394	479,780	564,226	651,885	726,951
Total do	17,456,012	18,828,022	19,868,085	21,303,821	22,804,679
Disposition:					
Consumption do	16,033,189	17,191,711	18,172,894	19,459,939	20,922,800
Exports do	26,132	24,639	81,614	93,745	51,304
Stored do	1,077,980	1,210,469	1,317,363	1,425,075	1,498,988
Lost in transmission, etc. do	318,711	401,203	296,214	325,062	331,587
Total do	17,456,012	18,828,022	19,868,085	21,303,821	22,804,679
Value at wellhead:					
Total thousand dollars	2,494,542	2,702,759	2,898,741	3,168,688	3,455,615
Average cents per Mcf	15.6	15.7	16.0	16.4	16.7

[1] Comprises gas sold or consumed by producers, including gas loss due to natural gas liquids recovery, losses in transmission, quantities added to storage, and increases of gas in pipelines.

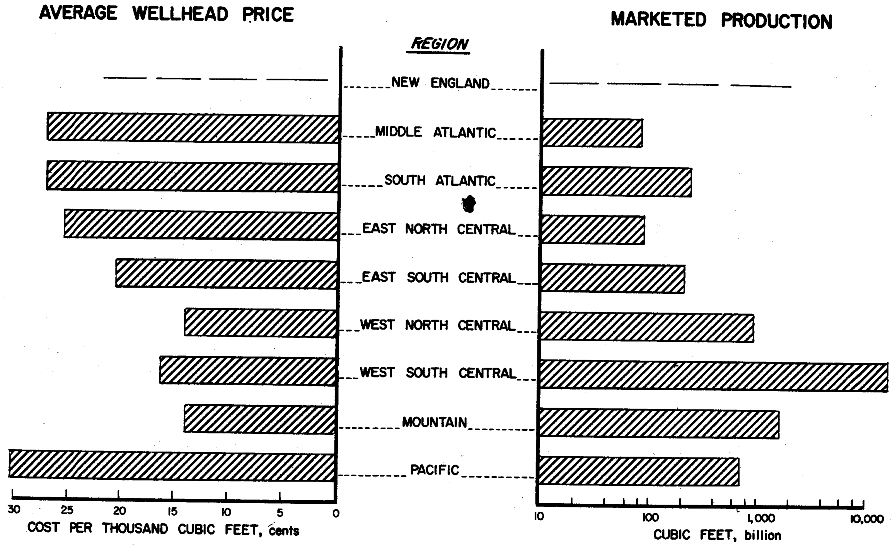

Figure 1.—Marketed production of natural gas by regions and average well head prices.

jurisdiction of the Federal Power Commission, and prices in contracts for new intrastate gas are higher than those allowed for interstate natural gas under FPC regulations. Also, intrastate gas has an added attraction of shorter reserve life requirements than interstate gas; hence, the shift to intrastate sales.

Natural gas processing plants processed 17.7 trillion cubic feet of natural gas in 1969. From this gas, 580 million barrels of natural gas liquids and ethane were recovered. To obtain these liquids 866.6 million cubic feet of natural gas were consumed in the extractive process, a volume 6.7 percent greater than in 1968. About 12.9 trillion cubic feet of this processed natural gas was shipped to transmission pipelines; and additional 1.8 trillion cubic feet was delivered directly to consumers. Comparisons with 1968 in terms of natural gas processed, extraction losses, shipments to tranmission companies, are shown in table 7.

According to American Gas Association (AGA), there were 883,824 miles of gas pipelines at the end of 1969. This includes 242,626 miles of main transmission lines, 64,488 miles of gathering lines, and 576,710 miles of distribution lines. Compared with 1968 figures, main transmission lines increased 8,176 miles, gathering lines 48 miles, distribution lines 13,960 miles for an overall increase of 22,184 miles.

Data on natural gas production, consumption, and value are collected by annual surveys of oil and gas producers, natural gasoline plant operators, gas pipeline companies, and gas utility companies, with separate reports obtained for each State in which they operate.

These reports reflect approximately 80 percent of gross natural gas production. The large number of respondents and the difficulty of canvassing each small producer have made direct acquisition of total production impractical. Most of the output of nonreporting producers has been shown in purchase listings of reporting companies. Marketed production for each State equals consumption in the State, plus losses in transmission, gas placed in storage, and shipment from storage and receipts from other States.

Gas volumes in this chapter are reported or converted to a pressure base of 14.73 pounds per square inch absolute (psia) at 60° F.

Legislation and Government Programs.—Subsequent to the Supreme Court decision upholding Federal Power Commission Opinion 468 in the Permian Basin Area Rate Processing (AR61–1) fixing gas producer rates for interstate sale for resale, the Federal Power Commission issued Opinion 546 on September 25, 1968, in the South

Louisiana Area Rate Proceeding (AR61–2 et al.). Shown below are the three price systems for South Louisiana sales established under Opinion 546:

	Cents at 15.025 psia	
	Onshore and offshore subject to State tax	Federal domain offshore
Gas well gas under contracts dated prior to 1–1–61, and all other gas regardless of contract date	18.5	17.0
Gas well gas (and residue therefrom) under contracts dated between 1–1–61 and 9–30–68	19.5	18.0
Gas well gas (and residue therefrom) under contracts dated 10–1–68 and later	20.0	18.5

Contracts dated October 1, 1968, and later are known as "third vintage" gas.

In a major departure from Opinion 468, which imposed a 2½-year moratorium on price increases above the Permian Basin Ceilings, Opinion 546 directed that the South Louisiana ceilings continue in effect "until such time as they may be changed by the Commission." On March 20, 1969, the FPC issued Opinion 546–A largely affirming but modifying in part its prior decision of September 25, 1968, in the South Louisiana Area Rate Proceeding. One of the major modifications was to lift the indefinite moratorium prescribed by Opinion 546 for offshore "third vintage" contracts (those dated October 1, 1968 or later) to one on which the moratorium would expire January 1, 1974, to the extent of permitting the filing of contracturally authorized rate increases up to a base area rate of 20 cents (that is the same as the base area rate established for third vintage gas contracts subject to Louisiana tax, 1.5 cents higher than the base rate for third vintage Federal Domain contracts).

At the same time Opinion 546–A was issued, the FPC instituted a new proceeding, the Offshore South Louisiana Area Rate Proceeding (AR69–1) in order to determine the need for possible revision of the area ceilings for offshore gas under contracts dated October 1, 1968, and later, and whether a "fourth vintage" ceiling should be established for the future.

The Federal Power Commission also referred to the "clear invitation" extended in Opinion 546 for a petition to reconsider "far offshore" rates whenever there was sufficient evidence indicating a need for a change in price, and to observations in Opinion 546 respecting the unsatisfactory correlation of offshore reserves data with input costs. In addition, the Commission reviewed the New York PSC's request for "an investigation into the adequacy of gas reserves held or controlled by the major producers and pipelines, and the claims of a shortage of natural gas;" a subsequent producer motion for a limited reopening of the South Louisiana record in order "to receive additional evidence demonstrating the substantial changes in supply-demand relationships for natural gas which have occurred since the record was closed over 3 years ago;" and suggestions by certain distributor interveners that the Commission obtain additional evidence as to the need for revision of the offshore price applicable to future contracts. The Commission accordingly concluded that "a further proceeding investigating the correlation between reserves found, including reserves not yet dedicated, and costs incurred in the offshore areas would be in the public interest."

The New York request referred to was prompted by a letter from the President of the American Gas Association to each member of the FPC indicating, among other things, that (1) gas distributors are being refused increases in long-term supplies by pipelines owing to a lack of sufficient price incentives for producers to explore for and develop needed reserves, (2) increasing dedication of reserves to the more attractive intrastate market, (3) pipeline unwillingness to undertake system expansions in the face of inadequate return allowances, and (4) delays in connection of offshore Louisiana reserves to interstate pipeline networks. "To offset an impending shortage," the AGA letter urged that the Commission take a new look at its methods for determining area rates, give renewed encouragement to settlement of area rate cases, reappraise its methods for determining acceptable rates of return and authorize the construction of new offshore Louisiana pipeline facilities in time to permit needed deliveries during the 1969–70 heating season.

In its subsequent request, New York charged that AGA's assertion of a producer "refusal to serve" because of insufficient prices warranted formal investigation on several grounds, including the necessity for "corrective measures" to protect the integrity of the FPC processes "to the extent that the actual or threatened withholding of gas was being used to coerce parties to FPC proceedings to modify their positions." Subsequently, the FPC issued notice of the PSC request for an investigation (R169-470) and provided for the submission of comments by interested parties.

The investigation instituted in AR69-1 encompassed Zones 2, 3 and 4 of offshore Louisiana as described in a 1956 interim agreement between the United States and the State of Louisiana, excluding certain lands awarded to the State by a supplemental decree of the Supreme Court in 1965. The Commission provided, however, that parties may raise the issue whether the geographical demarcation of the new proceeding should be changed.

As in Opinion 546-A, the Commission stated that any higher rates established for "fourth vintage" gas well gas sales from the offshore area would be applied prospectively to "third vintage" sales and would govern refunds pertaining to contractually authorized increased rates filed pursuant to the Opinion 546-A modification of the moratorium as to "third vintage" offshore contracts. However, the Commission declared, any lower area rate established for "fourth vintage" contracts would not be applied to deliveries thereafter made under "third vintage" contracts.

The FPC noted that the data required for correlation of offshore Louisiana gas reserves with the associated costs are in the possession of the lessee in the offshore area. Also, the Commission said, to determine the lag period between investment and production and the unit costs incurred during the buildup period to full production, it is apparently necessary to obtain reserve, production and cost data by leases.

The Commission stressed that it is interested also in the general question of potential supply in the offshore area. Furthermore, the FPC noted, the various pleadings filed "assert a critical supply situation exists which requires prompt remedial action."

Subsequently, the FPC issued notice of a rulemaking proposal (R-394) to terminate the moratorium provisions imposed by Opinions 546 and 546-A respecting rate increases for South Louisiana sales.

The notice stated that "circumstances have changed" since the issue of Opinions 546 and 546-A. Specifically, presently available data indicate (1) a "worsening" supply situation, with new findings of gas falling below production in 2 successive years; (2) a "sharp" drop in the level of gas exploration during 1968 and 1969, which has an adverse impact on future gas supplies; and (3) cost increases which have affected the amount of funds devoted to the industry's exploratory efforts. Thus, in these circumstances, the Commission expressed the opinion that—subject to comments to be filed herein—the moratorium established in Opinions 546 and 546-A should be dissolved "in order to encourage increased exploration and development efforts for natural gas in Southern Louisiana and the dedication of greater volumes of gas from that area to the interstate market."

In the event the moratorium is terminated, the FPC also suggested certain procedures to be followed thereafter. Among other things, the Commission proposes to issue an order providing that the higher of the rates to be established in AR69-1, or those previously established in AR61-2, would constitute a floor for the determination of refunds for all vintages of gas sold subsequent to the date of such order (except that the floor on refunds for new gas sales under contracts dated after July 17, 1970, may be determined in the recently instituted R-389A rulemaking proceeding to fix new contract rates in all areas). This floor would apply to gas sales made as a result of stay orders at rates in excess of Opinion 546 ceilings, as well as to sales which may be made as a result of rate increase filings subsequent to the proposed order. The order also would provide that any rate increase filing made after termination of the moratorium would become effective, subject to refund, 45 days after filing. This lapse, the FPC said, would allow pipeline customers to file rate increases so as to reflect their increased costs of purchased gas. The requirement for the simultaneous submission of supporting schedules would be waived if the pipeline rate increases were limited to tracking producer increases and if the supporting data were filed within the next 4 months.

The FPC invited comments on both the proposal to terminate the moratorium and on measures to be taken in the event the moratorium is ended.

Pipeline Safety.—The Natural Gas Pipeline Safety Act of 1968 (Public Law 90–481), which became law August 13, 1968, provides, among other things, that the Secretary of Transportation, within 2 years, establish minimum Federal safety standards applicable to the design, installation, inspection, testing, construction, extension, operation, replacement, and maintenance of pipeline facilities used in the transportation of natural gas. The Act also provided that the Department of Transportation, or DOT, initially adopt the State standards in effect on August 12, 1968, as the minimum Federal standards in each State. Where there was no State standard, DOT was directed to set as the Federal Standards those common to a majority of the jurisdictions having standards. Thereafter, DOT appointed a Technical Pipeline Safety Standards Committee, as established under the Act, to consider all proposed safety standards.

Consequently, the Department of Transportation published in the Federal Register on August 19, 1970, an amendment of the Code of Federal Regulations to provide minimum Federal safety standards "for the transportation of gas and for pipeline facilities used for this transportation." The new minimum Federal safety standards become effective on November 12, 1970, except for provisions applicable to new pipelines which become effective on March 13, 1971.

In its announcement in the Federal Register, DOT stated that the Office of Pipeline Safety will hold additional hearings on the question of the odorization of gas in transportation lines. On June 10, 1970, that Office issued a notice asking for further comments on a proposal to require odorization of all gas transportation by pipeline—except for gas moved in gathering lines in certain locations, gas enroute to storage fields and gas being delivered for further processing.

CONSUMPTION

More than 20.9 trillion cubic feet of natural gas was consumed in the United States during 1969. This was an increase of 1,463 billion cubic feet, or 7.5 percent, above the volume consumed in 1968. Consumption exceeded production by a sizeable margin both in 1968 and again in 1969.

In 1969, residential and commercial uses absorbed 31.9 percent, and oilfield use, natural gas processing plants, pipeline fuel, and refinery fuel accounted for 18.4 percent of the total 20.9 trillion cubic feet used. Electric utilities burned 16.7 percent; industrial and other uses accounted for 33.0 percent.

Of the 14.2 trillion cubic feet for other than residential and commercial purposes, nearly one-half of the volume was consumed in the West South Central States of Arkansas, Louisiana, Oklahoma, and Texas. Texas produced 7,853.2 billion, which was more gas than any other State, but used 4,324.7 billion or a volume equal to 55.1 percent of the gas produced within the State. Louisiana's consumption of about 1,942.1 billion cubic feet was equal to 26.9 percent of the 7,227.8 billion cubic feet produced in the State.

The U.S. gas industry in 1969, spent $2,998 million for new plants and equipment. Included were $1,569 million for new transmission facilities, $945 million for outlays related to distribution, $191 million for production and regular storage, $152 million for underground storage facilities, and other general expenditures totaling $141 million.

Industrial Uses.—In the industrial use category, electric power utilities in the West South Central region used 1.6 trillion cubic feet of natural gas for steam generation, and this accounted for 45 percent of the 3.5 trillion cubic feet used for this purpose in the entire United States. This is readily understandable, because no other fuel can compete costwise with natural gas in the Southwest. Natural gas also was used extensively in California for steam generation. However, this is due primarily to air pollution controls which restrict the use of other fuels.

Natural gas also was used extensively in the chemical and allied product industries, including carbon black, the metals industry, the building materials industry, the glass industry, foods, and paper and allied products. Next in importance in terms of industrial consumption was the gas used at

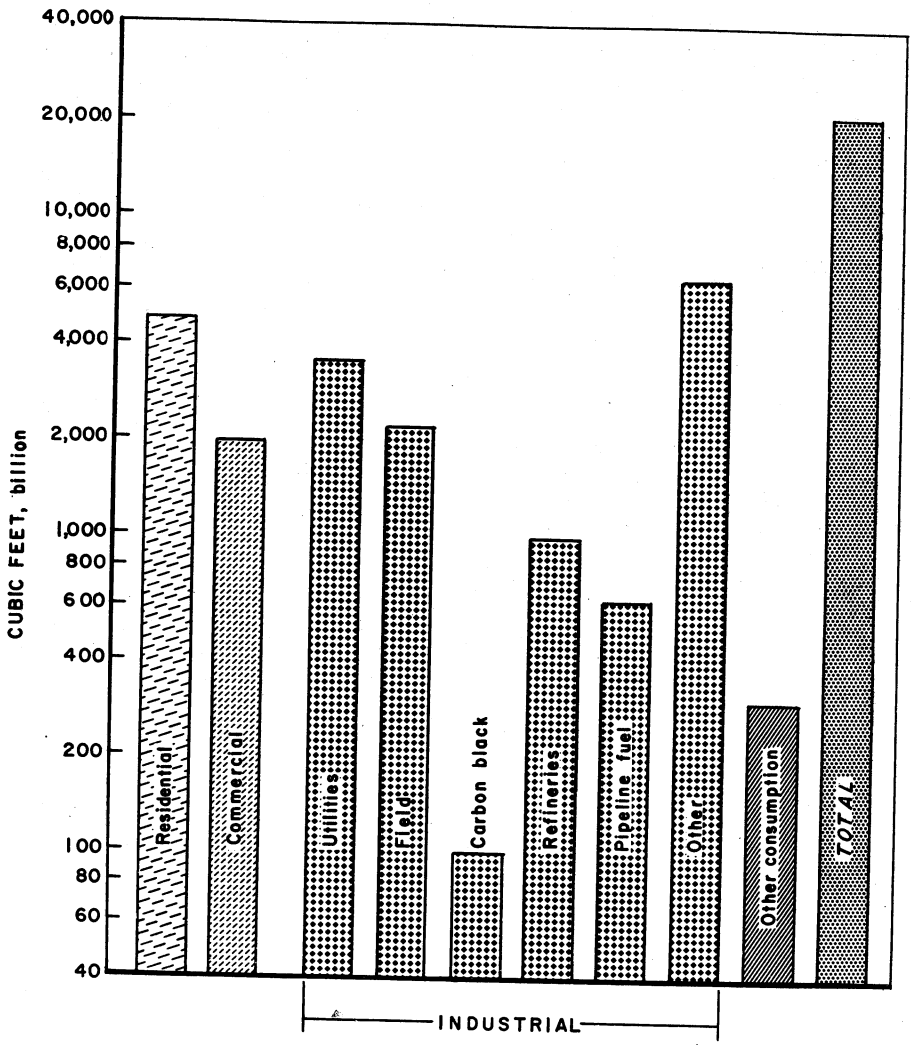

Figure 2.—Disposition of natural gas consumed in the United States by principal use.

natural gas processing plants, in the field for steam generation of electric power for drilling and pumping, as fuel in petroleum refineries, and for use as pipeline fuel in pumping stations. The combined petroleum-related uses in 1969, added to 3.9 trillion cubic feet or 28 percent of the entire industrial use of 13.9 trillion including utilities, in the United States.

Residential and Commercial Uses.—The number of residential and commercial gas consumers increased to 41.3 million at the end of 1969. Included in this category are consumers who solely or partially use gas for such applications as cooking, water heating, air conditioning, and house heating. There was a net increase of 837,000 residential accounts in 1969 and a net gain of 101,000 commercial users. This increase was smaller than the indicated gain in house-heating accounts reported by the American Gas Association (AGA) for 1968, which suggests that for applications other than house-heating, competitive fuels have made some inroads into the overall gas consumer demand.

Result of the AGA Heating Survey showed a net increase of 982,000 in customers who installed gas heating in 1969, bringing the total number of gas individual house-heating customers to over 30.7 million, a gain of 3 percent over the 1968 figure. New homes accounted for 599,000 or 61 percent of this increase; conversion from other fuels in existing dwelling represented 39 percent. In addition to these, 3,661,000 dwelling units in multi-family structures received gas heat from a central or master metered source, bringing the total number of families served by gas heating to 34,388,000, a gain of 4.9 percent over the 1968 figure.

The East North Central region leads the Nation with 7.4 million house-heating customers, and the Pacific region ranks second with nearly 5.9 million house-heating accounts. The AGA forecasts that in the 3-year period ending in 1972, 2.9 million additional heating customers will be recorded.

RESERVES

The Committee of Natural Gas Reserves of the AGA estimated that the total proved recoverable reserves of natural gas in the United States as of December 31, 1969. were 275.1 trillion cubic feet or a decrease of 12.2 trillion cubic feet from a year earlier. This includes proved offshore reserves, but it does not include any estimates of the gas reserves in the new oil and gas province, the North Slope of Alaska. At the end of 1968, proved natural gas reserves were 287.3 trillion cubic feet. During 1969, there were large downward revisions in previous estimates for six of the 12 Railroad Commission of Texas districts, which more than offset an upward revision in the estimate for South Louisiana. New fields discoveries accounted another 1.8 trillion cubic feet, and 2 trillion were from new reservoir discoveries. Total net additions to reserves aggregated about 8.5 trillion cubic feet during 1969, but with a production of 20.7 trillion, the drop in proved reserves of natural gas was 12.2 trillion cubic feet.

The decline in the total number of gas well completions was arrested in 1969 with 4,083 completions as compared with 3,456 in 1968, and this trend continued into the new year. Increases in 1969 of 151 wells in the exploratory category are reported. Also, the number of development wells increased by 476 in 1969. There were 114,476 producing gas wells at the end of 1969.

Index of Selected Jurisdictional Companies.—As of December 31, 1968, there were 117 pipeline companies subject to the Federal Power Commission's jurisdiction, that were engaged in the sale or transportation of natural gas in interstate commerce. Ninety-five of these companies filed with the Federal Power Commission annual reports of gas supply (Form 15 and Form 15–A) for 1968, together with (1) the total volumes of gas which they reported as purchased and produced, (2) the percent of these volumes sold under firm and interruptible sales contracts, and (3) jurisdictional sales for resale made during 1968. A complete list of these companies is available in the Federal Power Commission's publication, "The Gas Supplies of Interstate Natural Gas Pipeline Companies, 1968." The following is a list of 24 companies that have over 900 billion cubic feet of domestic natural gas reserves.

Arkansas Louisiana Gas Co.
Cities Service Gas Co.
Colorado Interstate Gas Co.
Consolidated Gas Supply Corp.
El Paso Natural Gas Co.
Florida Gas Transmission Co.
Kansas-Nebraska Natural Gas Co., Inc.
Michigan Wisconsin Pipe Line Co.
Montana-Dakota Utilities Co.
Mountain Fuel Supply Co.
Natural Gas Pipeline Co. of America
Northern Natural Gas Co.
Panhandle Eastern Pipe Line Co.
South Texas Nat. Gas Gathering Co.
Southern Natural Gas Co.
Tennessee Gas Pipeline Co. (Tenneco, Inc.)
Texas Eastern Transmission Corp.
Texas Gas Transmission Corp.
Transco. Gas Pipe Line Corp.
Transwestern Pipeline Co.
Trunkline Gas Co.
United Fuel Gas Co.
United Gas Pipe Line Co.
West Texas Gathering Co.

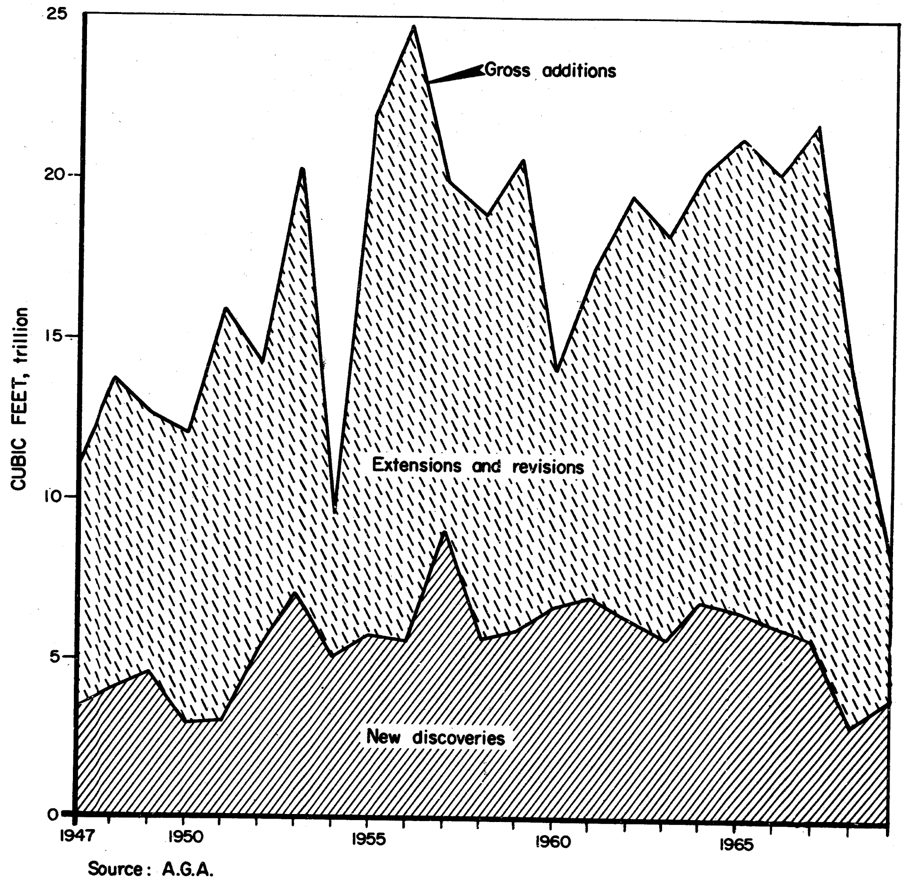

Figure 3.—Trends in annual gross additions to natural gas reserves.

PRODUCTIVE CAPACITY

The Committee on Natural Gas Reserves of the AGA has prepared estimates of the productive capacity of the natural gas industry as of December 31, 1969. The capacity for nonassociated reservoirs is estimated at 79,841 million cubic feet per day, and from associated-dissolved, 20,953. The total is 100,794 million cubic feet per day. The productive capacity of natural gas from nonassociated reservoirs is defined as the maximum sustainable daily rate at which existing gas wells completed in such reservoirs can produce under present conditions to an unlimited market without specific regard to the capacity of existing surface producing equipment and pipelines or established allowables. Capacity of a nonassociated gas well is considered to be the maximum safe rate at which the well is capable of producing through a producing string against back pressures usually maintained during the first 90 days of a given year. This estimate represents potential production, not openflow potential. The productive capacity of associated-dissolved gas is based on the productive capacity of crude oil and the estimated producing gas-oil ratios which would result from such capacity operation during the first 90 days of a given year.

The productive capacity of associated gas from gas wells is usually based on the volumetric withdrawal of crude oil from related oil wells at capacity rates during the first 90 days of a given year.

STORAGE

The development of underground gas storage facilities expanded in 1969 but at a slower pace than 1968. About 143.3 billion cubic feet of capacity was added, which boosted the aggregate to 4.9 trillion cubic feet by yearend 1969.

The ability to store gas in these underground facilities close to markets during off-season periods has been a major factor in the industry's growth. There were 320 pools in 26 States and 80 companies were participating in such facilities at the end of 1969.

In addition to underground storage, there is the growth in aboveground storage for liquefied natural gas (LNG). At present, most of this type of storage is associated with peak shaving facilities of gas distributing utilities and storage facilities for natural gas transmission pipelines. In the United States there were 14 such installations operating in 1969 and two more scheduled for operation in 1970. Inaddition, two companies were expanding existing plants at the 1969 yearend.

The continued growth and expansion of the natural gas industry has created a need for large volume storage near metropolitan areas to meet the winter peak loads. Requirements for natural gas on a peak winter day is currently about seven times that required on a summer day because of growth in use of natural gas for home heating. This places a heavy burden on a local gas utility to supply the gas when needed, particularly if there is a prolonged cold spell; hence, the growth in LNG facilities. The primary purpose of liquefaction is storage. By lowering the temperature at atmospheric pressure to approximately minus 260° F, natural gas volume contracts by a factor of 600 during liquefaction. Relatively small amounts of gas are liquefield over a long period—from 200 to 300 days per year—and stored for use during peak winter loads. The regasification rate, however, is high; in some instances, high enough to empty storage in 5 days. In addition to the conventional peak shaving facilities, which are connected directly with long distance natural gas transmission lines, there is an expanding interest in the import of LNG for base load purposes on a commodity basis and

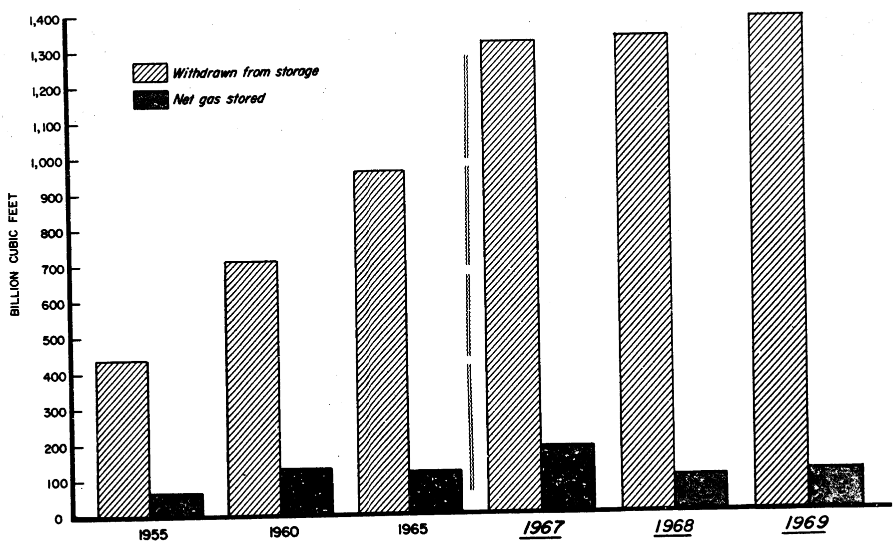

Figure 4.—Trends in net gas stored underground in U.S. storage fields.

not a project basis, such as the two cargoes of LNG from Algeria to Boston Gas in 1968.

The largest, thus far, of proposals to export LNG to the United States is the El Paso Natural Gas plan to import into the United States from Algeria 1 billion cubic feet per day of LNG for 25 years. This proposal is awaiting approval of the United States Government through the Federal Power Commission. Also awaiting approval is the proposal by Distrigas Corporation to import from Algeria LNG at the rate of 6 billion cubic feet annually for 20 years.

In addition Philadelphia Gas Works proposes to import Venezuelan natural gas at a rate of 500 million cubic feet per day. Also from Venezuela, the Columbia Gas System, through its subsidiary Columbia LNG Corporation, proposes to purchase from Esso LNG Co., a subsidiary of Standard Oil Co. (New Jersey), 425,000,000 cubic feet per day of natural gas. All of these proposals are awaiting approval by the United States Government.

VALUE AND PRICE

The average value of natural gas at the wellhead increased 0.3 cent to 16.7 cents per thousand cubic feet (Mcf). Prices at the wellhead, however, range widely with the highest price in States near large consumer markets. In New York, for example, the wellhead price of natural gas is 30 cents; in California, 30.6. Wellhead prices near the large eastern markets are 27 cents for West Virginia and 27.6 cents for Pennsylvania.

On November 3, 1969, the Federal Power Commission reported that the average wholesale prices charged by pipelines to distributing utility companies as of July 1, 1969 ranged from a low of 29.12 cents at Chicago to a high of 69.21 cents per Mcf at Boston. The higher average prices in 10 of the major cities resulted from general rate increases by five natural gas suppliers, according to the FPC.

These were followed by tracking increases of four other companies to which the major suppliers sell gas for resale to distributors in the 10 areas. Most of the increases were subject to refund contingent on the outcome of pending rate proceedings. The largest increase was in Boston, where the price rose from 61.34 cents/Mcf as of July 1, 1968, to 69.21 cents on July 1, 1969. The only decrease was for Chicago, and resulted from an FPC-approved settlement for Natural Gas Pipeline Co. of America. Prices in Baltimore, St. Louis, and Washington, D.C. remained constant during the 12-month period.

The specific charges in the 14 cities are as follows:

Average cents per Mcf (14.73 psia) rged by pipelines to distributors

Metropolitan area	7/1/68	7/1/69
Baltimore	41.58	41.58
Boston	61.34	[1]69.21
Chicago[2]	29.61	29.12
Cleveland[2]	39.05	[1]40.43
Detroit[2]	37.33	[1]39.32
Los Angeles[2]	29.24	[1]30.85
Minneapolis-St. Paul	35.46	36.72
Newark (N.J. Suburbs of N.Y.)[2]	42.63	[1]43.79
New York[2]	40.73	[1]41.63
Philadelphia[2]	41.86	[1]43.56
Pittsburgh[2]	37.40	[1]38.64
St. Louis (Mo. portion only)	33.80	33.80
San Francisco—Oakland[2]	28.13	[1]29.71
Washington, D.C.[2]	46.71	46.71

[1] Reflects rates in effect subject to refund in pending rate cases.

[2] Wholesale service furnished by more than one pipeline company in 1968. Average prices are computed from the weighted average charges of all suppliers.

The average cost of natural gas, of course, varies widely because of transportation costs. In Maine, New Hampshire, and Vermont, for example, the price to residential consumers was $1.97 per Mcf in 1969, as compared with 90 cents in Texas. In West Virginia, which is a producer of natural gas and which has an average wellhead price of 27 cents per Mcf, the price of gas to residential consumers is 88 cents per Mcf, or nearly the same paid by a residential user in Texas.

Costs to commercial consumers follow the same pattern as indicated with residential uses—that is, the highest prices are in New England; the lowest in the West South Central States of Arkansas, Louisiana, Oklahoma, and Texas. The average price of natural gas to commercial users in the latter region was 52.6 cents per Mcf in 1969. In New England, a commercial user paid 1.48 cents per Mcf. Industrial accounts, excluding the electric utilities, averaged 96.4 cents. In the West South Central Region the average was about 21 cents. In the East North Central Region, with consumption second only to that in the Southwest, the average price for an industrial customer was about 49 cents per Mcf

The total value of marketed production of natural gas was $3,455.6 million in 1969 or 9 percent higher than the $3,168.7 million of 1968. The total value of all the natural gas used in 1969 aggregated $10,769.4 million, which was 9.9 percent above the values estimated for 1968.

FOREIGN TRADE

Exports of natural gas, similar to the pattern for imports, involved both Canada and Mexico. Exports to Canada in 1969 fell to 34.9 billion cubic feet or 57.2 percent below the 1968 levels.

Exports to Mexico which exit the United States from Arizona and Texas were 13.4 billion cubic feet or 10.7 percent higher in 1969.

The first large scale commercial export of liquefied natural gas (LNG) from Alaska is a joint venture of the Phillips Petroleum Company and the Marathan Oil Company. A sale has been negotiated for 139,000,000 cubic feet a day of liquefied natural gas to the Tokyo Electric Power Company and the Tokyo Gas Company for an initial 15 year term. The first shipment of LNG arrived in Tokyo Bay in November 1969. A second tanker went into service in January 1970.

Foreign trade in natural gas is increasing steadily in magnitude, particularly imports. During 1969, imports reached a record high of 726.9 billion cubic feet which was 75 billion or 11.5 percent higher than in 1968. Most of United States imports are from Canada and enter at Noyes, Minn.; Eastport, Idaho, and Sumas, Wash. Imports in these regions in 1969 accounted for 621.7 billion cubic feet or 85.5 percent of total imports. Another 47 billion cubic feet, imported from Canada, entered the United States to supply gas utility systems in Montana, upper New York State, and Vermont.

WORLD REVIEW

The United States, the Soviet Union, Canada, and Rumania led the world in production of natural gas. In fact, these four countries accounted for 88 percent of world production, totaling nearly 30 trillion cubic feet as indicated in table 14. Also, Netherlands' production expanded from 514 billion to 773 billion in 1969, an increase of 50.3 percent. The Netherlands is considered to have one of the world's largest gas reserves at Groningen. Some of the gas produced in the Netherlands is moving into markets in West Germany, Belgium, and France.

The Netherlands and Italy signed a 120-billion-cubic-meter (4,237 billion cubic feet) natural gas agreement in 1970. Italy's state owned company Ente Nazionale Idrocarburi (ENI), will buy natural gas over a 20-year period beginning with 1974. Sales of natural gas in the Netherlands in 1969, are reported to have been 759 billion cubic feet and are expected to climb to 989 billion cubic feet in 1970. Of the 989 billion in 1970 350 billion are expected to be exported, as compared with about 265 billion cubic feet exported in 1969.

Developments of gas fields in the North Sea has caused a sharp jump in marketed production of gas in the United Kingdom to 178.7 billion cubic feet in 1969, or more than double the 71.4 billion produced in 1968. The Hewitt Field, located about 20 miles off the eastern coast of Great Britain, started delivery of gas to the British Gas Council's distribution system in 1969. The Gas Council has received approval to construct a third coastal terminal to handle supplies of natural gas from the North Sea. It will be located in Lincolnshire and will initially handle natural gas from the most recent large field found in the North Sea, the Viking Field, discovered by the Conoco/National Coal Board Group. Ultimately, the terminal may have the processing capacity of 3 million cubic feet of natural gas per day from which the natural gas liquids such as natural gasoline, butane, propane could be extracted. The United Kingdom's needs also, are being supplied in part by LNG shipped from Arzew, Algeria, to Canvey Island in the Thames Estuary. Gas from other North Sea gasfields is also entering the British market.

Natural gas use is rapidly becoming an important factor in the energy patterns of many other nations as large gasfields have been found in the Soviet Union, Algeria, United Arab Republic, Austria, Iran, Bolivia, Afghanistan, Pakistan, Canada, and France.

Next to Western Europe gas usage in the Soviet Union is growing faster than in any other part of the world. In 1969, the Soviet Union produced 6.4 trillion cubic feet of natural gas, which is more than four times the 1959 production. Soviet gas now flows into Eastern Europe and Austria.

Italy signed an agreement with the Soviet Union in 1970 for 100 billion cubic meters (3.5 trillion cubic feet) over a 20-year period. The U.S.S.R. will sell natural gas to ENI and in exchange will receive $200 million in Italian industrial products. The Soviet Union, at the same time, has also arranged for large volume imports from Iran and Afghanistan. Natural gas imports into the Soviet Union have been limited thus far to Afghanistan. But completion of the 40 to 48-inch pipelines from south Iranian fields will be followed soon with shipments of natural gas to the U.S.S.R. It is expected that delivery of gas from Iran to the U.S.S.R. will build up gradually so that by 1975 the volumes will have reached 10 billion cubic meters or 353 billion cubic feet annually and be sustained at that level through 1984. Deliveries from Afghanistan, which began in 1967, are expected to expand to 2.5 billion cubic meters (88.2 billion cubic feet) by 1970.

As to Africa, movement of LNG from Algeria to Great Britain has already been mentioned. The other important development, however, will be the movement of LNG from Libya to Italy and to Spain. The Esso Libya project involves the sale of 245 million standard cubic feet per day (scfd) of 1,350-Btu gas (equivalent to 465 million scfd of 1,000-Btu gas). Most of the gas to be liquefied is produced in association with oil. The gas will be liquefied at Marsa el Brega, Libya, and then transported in four LNG tankers to La Spezia, Italy, and Barcelona, Spain. Nearly all of the gas to be liquefied is associated gas from the Zelton field and the Reguba field in the Libyan Desert.

Table 2.—Quantity and value of marketed production of natural gas in the United States

State	1968			1969		
	Quantity (million cubic feet)[1]	Value (thousands)	Average wellhead value, cents per Mcf	Quantity (million cubic feet)[1]	Value (thousands)	Average wellhead value, cents per Mcf
Alabama	230	$30	13.1	180	$24	13.4
Alaska	17,343	4,388	25.3	50,864	12,665	24.9
Arizona	881	142	16.1	1,136	199	17.5
Arkansas	156,627	24,456	15.6	169,257	26,743	15.8
California	714,893	221,077	30.9	677,689	207,440	30.6
Colorado	121,424	16,392	13.5	118,754	17,219	14.5
Florida	108	16	15.2	50	8	15.7
Illinois	4,380	552	12.6	3,800	536	14.1
Indiana	234	55	23.4	171	40	23.6
Kansas	835,555	115,307	13.8	883,156	122,759	13.9
Kentucky	89,024	22,256	25.0	81,304	20,407	25.1
Louisiana	6,416,015	1,212,627	18.9	7,227,826	1,387,743	19.2
Maryland	864	221	25.6	978	248	25.4
Michigan	40,480	10,160	25.1	36,163	9,294	25.7
Mississippi	135,051	22,601	16.7	131,234	23,097	17.6
Missouri	14	4	28.6	126	17	13.8
Montana	19,313	1,757	9.1	41,229	4,205	10.2
Nebraska	8,129	1,423	17.5	6,989	1,209	17.3
New Mexico	1,164,182	156,000	13.4	1,138,133	155,924	13.7
New York	4,632	1,390	31.9	4,861	1,458	30.0
North Dakota	41,023	6,769	16.5	33,587	5,441	16.2
Ohio	42,673	10,540	24.7	49,793	12,837	25.8
Oklahoma	1,390,884	197,506	14.2	1,523,715	233,128	15.3
Pennsylvania	87,987	24,460	27.8	79,134	21,841	27.6
Tennessee	48	9	19.4	57	11	19.6
Texas	7,495,414	1,011,881	13.5	7,853,199	1,075,888	13.7
Utah	46,151	7,292	15.8	46,733	7,197	15.4
Virginia	3,389	1,013	29.9	2,846	845	29.7
West Virginia	236,971	62,086	26.2	231,759	62,575	27.0
Wyoming	248,481	36,278	14.6	303,517	44,617	14.7
Total	19,322,400	3,168,688	16.4	20,698,240	3,455,615	16.7

[1] Marketed production of natural gas represents gross withdrawals less gas used for repressuring and quantities vented and flared.

Table 3.—Marketed production, interstate shipments, and total consumption of natural gas in the United States in 1969

(Million cubic feet)

State by region	Marketed production	Interstate movements: Receipts	Interstate movements: Deliveries	Interstate movements: Net receipts or deliveries (−)	Change in underground storage	Transmission loss and unaccounted for	Consumption
New England:							
Connecticut	-----	148,570	89,137	59,433	-----	1,948	57,485
Maine, New Hampshire, and Vermont	-----	11,577	1,887	9,690	-----	494	9,196
Massachusetts	-----	159,908	21,537	138,371	−253	1,636	136,988
Rhode Island	-----	94,348	71,218	23,130	-----	575	22,555
Total	-----	414,403	183,779	230,624	−253	4,653	226,224
Middle Atlantic:							
New Jersey	-----	801,428	484,644	316,784	206	11,743	304,835
New York	4,861	937,040	234,203	702,837	2,726	21,284	683,688
Pennsylvania	79,134	2,022,425	1,291,854	730,571	4,519	39,152	766,034
Total	83,995	3,760,893	2,010,701	1,750,192	7,451	72,179	1,754,557
East North Central:							
Illinois	3,800	2,230,926	1,073,480	1,157,446	48,160	14,269	1,098,817
Indiana	171	1,802,014	1,254,114	547,900	4,098	12,992	530,981
Michigan	36,163	776,010	29,770	746,240	−3,244	6,369	779,278
Ohio	49,793	2,830,201	1,846,031	984,170	−3,936	5,936	1,031,963
Wisconsin	-----	336,019	17,888	318,131	-----	1,852	316,279
Total	89,927	7,975,170	4,221,283	3,753,887	45,078	41,418	3,757,318
West North Central:							
Iowa	-----	1,296,021	973,565	322,456	−2,306	6,421	318,341
Kansas	883,156	1,956,738	2,251,021	−294,283	632	5,201	583,040
Minnesota	-----	482,966	156,936	326,030	-----	343	325,687
Missouri	126	1,706,524	1,308,335	398,189	−865	483	398,697
Nebraska	6,989	1,276,838	1,073,502	203,336	1,312	−1,618	210,631
North Dakota	33,587	12,823	8,383	4,440	-----	638	37,389
South Dakota	-----	36,258	1,286	34,972	-----	1,146	33,826
Total	923,858	6,768,168	5,773,028	995,140	−1,227	12,614	1,907,611
South Atlantic:							
Delaware	-----	27,559	1,922	25,637	−699	473	25,863
Florida	50	314,216	-----	314,216	-----	658	313,608
Georgia	-----	1,333,701	1,016,515	317,186	-----	5,643	311,543
Maryland and District of Columbia	978	830,054	661,936	168,118	−4,136	4,288	168,944
North Carolina	-----	848,423	710,066	138,357	-----	1,706	136,651
South Carolina	-----	994,488	848,423	146,065	-----	5,239	140,826
Virginia	2,846	957,370	823,196	134,174	2,009	6,263	128,748

West Virginia	231,759	1,356,800	1,408,566	−51,766	1,972	−259	178,280
Total	235,633	6,662,611	5,470,624	1,191,987	−854	24,011	1,404,463
East South Central:							
Alabama	180	3,162,432	2,863,081	299,351	142	−1,739	301,128
Kentucky	81,304	3,658,171	3,480,571	177,600	3,760	11,683	243,461
Mississippi	131,234	6,062,845	5,860,437	202,408	−905	7,048	327,499
Tennessee	57	3,921,292	3,657,812	263,480	-----	15,680	247,857
Total	212,775	16,804,740	15,861,901	942,839	2,997	32,672	1,119,945
West South Central:							
Arkansas	169,257	2,711,753	2,519,758	191,995	661	7,126	353,465
Louisiana	7,227,826	1,278,995	6,522,705	−5,243,710	15,232	26,812	1,942,072
Oklahoma	1,523,715	1,376,159	2,263,047	−886,888	16,159	17,207	603,461
Texas	7,853,199	485,293	3,993,263	−3,507,970	3,361	17,167	4,324,701
Total	16,773,997	5,852,200	15,298,773	−9,446,573	35,413	68,312	7,223,699
Mountain:							
Arizona	1,136	1,421,296	1,226,680	194,616	-----	276	195,476
Colorado	118,754	253,398	89,723	163,675	535	5,399	276,495
Idaho	-----	402,737	360,618	42,119	-----	683	41,436
Montana	41,229	71,177	20,789	50,388	9,555	3,074	78,988
Nevada	-----	44,899	-----	44,899	-----	759	44,140
New Mexico	1,138,133	745,257	1,564,480	−819,223	218	16,303	302,389
Utah	46,733	220,174	141,310	78,864	213	2,093	123,291
Wyoming	303,517	74,071	258,667	−184,596	3,674	2,636	112,611
Total	1,649,502	3,233,009	3,662,267	−429,258	14,195	31,223	1,174,826
Pacific:							
Alaska	50,864	-----	2,982	−2,982	[1] 2,581	2,387	42,914
California	677,689	1,452,623	-----	1,452,623	13,027	38,417	2,078,868
Oregon	-----	350,678	260,308	90,370	-----	2,516	87,854
Washington	-----	487,810	341,012	146,798	1,092	1,185	144,521
Total	728,553	2,291,111	604,302	1,686,809	16,700	44,505	2,354,157
Total United States	20,698,240	[2] 53,762,305	[3] 53,086,658	675,647	119,500	331,587	20,922,800

[1] Liquefied natural gas.

[2] Includes receipts from Canada of 312,096 million cubic feet into Idaho; 171,938 million cubic feet into Washington; 137,687 million cubic feet into Minnesota; 39,830 million cubic feet into Montana; 16,460 million cubic feet into New York; 2,095 million cubic feet into Vermont and from Mexico 46,845 million cubic feet into Texas.

[3] Includes deliveries into Canada of 29,765 million cubic feet from Michigan; 5,054 million cubic feet from New York; 112 million cubic feet from Montana and into Mexico 9,511 million cubic feet from Texas and 3,880 million cubic feet from Arizona, also 2,982 million cubic feet from Alaska to Japan (LNG).

Table 4.—Interstate pipeline movements of natural gas in the United States, 1969

(Billion cubic feet at 14.73 psia)

Region and State and State abbreviation	Net receipt or delivery (−)	Moved from (receipts)						Moved to (deliveries)					
		State	Quantity	State	Quantity	State	Quantity	State	Quantity	State	Quantity	State	Quantity
New England:													
Connecticut (CT)	59.4	NY	139.8	MA	8.7	----	-------	RI	89.1	----	-------	----	-------
Maine (ME), New Hampshire (NH), Vermont (VT)	9.7	MA	7.6	CN	2.1	----	-------	----	-------	----	-------	----	-------
Massachusetts (MA)	138.4	NY	88.7	RI	71.2	----	-------	CT	8.7	NH	7.6	RI	5.2
Rhode Island (RI)	23.1	CT	89.1	MA	5.2	----	-------	MA	71.2	----	-------	----	-------
Total	230.6	NY	228.5	CN	2.1	----	-------	----	-------	----	-------	----	-------
Middle Atlantic:													
New Jersey (NJ)	316.8	PA	801.0	NY	.5	----	-------	NY	484.7	----	-------	----	-------
New York (NY)	702.8	NJ	484.7	PA	435.9	CN	16.5	CT	139.8	MA	88.7	CN	5.1
	-------	----	-------	----	-------	----	-------	PA	.2	NJ	.5	----	-------
Pennsylvania (PA)	730.6	WV	799.8	MD	661.9	OH	560.6	NJ	801.0	NY	435.9	DE	27.6
	-------	NY	.2	----	-------	----	-------	OH	17.1	MD	5.1	WV	5.2
Total	1,750.3	WV	794.6	MD	656.8	OH	543.5	CT	139.8	MA	88.7	DE	27.6
	-------	CN	16.5	----	-------	----	-------	CN	5.1	----	-------	----	-------
East North Central:													
Illinois (IL)	1,157.4	MO	1,069.4	IA	618.0	KY	441.4	IN	886.9	WI	186.6	----	-------
	-------	IN	102.1	----	-------	----	-------	----	-------	----	-------	----	-------
Indiana (IN)	547.9	IL	886.9	KY	915.1	----	-------	OH	1,029.5	IL	102.1	MI	122.5
Michigan (MI)	746.2	OH	635.6	IN	122.5	WI	17.9	CN	29.8	----	-------	----	-------
Ohio (OH)	984.2	KY	1,426.3	IN	1,029.5	WV	357.2	WV	649.7	MI	635.6	PA	560.6
	-------	PA	17.1	----	-------	----	-------	----	-------	----	-------	----	-------
Wisconsin (WI)	318.1	IL	186.6	MN	149.4	----	-------	MI	17.9	----	-------	----	-------
Total	3,753.8	KY	2,782.8	MO	1,069.4	IA	618.0	PA	543.5	WV	292.5	CN	29.8
	-------	MN	149.4	----	-------	----	-------	----	-------	----	-------	----	-------
West North Central:													
Iowa (IA)	322.5	NB	1,061.2	MO	234.5	SD	.4	IL	618.0	MN	344.9	SD	10.7
Kansas (KA)	−294.3	OK	1,952.8	MO	3.9	----	-------	NB	1,250.0	MO	913.3	CO	59.0
	-------	----	-------	----	-------	----	-------	OK	28.7	----	-------	----	-------
Minnesota (MN)	326.0	IA	344.9	CN	137.7	SD	.4	WI	149.4	ND	7.6	----	-------
Missouri (MO)	398.2	KA	913.3	AR	793.3	----	-------	IL	1,069.4	IA	234.5	KA	3.9
	-------	----	-------	----	-------	----	-------	AR	.6	----	-------	----	-------
Nebraska (NE)	203.3	KA	1,250.0	WY	20.7	CO	6.1	IA	1,061.2	SD	10.2	CO	2.1
North Dakota (ND)	4.4	MN	7.6	MT	5.2	----	-------	MT	8.4	----	-------	----	-------
South Dakota (SD)	35.0	IA	10.7	NB	10.2	MT	15.4	WY	.5	IA	.4	MN	.4
Total	995.1	OK	1,924.0	AR	793.3	CN	137.7	IL	1,687.4	WI	149.4	CO	55.0
	-------	WY	20.0	MT	12.2	----	-------	----	-------	----	-------	----	-------
South Atlantic:													
Delaware (DE)	25.6	PA	27.6	----	-------	----	-------	MD	2.0	----	-------	----	-------
Florida (FL)	314.2	AL	304.8	GA	9.4	----	-------	----	-------	----	-------	----	-------
Georgia (GA)	317.2	AL	1,333.7	----	-------	----	-------	SC	994.5	TN	12.6	FL	9.4
Maryland & D. C. (MD)	168.1	VA	818.7	PA	5.1	WV	4.4	PA	661.9	----	-------	----	-------
	-----	DE	2.0	----	-------	----	-------	----	-------	----	-------	----	-------
North Carolina (NC)	138.4	SC	848.4	----	-------	----	-------	VA	710.0	----	-------	----	-------
South Carolina (SC)	146.1	GA	994.5	----	-------	----	-------	NC	848.4	----	-------	----	-------
Virginia (VA)	134.2	NC	710.0	WV	239.3	TN	8.0	MD	818.7	WV	4.0	KY	.4

West Virginia (WV)	-51.8	OH	649.7	PA	5.2	KY	697.7	PA	799.8	OH	357.2	VA	239.3
	-----	VA	4.0	----	-------	----	-------	KY	7.7	MD	4.4	----	-------
Total	1,192.0	AL	1,638.5	KY	689.4	OH	292.5	PA	1,423.8	TN	4.6	----	-------
East South Central:													
Alabama (AL)	299.4	MS	3,162.4	----	-------	----	-------	GA	1,333.7	TN	1,211.9	FL	304.8
	-----	----	-------	----	-------	----	-------	MS	12.6	----	-------	----	-------
Kentucky (KY)	177.6	TN	3,650.0	WV	7.7	VA	.4	OH	1,426.3	IN	915.1	WV	697.7
	-----	----	-------	----	-------	----	-------	IL	441.4	----	-------	----	-------
Mississippi (MS)	202.4	LA	4,331.6	AR	1,718.6	AL	12.6	AL	3,162.4	TN	2,696.7	LA	1.3
Tennessee (TN)	263.5	MS	2,696.7	AL	1,211.9	GA	12.6	KY	3,650.0	VA	8.0	----	-------
Total	942.9	LA	4,330.3	AR	1,718.6	----	-------	OH	1,426.3	GA	1,321.0	IN	915.1
	-------	----	-------	----	-------	----	-------	WV	689.8	IL	441.4	FL	304.8
	-----	----	-------	----	-------	----	-------	VA	7.6	----	-------	----	-------
West South Central:													
Arkansas (AR)	192.0	LA	1,966.3	TX	621.5	OK	123.4	IA	.4	MS	1,718.6	MO	793.3
	-----	MO	.6	----	-------	----	-------	TX	7.5	----	-------	----	-------
Louisiana (LA)	-5,243.7	TX	1,277.4	MS	1.3	AR	.4	AR	1,966.3	MS	4,331.6	TX	224.9
Oklahoma (OK)	-886.9	TX	1,347.4	KA	28.7	----	-------	KA	1,952.8	TX	86.5	AR	123.4
	-------	----	-------	----	-------	----	-------	CO	100.3	----	-------	----	-------
Texas (TX)	-3,508.0	LA	224.9	NM	119.6	OK	86.5	AR	621.5	LA	1,227.4	NM	737.5
	-------	MX	46.8	AR	7.5	----	-------	OK	1,347.4	MX	9.5	----	-------
Total	-9,446.6	MX	46.8	----	-------	----	-------	MS	6,048.9	KA	1,924.1	MO	792.7
	-----	----	-------	----	-------	----	-------	NM	617.9	CO	100.3	MX	9.5
Mountain:													
Arizona (AZ)	194.6	NM	1,419.7	UT	1.7	----	-------	CA	1,193.7	NV	22.6	NM	6.6
	-----	----	-------	----	-------	----	-------	MX	3.9	----	-------	----	-------
Colorado (CO)	163.7	OK	100.3	WY	66.8	KA	59.0	UT	72.0	WY	10.4	NB	6.1
	-----	NM	25.2	NB	2.1	----	-------	NM	1.2	----	-------	----	-------
Idaho (ID)	42.1	CN	312.1	UT	76.5	WA	14.1	WA	314.5	OR	23.8	NV	22.3
Montana (MT)	50.4	CN	39.8	WY	23.0	ND	8.4	SD	15.4	ND	5.3	CN	.1
Nevada (NV)	44.9	AZ	22.6	ID	22.3	----	-------	----	-------	----	-------	----	-------
New Mexico (NM)	-819.2	TX	737.5	AZ	6.6	CO	1.2	AZ	1,419.7	TX	119.6	CO	25.2
Utah (UT)	78.9	WY	148.2	CO	72.0	----	-------	WY	63.2	ID	76.5	AZ	1.7
Wyoming (WY)	-184.6	UT	63.2	CO	10.4	SD	.5	UT	148.2	CO	66.8	MT	23.0
	-----	----	-------	----	-------	----	-------	NB	20.7	----	-------	----	-------
Total	-429.2	TX	617.8	CN	351.9	OK	100.3	CA	1,193.7	WA	300.4	NB	24.0
	-----	KA	59.0	ND	3.1	----	-------	SD	14.9	OR	23.8	MX	3.0
	-----	----	-------	----	-------	----	-------	CN	.1	----	-------	----	-------
Pacific:													
Alaska (AK)	-3.0	----	-------	----	-------	----	-------	JA	3.0	----	-------	----	-------
California (CA)	1,452.6	AZ	1,193.7	OR	258.9	----	-------	----	-------	----	-------	----	-------
Oregon (OR)	90.4	WA	326.9	ID	23.8	----	-------	CA	253.9	WA	1.4	----	-------
Washington (WA)	146.8	ID	314.5	CN	171.9	OR	1.4	OR	326.9	ID	14.1	----	-------
Total	1,686.8	AZ	1,193.7	ID	324.2	CN	171.9	JA	3.0	----	-------	----	-------
Total United States	675.6	----	-------	----	-------	----	-------	----	-------	----	-------	----	-------
Foreign:													
Canada (CN)	-----	----	680.1	----	-------	----	-------	----	34.9	----	-------	----	-------
Mexico (MX)	-----	----	46.8	----	-------	----	-------	----	13.4	----	-------	----	-------
Japan (JA)	-----	----	-------	----	-------	----	-------	----	3.0	----	-------	----	-------

Note: Detail figures may not add to totals shown because of independent rounding.

Table 5.—Quantity and value of natural gas delivered

Region and State	Residential: Number of consumers (thousands)	Residential: Quantity (million cubic feet) [3]	Residential: Value (thousands)	Commercial: Number of consumers (thousands)	Commercial: Quantity (million cubic feet) [3]	Commercial: Value (thousands)
New England:						
Connecticut	367	29,048	$52,751	27	9,231	$14,170
Maine, New Hampshire, Vermont	75	4,910	9,671	5	1,832	2,878
Massachusetts	977	78,451	145,527	62	27,305	39,783
Rhode Island	152	11,374	20,246	9	3,596	5,293
Total	1,571	123,783	228,195	103	41,964	62,124
Middle Atlantic:						
New Jersey	1,572	145,487	269,733	168	33,542	46,925
New York	3,852	331,326	455,242	270	109,943	136,659
Pennsylvania	2,212	295,027	347,837	140	87,418	81,124
Total	7,636	771,840	1,072,812	578	230,903	264,708
East North Central:						
Illinois	2,725	434,065	436,235	204	183,180	132,622
Indiana	988	156,699	146,984	103	69,666	55,524
Michigan	1,863	333,264	327,932	157	127,848	104,324
Ohio	2,429	456,414	397,080	187	155,584	117,310
Wisconsin	737	101,124	117,405	57	40,515	38,125
Total	8,742	1,481,566	1,425,636	708	576,793	447,905
West North Central:						
Iowa	558	91,219	85,563	71	51,958	34,864
Kansas	595	94,320	60,365	58	46,536	20,709
Minnesota	581	95,580	102,557	51	45,720	35,113
Missouri	974	151,778	134,475	88	67,218	43,423
Nebraska	314	55,163	45,840	48	34,370	20,210
North Dakota	47	7,661	7,263	7	6,919	4,477
South Dakota	73	12,906	12,983	10	9,017	5,780
Total	3,142	508,627	449,046	333	261,738	164,576
South Atlantic:						
Delaware	76	7,475	11,242	5	2,526	3,092
Florida	343	11,636	28,915	26	20,004	21,584
Georgia	736	87,879	89,285	57	36,734	25,604
Maryland and District of Columbia	809	84,406	119,944	63	30,963	35,027
North Carolina	281	27,784	34,758	39	16,355	17,565
South Carolina	205	18,162	24,155	24	11,526	10,604
Virginia	445	46,663	66,495	47	23,052	23,744
West Virginia	348	56,366	49,489	30	18,266	12,896
Total	3,243	340,371	424,283	291	159,426	150,116
East South Central:						
Alabama	536	54,804	59,736	38	35,490	19,803
Kentucky	522	83,815	67,052	50	32,741	21,904
Mississippi	316	30,233	26,605	36	15,124	8,817
Tennessee	384	45,396	40,221	51	37,726	26,597
Total	1,758	214,248	193,614	175	121,081	77,121
West, South Central:						
Arkansas	373	58,322	41,292	53	37,857	19,042
Louisiana	823	82,965	62,307	71	32,680	15,523
Oklahoma	628	75,310	61,754	66	36,217	18,652
Texas	2,494	220,728	198,434	239	92,071	51,468
Total	4,318	437,325	363,787	429	198,825	104,685
Mountain:						
Arizona	383	28,426	29,478	38	16,719	10,951
Colorado	542	81,068	55,613	66	50,843	28,116

See footnotes at end of table.

to consumers by type of consumer and by State, 1969

Industrial [1]		Electric utilities		Other consumers [2]		Total	
Quantity (million cubic feet) [3] [4]	Value (thousands)	Quantity (million cubic feet) [2] [5]	Value (thousands)	Quantity (million cubic feet) [3]	Value (thousands)	Quantity (million cubic feet) [3]	Value (thousands)
15,651	$15,933	290	$98	3,204	$3,576	57,424	$86,528
1,948	1,663	----------	----------	506	395	9,196	14,607
22,257	21,723	5,494	1,846	2,516	2,312	136,023	211,191
6,170	5,035	1,143	418	254	335	22,537	31,327
46,026	44,354	6,927	2,362	6,480	6,618	225,180	343,653
76,953	52,790	47,263	15,975	968	809	304,213	386,232
113,561	72,906	107,260	40,866	18,339	16,377	680,429	722,050
340,840	187,462	7,188	2,444	8,302	6,575	738,775	625,442
531,354	313,158	161,711	59,285	27,609	23,761	1,723,417	1,733,724
358,731	165,016	81,355	25,220	5,826	2,068	1,063,157	761,161
269,736	112,750	20,558	6,023	2,748	1,932	519,407	323,213
286,856	150,026	15,566	5,822	2,214	1,408	765,748	589,512
367,679	195,238	17,477	6,746	19,788	14,069	1,016,942	730,443
128,385	68,686	31,384	11,110	11,800	3,882	313,208	239,208
1,411,387	691,716	166,340	54,921	42,376	23,359	3,678,462	2,643,537
90,674	28,200	67,848	18,523	742	267	302,441	167,417
156,913	37,816	160,684	43,545	7,526	2,115	465,979	164,550
92,765	36,735	64,117	16,414	24,512	11,643	322,694	202,462
100,821	37,405	57,612	14,173	11,801	3,576	389,230	233,052
50,303	15,896	45,179	12,063	11,671	3,361	196,686	97,370
2,805	1,004	75	26	525	314	17,985	13,084
6,269	1,975	3,435	1,041	2,184	998	33,811	22,777
500,550	159,031	398,950	105,785	58,961	22,274	1,728,826	900,712
11,967	6,773	3,895	1,313	----------	----------	25,863	22,420
90,481	32,302	180,307	65,091	4,717	1,425	307,145	149,317
142,965	54,041	34,833	9,927	2,286	1,628	304,697	180,485
40,926	27,543	6,541	2,067	3,711	3,317	166,547	187,898
70,189	35,516	8,339	2,869	8,169	5,367	130,836	96,075
77,946	32,659	28,927	8,910	1,412	631	137,973	76,959
42,284	21,142	4,482	1,282	4,103	2,560	120,584	115,223
91,182	41,305	759	238	3,268	2,271	169,841	106,199
567,940	251,281	268,083	91,697	27,666	17,199	1,363,486	934,576
173,508	56,043	14,757	3,822	1,785	774	280,344	140,178
65,639	29,209	7,013	1,936	9,193	5,258	198,401	125,359
123,854	34,431	89,632	24,111	2,543	977	261,386	94,941
117,205	43,366	18,239	4,250	3,343	1,635	221,909	116,069
480,206	163,049	129,641	34,119	16,864	8,644	962,040	476,547
147,927	39,349	85,155	22,055	2,105	674	331,366	122,412
963,897	206,274	316,965	68,781	21,330	5,141	1,417,837	358,026
116,260	28,949	196,060	39,604	4,934	2,117	428,781	151,076
1,714,167	341,119	973,423	214,153	48,783	13,074	3,049,172	818,248
2,942,251	615,691	1,571,603	344,593	77,152	21,006	5,227,156	1,449,762
58,654	24,635	56,966	19,141	7,782	3,354	168,547	87,559
86,682	23,231	48,021	10,853	1,413	507	268,027	118,320

Table 5.—Quantity and value of natural gas delivered

Region and State	Residential			Commercial		
	Number of consumers (thousands)	Quantity (million cubic feet) [3]	Value (thousands)	Number of consumers (thousands)	Quantity (million cubic feet) [3]	Value (thousands)
Mountain—Continued						
Idaho	69	6,980	$9,563	11	5,325	$5,320
Montana	133	21,463	18,973	19	14,239	9,170
Nevada	64	6,297	9,357	4	4,577	4,197
New Mexico	223	28,061	25,536	23	15,091	9,326
Utah	236	43,948	36,477	16	9,425	5,457
Wyoming	74	16,592	11,299	12	12,502	5,726
Total	1,724	232,835	196,296	189	128,721	78,263
Pacific:						
Alaska	14	4,573	6,937	4	5,218	5,108
California	5,515	562,127	521,654	357	202,946	140,033
Oregon	182	20,507	30,576	23	9,965	12,675
Washington	251	30,479	41,512	32	16,943	18,807
Total	5,962	617,686	600,679	416	235,072	176,623
Total United States	38,096	4,728,281	4,954,348	3,222	1,954,523	1,526,121

[1] Includes refinery fuel use.
[2] Includes deliveries to municipalities and public authorities for institutional heating, street lighting, etc.
[3] Quantities in million cubic feet at 14.73 psia.
[4] Includes 98,251 million cubic feet used for carbon black production.
[5] Source: Federal Power Commission.

to consumers by type of consumer and by State, 1969—Continued

Industrial [1]		Electric utilities		Other consumers [2]		Total	
Quantity (million cubic feet) [3,4]	Value (thousands)	Quantity (million cubic feet) [2,5]	Value (thousands)	Quantity (million cubic feet) [3]	Value (thousands)	Quantity (million cubic feet) [3]	Value (thousands)
25,485	$11,315	----------	----------	1,288	$711	39,078	$26,909
31,917	10,788	1,520	$357	2,354	949	71,493	40,237
9,796	4,829	19,843	7,977	3,627	1,969	44,140	28,329
67,191	16,865	54,170	15,113	13,589	4,199	178,102	71,039
60,639	17,767	3,528	967	17	11	117,557	60,679
42,665	10,282	2,475	527	1,567	381	75,801	28,215
383,029	119,712	186,523	54,935	31,637	12,081	962,745	461,287
13,653	4,942	6,618	2,177	5,800	2,053	35,862	21,217
589,750	231,182	589,531	195,724	3,915	1,742	1,948,269	1,090,335
53,271	22,800	464	171	----------	----------	84,207	66,222
92,335	36,472	----------	----------	223	103	139,980	96,894
749,009	295,396	596,613	198,072	9,938	3,898	2,208,318	1,274,668
7,611,752	2,653,388	3,486,391	945,769	298,683	138,840	18,079,630	10,218,466

Table 6.—Consumption of natural gas by use and by State, 1969

Region and State	Delivered to consumers		Extraction loss		Lease and plant fuel		Pipeline fuel		Total	
	Quantity (million cubic feet) [1]	Value (thousands)	Quantity (million cubic feet) [1]	Value (thousands)	Quantity (million cubic feet) [1]	Value (thousands)	Quantity (million cubic feet) [1]	Value (thousands)	Quantity (million cubic feet) [1]	Value (thousands)
New England:										
Connecticut	57,424	$86,528	---	---	---	---	61	$18	57,485	$86,546
Maine, New Hampshire, and Vermont	9,196	14,607	---	---	---	---	---	---	9,196	14,607
Massachusetts	136,023	211,191	---	---	---	---	965	242	136,988	211,433
Rhode Island	22,537	31,327	---	---	---	---	18	7	22,555	31,334
Total	225,180	343,653	---	---	---	---	1,044	267	226,224	343,920
Middle Atlantic:										
New Jersey	304,213	386,232	---	---	---	---	622	132	304,835	386,364
New York	680,429	722,050	---	---	561	$245	2,698	672	683,688	722,967
Pennsylvania	738,775	625,442	93	$28	1,924	816	25,242	6,159	766,034	632,445
Total	1,723,417	1,733,724	93	28	2,485	1,061	28,562	6,963	1,754,557	1,741,776
East North Central:										
Illinois	1,063,157	761,161	13,425	2,698	542	131	21,693	4,360	1,098,817	768,350
Indiana	519,407	323,213	---	---	---	---	11,574	2,454	530,981	325,667
Michigan	765,748	589,512	2,705	722	2,074	288	8,751	2,354	779,278	592,876
Ohio	1,016,942	730,443	---	---	2,879	987	12,142	2,756	1,031,963	734,186
Wisconsin	313,208	239,208	---	---	---	---	3,071	703	316,279	239,911
Total	3,678,462	2,643,537	16,130	3,420	5,495	1,406	57,231	12,627	3,757,318	2,660,990
West North Central:										
Iowa	302,441	167,417	---	---	---	---	15,900	2,639	318,341	170,056
Kansas	465,979	164,550	35,813	5,479	17,587	3,553	63,661	10,886	583,040	184,468
Minnesota	322,694	202,462	---	---	---	---	2,993	664	325,687	203,126
Missouri	389,230	233,052	---	---	---	---	9,467	1,912	398,697	234,964
Nebraska	196,686	97,370	598	101	1,877	400	11,470	1,721	210,631	99,592
North Dakota	17,985	13,084	4,707	890	14,691	2,277	6	1	37,389	16,252
South Dakota	33,811	22,777	---	---	---	---	15	3	33,826	22,780
Total	1,728,826	900,712	41,118	6,470	34,155	6,230	103,512	17,826	1,907,611	931,238
South Atlantic:										
Delaware	25,863	22,420	---	---	---	---	---	---	25,863	22,420
Florida	307,145	149,317	1,723	501	176	30	4,564	890	313,608	150,738
Georgia	304,697	180,485	---	---	---	---	6,846	1,328	311,543	181,813
Maryland and District of Columbia	166,547	187,898	---	---	381	180	2,016	385	168,944	188,463
North Carolina	130,836	96,075	---	---	---	---	5,815	1,146	136,651	97,221
South Carolina	137,973	76,959	---	---	---	---	2,853	613	140,826	77,572
Virginia	120,584	115,223	---	---	211	71	7,953	1,559	128,748	116,853
West Virginia	169,841	106,199	8,439	2,245	---	---	---	---	178,280	108,444
Total	1,363,486	934,576	10,162	2,746	768	281	30,047	5,921	1,404,463	943,524

East South Central:										
Alabama	280,344	140,178	236	45	150	59	20,398	3,998	301,128	144,280
Kentucky	198,401	125,359	8,579	1,621	2,277	485	34,204	7,833	243,461	135,298
Mississippi	261,386	94,941	1,334	253	8,521	1,414	56,258	10,970	327,499	107,578
Tennessee	221,909	116,069	-	-	986	233	24,962	4,918	247,857	121,220
Total	962,040	476,547	10,149	1,919	11,934	2,191	135,822	27,719	1,119,945	508,376
West South Central:										
Arkansas	331,366	122,412	3,475	841	6,268	1,109	12,356	2,235	353,465	126,598
Louisiana	1,417,837	358,026	179,117	5,445	273,213	52,730	71,905	3,806	1,942,072	420,007
Oklahoma	428,781	151,076	57,270	9,335	103,361	14,574	14,049	23,181	603,461	198,166
Texas	3,049,172	818,248	447,325	128,382	741,902	127,607	86,302	14,412	4,324,701	1,088,649
Total	5,227,156	1,449,762	687,187	144,003	1,124,744	196,020	184,612	43,635	7,223,699	1,833,420
Mountain:										
Arizona	168,547	87,559	-	-	34	5	26,895	4,115	195,476	91,679
Colorado	268,027	118,320	4,058	759	2,604	315	1,806	307	276,495	119,701
Idaho	39,078	26,909	-	-	-	-	2,358	507	41,436	27,416
Montana	71,493	40,237	705	103	6,183	791	607	64	78,988	41,195
Nevada	44,140	28,329	-	-	-	-	-	-	44,140	28,329
New Mexico	178,102	71,039	50,484	7,522	45,309	5,120	28,494	4,388	302,389	88,069
Utah	117,557	60,679	3,412	611	2,113	317	209	44	123,291	61,651
Wyoming	75,801	28,215	12,540	1,931	19,964	2,715	4,306	710	112,611	33,571
Total	962,745	461,287	71,199	10,926	76,207	9,263	64,675	10,135	1,174,826	491,611
Pacific:										
Alaska	35,862	21,217	188	48	6,864	1,146	-	-	42,914	22,411
California	1,948,269	1,090,335	30,334	10,496	82,996	21,247	17,269	5,198	2,078,868	1,127,276
Oregon	84,207	66,222	-	-	-	-	3,647	788	87,854	67,010
Washington	139,980	96,894	-	-	-	-	4,541	981	144,521	97,875
Total	2,208,318	1,274,668	30,522	10,544	89,860	22,393	25,457	6,967	2,354,157	1,314,572
Total United States	18,079,630	10,218,466	866,560	180,056	1,345,648	238,845	630,962	132,060	20,922,800	10,769,427

[1] Quantities in million cubic feet at 14.73 psia.

Table 7.—Production of natural gas liquids at natural gas processing plants, and disposition of residue gas in the United States, by States

(Million cubic feet at 14.73 psia at 60° F unless otherwise stated)

State	Total natural gas liquids and ethane production (thousand barrels) [1]	Natural gas processed	Extraction loss (shrinkage)	Disposition of residue gas: Used at plants	Returned to formation	Vented or flared	Shipped to transmission companies	Direct deliveries to consumers	Unaccounted for	Total
1968										
Arkansas	2,188	88,011	3,667	6,204	541	26	58,189	19,288	96	84,344
California	21,992	476,596	32,639	27,471	106,221	330	211,125	97,776	1,034	443,957
Colorado	3,276	96,397	4,546	4,012	6,728	144	80,794	161	12	91,851
Kansas	20,572	1,239,723	29,042	7,499	-----	29	1,154,419	48,782	−48	1,210,681
Kentucky and Illinois	13,802	483,336	22,230	2,411	-----	-----	451,787	6,776	132	461,106
Louisiana	107,093	3,728,717	140,290	61,681	105,778	2,092	2,862,673	555,487	716	3,588,427
Michigan	2,450	156,996	3,244	2,339	19,563	-----	131,850	-----	-----	153,752
Mississippi	977	44,510	971	1,509	11,061	68	29,560	1,209	132	43,539
Montana and Utah	2,849	59,058	4,010	5,025	17,956	852	31,162	-----	53	55,048
Nebraska	604	9,437	794	679	53	24	7,367	-----	520	8,643
New Mexico	32,670	1,058,587	48,635	44,906	1,720	9,820	772,751	175,940	4,815	1,009,952
North Dakota	2,714	41,318	5,428	2,684	7,009	241	24,713	-----	1,243	35,890
Oklahoma	39,402	1,122,692	55,724	48,478	69,746	1,244	826,433	120,287	780	1,066,968
Pennsylvania	64	2,390	116	13	27	-----	2,234	-----	-----	2,274
Texas	286,237	7,239,621	r 441,326	315,043	896,474	20,558	r 5,034,606	503,133	28,481	r 6,798,295
West Virginia and Florida	7,173	210,058	8,034	1,498	48	-----	197,842	2,636	-----	202,024
Wyoming	6,248	259,227	11,390	9,102	13,934	371	211,175	13,935	−680	247,837
Total	550,311	16,316,674	r 812,086	540,554	1,256,859	35,799	r 12,088,680	1,545,410	37,286	r 15,504,588
1969										
Arkansas	1,971	56,190	3,475	4,564	542	7	29,002	18,607	11	52,715
California and Alaska	21,262	455,692	30,522	25,764	116,371	312	199,645	80,415	2,663	425,170
Colorado	2,858	85,171	4,058	3,277	6,517	107	71,079	169	−36	81,113
Kansas	24,429	1,493,907	35,813	8,571	1,238	84	1,392,782	55,776	−357	1,458,094
Kentucky and Illinois	14,227	478,291	22,004	3,024	-----	-----	449,708	2,868	687	456,287
Louisiana	125,432	4,465,379	179,117	66,001	91,590	3,667	3,560,950	564,611	−557	4,286,262
Michigan	2,118	143,802	2,705	2,178	16,549	-----	122,370	-----	-----	141,097
Mississippi and Alabama	1,254	57,208	1,570	1,931	10,286	46	41,723	1,479	173	55,638
Montana and Utah	2,794	57,793	4,117	5,147	21,989	883	25,738	-----	−81	53,676
Nebraska	536	6,415	598	438	195	-----	4,959	-----	225	5,817
New Mexico	33,973	1,079,492	50,484	49,696	4,003	13,516	777,589	176,737	7,467	1,029,008
North Dakota	2,459	37,818	4,707	3,908	7,906	84	19,367	295	1,551	33,111
Oklahoma	41,925	1,167,150	57,270	51,320	80,813	991	845,775	129,028	1,953	1,109,880
Pennsylvania	57	1,708	93	9	76	-----	1,530	-----	-----	1,615
Texas	291,227	7,613,234	447,325	345,966	983,638	21,635	5,024,396	748,455	41,819	7,165,909
West Virginia and Florida	6,767	185,937	10,162	981	26	-----	172,443	2,325	-----	175,775
Wyoming	6,951	269,921	12,540	9,001	15,101	562	220,493	13,120	−896	257,381
Total	580,240	17,655,108	866,560	581,776	1,356,822	41,894	12,959,549	1,793,885	54,622	16,788,548

r Revised. [1] 42-gallons.

Table 8.—Estimated proved recoverable reserves of natural gas in the United States as of December 31, 1969

(Million cubic feet at 14.73 psia at 60° F)

State	Nonassociated	Associated-dissolved	Underground storage [1]	Total
Alaska [2]	4,882,363	319,780	----------	5,202,143
Arkansas	2,466,209	129,347	37,217	2,632,773
California [3]	2,857,084	3,826,608	187,254	6,870,946
Colorado	1,454,043	122,932	19,311	1,596,286
Illinois	1,070	16,238	320,504	337,812
Indiana	1,646	5,341	70,574	77,561
Kansas	13,671,686	361,681	91,758	14,125,125
Kentucky	817,257	53,263	50,000	920,520
Louisiana [3]	69,429,161	15,514,268	113,210	85,056,639
Michigan	73,268	82,186	595,510	750,964
Mississippi	1,124,539	281,022	5,337	1,410,898
Montana	799,770	147,927	162,511	1,110,208
Nebraska	26,934	13,204	16,456	56,594
New Mexico	11,147,421	3,124,818	9,264	14,281,503
New York	22,371	151	98,018	120,540
North Dakota	5,737	642,827	----------	648,564
Ohio	280,348	112,031	416,914	809,293
Oklahoma	13,870,792	3,515,459	206,946	17,593,197
Pennsylvania	791,804	13,534	498,569	1,303,907
Texas [3]	82,060,656	30,237,370	94,596	112,392,622
Utah	644,180	445,276	1,312	1,090,768
Virginia	31,438	----------	----------	31,438
West Virginia	2,050,917	58,044	338,363	2,447,324
Wyoming	3,295,851	599,089	42,105	3,937,045
Other States [4]	66,737	11,248	226,180	304,165
Total	211,873,282	59,633,644	3,601,909	275,108,835

[1] Gas held in underground reservoirs (including native and net injected gas) for storage.
[2] Reserves on certain portions of the North Slope of Alaska are not included because the A.G.A. Reserves Committee did not have sufficient data upon which it could base an estimate of proved reserves for this area as of December 31, 1969.
[3] Includes offshore reserves. Total remaining recoverable natural gas reserves in the Gulf of Mexico are estimated to be 35,306,705 million cubic feet, of which 30,349,309 million cubic feet are nonassociated, and 4,957,396 million cubic feet are associated-dissolved. As of this date the ultimate natural gas reserves in the Gulf of Mexico are estimated to be 48,607,745 million cubic feet; of which 40,921,160 million cubic feet are nonassociated, and 7,686,585 million cubic feet are associated-dissolved.
[4] Includes Alabama, Arizona, Florida, Iowa, Maryland, Minnesota, Missouri, South Dakota, Tennessee, and Washington.

Source: Committee on Natural Gas Reserves, American Gas Association.

Table 9.—Estimated productive capacity of natural gas in the United States, December 31, 1969

(Million cubic feet per day)

State	Productive capacity			State	Productive capacity		
	Nonassociated	Associated-dissolved	Total		Nonassociated	Associated-dissolved	Total
Alaska	450	93	543	New Mexico	3,644	1,226	4,870
Arkansas	760	74	834	New York	13	------	13
California [1]	1,649	1,095	2,744	North Dakota	1	123	124
Colorado	430	49	479	Ohio	135	31	166
Illinois	------	10	10	Oklahoma	8,929	2,223	11,152
Indiana	------	4	4	Pennsylvania	215	4	219
Kansas	7,968	359	8,327	Texas [1]	27,837	9,916	37,753
Kentucky	225	15	240	Utah	137	68	205
Louisiana [1]	24,797	5,097	29,894	Virginia	9	------	9
Michigan	91	56	147	West Virginia	704	20	724
Mississippi	519	123	642	Wyoming	1,117	286	1,403
Montana	176	67	243	Other States [2]	20	4	24
Nebraska	15	10	25	Total	79,841	20,953	100,794

[1] Includes offshore.
[2] Includes Alabama, Arizona, Florida, Iowa, Maryland, Missouri, South Dakota, Tennessee, and Washington.

Source: Committee on Natural Gas Reserves, American Gas Association.

Table 10.—Underground storage statistics, December 31, 1969

(Million cubic feet at 14.73 psia at 60° F)

State	Pools	Wells	Total gas in storage reservoirs	Total reservoir capacity
Arkansas	7	30	13,004	40,182
California	6	160	111,899	289,007
Colorado	3	41	11,462	23,523
Illinois	23	1,119	309,311	557,960
Indiana	26	794	55,125	144,561
Iowa	7	248	133,981	187,568
Kansas	16	744	77,881	106,034
Kentucky	17	859	29,674	64,905
Louisiana	4	93	84,457	165,079
Maryland	1	59	23,606	64,770
Michigan	30	2,105	323,702	694,063
Minnesota	1	16	813	813
Mississippi	2	23	4,837	6,906
Missouri	1	70	25,592	45,000
Montana	6	133	122,773	186,752
Nebraska	1	15	5,397	39,270
New Mexico	3	35	2,400	58,650
New York	15	893	89,793	109,723
Ohio	21	2,728	335,561	492,652
Oklahoma	11	185	189,814	309,056
Pennsylvania	63	2,117	478,835	706,581
Texas	17	164	65,454	118,063
Utah	1	8	1,312	1,312
Washington	1	46	9,732	25,000
West Virginia	34	1,208	316,574	412,726
Wyoming	3	11	29,170	76,628
Total	320	13,924	2,852,159	4,926,784

Source: American Gas Association.

Table 11.—Gas wells and condensate wells in the United States

State	Completed during 1968 [1]	Producing Dec. 31, 1968	Completed during 1969 [1]	Producing Dec. 31, 1969
Alabama	1	1	1	1
Alaska	7	18	11	44
Arizona	-----	4	2	4
Arkansas	46	947	40	998
California	77	994	59	897
Colorado	50	810	47	805
Illinois	1	5	5	5
Indiana	14	265	7	263
Kansas	90	8,509	184	8,567
Kentucky	205	6,290	142	6,413
Louisiana	537	9,163	543	9,354
Maryland	-----	15	-----	13
Michigan	28	199	15	211
Mississippi	12	347	16	322
Missouri	-----	11	-----	11
Montana	40	r 1,196	31	1,098
Nebraska	-----	36	1	35
New Mexico	150	8,754	263	9,100
New York	10	1,155	12	818
North Dakota	-----	19	-----	33
Ohio	230	r 7,211	395	7,334
Oklahoma	370	8,337	397	8,432
Pennsylvania	253	17,000	277	16,600
Tennessee	6	23	7	26
Texas	763	23,805	903	23,689
Utah	5	165	16	171
Virginia	-----	111	-----	111
West Virginia	522	18,214	652	18,600
Wyoming	39	787	57	521
Total	3,456	r 114,391	4,083	114,476

r Revised.

[1] From data compiled by the American Association of Petroleum Geologists and American Petroleum Institute.

Table 12.—Natural gas stored underground in and withdrawn from storage fields
(Million cubic feet at 14.73 psia)

State	1968 Total stored	1968 Total withdrawn	1968 Net stored	1969 Total stored	1969 Total withdrawn	1969 Net stored
Alabama	536	509	27	577	435	142
Arkansas	1,210	854	356	1,168	507	661
California	58,085	62,631	−4,546	77,617	64,590	13,027
Colorado	6,849	6,850	−1	8,663	8,128	535
Delaware	1,500	1,255	245	179	878	−699
Illinois	143,180	97,146	46,034	153,497	105,337	48,160
Indiana	26,679	24,906	1,773	26,483	22,385	4,098
Iowa	57,082	54,574	2,508	43,037	45,343	−2,306
Kansas	44,524	41,190	3,334	50,772	50,140	632
Kentucky	28,993	28,049	944	31,726	27,966	3,760
Louisiana	33,037	22,799	10,238	58,753	43,521	15,232
Maryland	10,520	6,235	4,285	5,281	9,417	−4,136
Massachusetts	769	667	102	314	567	−253
Michigan	255,365	250,874	4,491	257,737	260,981	−3,244
Mississippi	6,904	6,710	194	7,493	8,398	−905
Missouri	8,919	10,167	−1,248	9,044	9,909	−865
Montana	17,398	8,009	9,389	20,409	10,854	9,555
Nebraska	2,959	3,764	−805	4,838	3,526	1,312
New Jersey	975	968	7	1,281	1,075	206
New Mexico	74	60	14	383	165	218
New York	44,978	45,482	−504	41,874	39,148	2,726
Ohio	169,955	158,914	11,041	168,142	172,078	−3,936
Oklahoma	46,871	36,464	10,407	53,945	37,786	16,159
Pennsylvania	235,415	235,570	−155	244,892	240,373	4,519
Tennessee	2,140	1,906	234	-----	-----	-----
Texas	31,597	34,242	−2,645	33,943	30,582	3,361
Utah	640	611	29	580	367	213
Virginia	272	104	168	2,143	134	2,009
Washington	974	974	-----	1,827	735	1,092
West Virginia	181,338	182,982	−1,644	183,114	181,142	1,972
Wyoming	5,337	4,070	1,267	6,695	3,021	3,674
Total	1,425,075	1,329,536	95,539	1,496,407	1,379,488	116,919

Table 13.—Gross withdrawals and disposition of natural gas in the United States

(Million cubic feet at 14.73 psia)

State	Gross withdrawals			Disposition		
	From gas wells	From oil wells	Total [1]	Marketed production	Repressuring	Vented and flared [2]
1968						
Alaska	48,933	50,370	99,303	17,343	57,702	24,258
Arkansas	110,898	51,257	162,155	156,627	4,633	895
California	505,605	311,320	816,925	714,893	99,252	2,780
Colorado	93,556	36,027	129,583	121,424	6,645	1,514
Illinois	183	4,299	4,482	4,380	-----	102
Indiana	234	-----	234	234	-----	-----
Kansas	690,216	149,557	839,773	835,555	1,689	2,529
Kentucky	88,709	330	89,039	89,024	-----	15
Louisiana	5,623,961	1,153,555	6,777,516	6,416,015	195,062	166,439
Maryland	864	-----	864	864	-----	-----
Michigan	24,151	19,779	43,930	40,480	2,330	1,120
Mississippi	136,972	34,645	171,617	135,051	30,656	5,910
Montana	11,208	21,021	32,229	19,313	365	12,551
Nebraska	5,681	3,648	9,329	8,129	1,200	-----
New Mexico	873,211	297,313	1,170,524	1,164,182	355	5,987
New York	4,632	-----	4,632	4,632	-----	-----
North Dakota	225	62,848	63,073	41,023	-----	22,050
Ohio	33,742	8,931	42,673	42,673	-----	-----
Oklahoma	1,225,620	380,957	1,606,577	1,390,884	86,285	129,408
Pennsylvania	87,627	680	88,307	87,987	320	-----
Texas	6,477,441	2,088,647	8,566,088	7,495,414	946,090	124,584
Utah	20,443	58,856	79,299	46,151	30,242	2,906
Virginia	3,389	-----	3,389	3,389	-----	-----
West Virginia	234,361	3,380	237,741	236,971	770	-----
Wyoming	237,156	46,760	283,916	248,481	22,397	13,038
Other States [3]	907	895	1,802	1,281	99	422
Total	16,539,925	4,785,075	21,325,000	19,322,400	1,486,092	516,508
1969						
Alaska	77,816	71,831	149,647	50,864	66,240	32,543
Arkansas	119,230	56,105	175,335	169,257	4,752	1,326
California	294,026	473,316	767,342	677,689	86,579	3,074
Colorado	92,133	31,204	123,337	118,754	3,257	1,326
Illinois	158	3,735	3,893	3,800	-----	93
Indiana	171	-----	171	171	-----	-----
Kansas	744,631	142,972	887,603	883,156	1,781	2,666
Kentucky	81,086	218	81,304	81,304	-----	-----
Louisiana	6,305,897	1,255,130	7,561,027	7,227,826	174,349	158,852
Maryland	978	-----	978	978	-----	-----
Michigan	22,285	16,405	38,690	36,163	1,719	808
Mississippi	133,105	35,609	168,714	131,234	29,383	8,097
Montana	37,163	30,901	68,064	41,229	377	26,458
Nebraska	4,739	2,677	7,416	6,989	427	-----
New Mexico	837,521	305,073	1,142,594	1,138,133	403	4,058
New York	4,861	-----	4,861	4,861	-----	-----
North Dakota	127	56,415	56,542	33,587	-----	22,955
Ohio	38,540	11,253	49,793	49,793	-----	-----
Oklahoma	1,356,766	384,911	1,741,677	1,523,715	87,196	130,766
Pennsylvania	763	78,683	79,446	79,134	312	-----
Texas	6,800,882	2,113,912	8,914,794	7,853,199	950,096	111,499
Utah	21,510	53,657	75,167	46,733	25,632	2,802
Virginia	2,846	-----	2,846	2,846	-----	-----
West Virginia	229,815	2,556	232,371	231,759	612	-----
Wyoming	280,572	62,426	342,998	303,517	21,849	17,632
Other States [3]	1,794	791	2,585	1,549	241	795
Total	17,489,415	5,189,780	22,679,195	20,698,240	1,455,205	525,750

[1] Marketed production plus quantities used in repressuring, vented and flared.
[2] Partly estimated; includes direct losses on producing properties and residue blown to the air.
[3] Alabama, Arizona, Florida, Missouri, South Dakota, and Tennessee.

Table 14.—Marketed production of natural gas by countries

(Million cubic feet)

Country	1967	1968	1969 p
North America:			
Barbados	e 100	97	108
Canada	1,471,725	1,692,301	1,985,281
Mexico	275,502	285,430	283,057
Trinidad	51,494	51,594	53,213
United States	18,171,325	19,322,400	20,698,240
South America:			
Argentina	169,259	188,806	188,133
Bolivia e	r 700	400	400
Brazil e	6,000	7,000	8,000
Chile e	33,000	33,500	33,500
Colombia	37,721	38,247	44,767
Ecuador e	550	500	500
Peru	e 16,500	16,803	17,453
Venezuela	292,655	301,197	314,086
Europe:			
Austria	63,468	57,562	52,371
Czechoslovakia	r 35,000	34,000	33,000
France	196,313	201,293	229,500
Germany, West	148,474	204,321	289,129
Hungary [1]	72,218	95,031	109,333
Italy	323,671	367,729	416,711
Netherlands	253,731	514,172	773,164
Poland [1]	55,373	90,264	137,250
Rumania	559,525	774,923	850,618
U.S.S.R.	5,600,880	6,038,690	6,380,000
United Kingdom	16,664	71,351	178,673
Yugoslavia	16,313	20,615	25,784
Africa:			
Algeria	76,226	85,669	105,403
Gabon	611	879	863
Morocco	379	382	1,484
Nigeria	5,424	5,190	2,213
Tunisia	328	338	e 350
United Arab Republic e	2,000	2,000	2,500
Asia:			
Afghanistan e	76	53,000	72,000
Bahrain	r e 8,500	e 9,000	10,906
Brunei	e 8,000	7,530	e 7,500
India	16,439	21,347	25,758
Indonesia	e 22,000	24,066	30,161
Iran	51,784	55,534	98,201
Iraq	18,191	27,293	31,139
Israel	3,859	5,015	4,873
Japan	66,734	72,617	77,890
Kuwait	e 90,000	114,750	129,273
Kuwait-Saudi Arabia Neutral Zone e	8,500	8,000	7,400
Pakistan	83,288	91,525	116,923
Qatar	e 3,500	e 4,200	37,290
Saudi Arabia	e 45,000	e 50,000	93,826
Taiwan	18,616	24,877	31,553
Oceania:			
Australia	152	216	9,375
New Zealand	4	3	2
Total	28,397,772	31,071,657	33,999,154

e Estimate. p Preliminary. r Revised.

[1] Including gas for repressuring.

NOTE.—The data relate, as far as possible, to natural gas actually collected and utilized as fuel or raw material. They exclude gas used for repressuring (except where otherwise noted), as well as gas flared, vented, or otherwise wasted, whether or not it has first been processed for the extraction of natural gas liquids.

Natural Gas Liquids

By William B. Harper [1] and Leonard L. Fanelli [2]

Reflecting the continued growth in production of natural gas, and to meet demands for ethane in chemical manufacture, for propane in both chemical manufacture and fuel use, and for butane and natural gasoline in gasoline blending, the output of natural gas liquids rose to 580.2 million barrels in 1969, a 30-million-barrel or 5.4-percent increase over that of 1968. The total value of this production, however, declined to $1,102 million, which was nearly $22 million below the value for 1968. This decline was attributable primarily to a softening of prices for liquefied petroleum gases from $2.04 per barrel to $1.90 per barrel.

Natural gas liquids are products obtained from natural gasoline plants, cycling plants, and fractionators after separating the natural gas. Included are ethane, the liquefied petroleum (LP) gases (butane, propane, and butane-propane mixtures), isobutane, and other mixed gases. Also, included in the output of these plants are natural gasolines, plant condensate, and finished products such as gasoline, special naphthas, jet fuel kerosine, distillate fuel oil, and other finished products.

Shipments from natural gas processing plants of ethane in 1969 totaled 63 million barrels, nearly 38 percent above the volume shipped in 1968. Shipments of LP gases of 332.6 million barrels were 13.5 percent higher than in 1968. Natural gas liquids used as blending material in gasoline, totaled 264.6 million barrels, an increase of 2 percent.

These data presented in this chapter are compiled from reports submitted by natural gasoline plants, cycling plants, and fractionators that handle natural gas liquids and include all natural gas liquids except the small volume recovered at pipeline compressor stations and gas dehydration plants. Such recovery is considered to be of little significance in the national and State totals. Plant condensate is included in the category of natural gas liquids. Field condensate, however, is reported with crude oil and is excluded from the total for natural gas liquids. Also, ethane and liquefied gases such as butane and propane, are derived from certain refinery processes.

Annual reports were received from all producers and distributors and from most of the dealers that sell more than 100,000 gallons of LP gases annually. To reflect total shipments, the sample of dealer shipments was expanded by Petroleum Administration for Defense (PAD) districts on the basis of domestic demand in the districts.

Data on shipments of LP gases, normally reported in this chapter, were not available at the time of publication and will be published in the Mineral Industry Survey "Liquefied Petroleum Gas Shipments, Annuals."

For the purpose of this chapter, liquefied gases and ethane, whether obtained from natural gas or from processing in refineries, are defined as follows:

Ethane.—Includes ethane only. All other LP gases mixed with ethane are reported in their respective product classification.

Propane.—Includes all products covered by Natural Gas Processors Association (NGPA) specifications for commercial and HD–5 propane.

Butane-propane.—Includes all products covered by NGPA specifications for commerical butane propane mixtures.

Butane.—Includes all products covered by NGPA specifications for commercial butane, except those that contain 80 percent or more isobutane.

Isobutane.—Includes all products covered by NGPA specifications for commercial bu-

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tane that contains 80 percent or more isobutane.

Isopentane.—Includes segregated isopentane.

Natural Gasoline. —Breakdown by various Reid vapor pressure classifications indicated.

Plant Condensate.—Includes those liquids mostly pentanes and heavier, recovered and separated at raw natural gas inlet separators and scrubbers.

Gasoline.—Includes all products within the gasoline range for shipments as motor fuel.

Special Naphtha.—Includes all hexanes and heptanes.

Jet Fuel.—Includes all aviation turbine engine fuel for both military (JP–4 and JP–5) and commercial use.

Kerosine.—Includes all grades of kerosine or range oil.

Distillate Fuel Oil.—Includes all light oil for shipment as fuel, including diesel fuel oil.

Other Products.—All products not otherwise classified.

Production of natural gas liquids is reported by States, although data for Louisiana and Texas are also reported by districts.

Louisiana is divided into an Inland district and a Gulf Coast district. The Gulf Coast district includes Veron, Rapides, Avoyelles, Pointe Coupee, West Feliciana, East Feliciana, Tangipahoa, St. Helena, and Washington Parishes (counties) and all parishes in the State south of these. All parishes not included in the Gulf Coast district are in the Inland district.

The Bureau of Mines producing districts in Texas correspond, with one exception, to grouping of the Texas Railroad Commission districts:

Bureau of mines districts	*Railroad Commission districts*
Gulf Coast	Nos. 2 and 3
West Texas	Nos. 7C, 8 and 8A
East Proper	Part of No. 6 (East Texas field in Cherokee, Smith, Upshur, Rusk, and Gregg Counties)
Panhandle	No. 10
Rest of State:	
North	Nos. 7B and 9
Central	No. 1
South	No. 4
Other East Texas	Nos. 5 and 6 (exclusive of East Proper)

Refineries are also grouped by the Bureau of Mines into a set of refining districts. These refining districts may be combined to correspond with the Petroleum Administration for Defense districts.

PAD *district*	*Refining district*

1.—*East Coast.*—District of Columbia, Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New Jersey, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, Florida, the following counties of New York: Cayuga, Tompkins, Chemung, and all counties east and north thereof, and the following counties of Pennsylvania: Bradford, Sullivan, Columbia, Montour, Northumberland, Dauphin, York and all counties east thereof.

1.—*Appalachian No.* 1—West Virginia and those parts of Pennsylvania and New York not included in the East Coast district.

2.—*Appalachian No.* 2—The following counties of Ohio: Erie, Huron, Crawford, Marion, Delaware, Franklin, Pickaway, Ross, Pike, Scioto, and all counties east thereof.

2.—*Indiana-Illinois-Kentucky* — Indiana, Illinois, Kentucky, Tennessee, Michigan, and that part of Ohio not included in the Appalachian district.

2.—*Oklahoma-Kansas-Missouri* — Oklahoma, Kansas, Missouri, Nebraska, and Iowa.

2.—*Minnesota-Wisconsin-North Dakota-South Dakota*—Minnesota, Wisconsin, North Dakota, and South Dakota.

3.—*Texas Inland*—Texas, except Texas Gulf Coast district.

3.—*Texas Gulf Coast*—The following counties of Texas: Newton, Orange, Jefferson, Jasper, Tyler, Hardin, Liberty, Chambers, Polk, San Jacinto, Montgomery, Galveston, Waller, Fort Bend, Brazoria, Wharton, Harris, Matagorda, Jackson, Victoria, Calhoun, Refugio, Aransas, San Patricio, Nueces, Kleberg, Kenedy, Willacy, and Cameron.

3.—*Louisiana Gulf Coast*—The following parishes of Louisiana: Vernon, Rapides, Avoyelles, Pointe Coupee, West Feliciana, East Feliciana, Tangipahoa, St. Helena, Washington, and all parishes south thereof; the following counties of Mississippi: Pearl River, Stone, George Hancock, Harrison, and Jackson; and Mobile and Baldwin Counties, Alabama.

PAD district *Refining district*

3.—*North Louisiana-Arkansas*—Arkansas and those parts of Louisana, Mississippi, and Alabama not included in the Louisiana Gulf Coast District.

3.—*New Mexico*—New Mexico.

4.—*Rocky Mountains*—Montana, Idaho, Wyoming, Utah, and Colorado.

5.—*West Coast*—Washington, Oregon, California, Nevada, Alaska, Arizona, and Hawaii.

Some data in the chapter are based on the Bureau of Mines refining districts, while others refer to the PAD districts. Maps showing the PAD and Bureau of Mines refining districts appear in figure 2 of the Crude Petroleum and Petroleum Products chapter of this volume.

Unlike 1967 and prior years, the format and content of table 1 no longer include supply and demand balances for that part of natural gas liquids relating to the finished petroleum products defined on the first page of this chapter. This is readily understandable as the relative importance of these finished products in terms of volumes and values is small—only 2 percent of the yield at natural gas processing plants and less than 4 percent of the value.

Finished petroleum products lose their identity as "natural gas liquids" by being absorbed into the supply stream but information on production and on stocks is available in the Minerals Yearbook Chapter, "Crude Petroleum and Petroleum Products," in the table captioned "Salient Statistics of the major refined products in the United States." Also, these data are identified as to origin in table 2 of the Monthly Petroleum Statements, which are included in the Mineral Industry Surveys published by the Bureau of Mines.

DOMESTIC PRODUCTION

Production of natural gas liquids and ethane continued to rise in 1969 along with the expansion in the demand for natural gas and ethylene. Production of natural gas liquids and ethane at natural gas processing plants in the United States totaled 580.2 million barrels in 1969, which is 5.4 percent above the 1968 output.

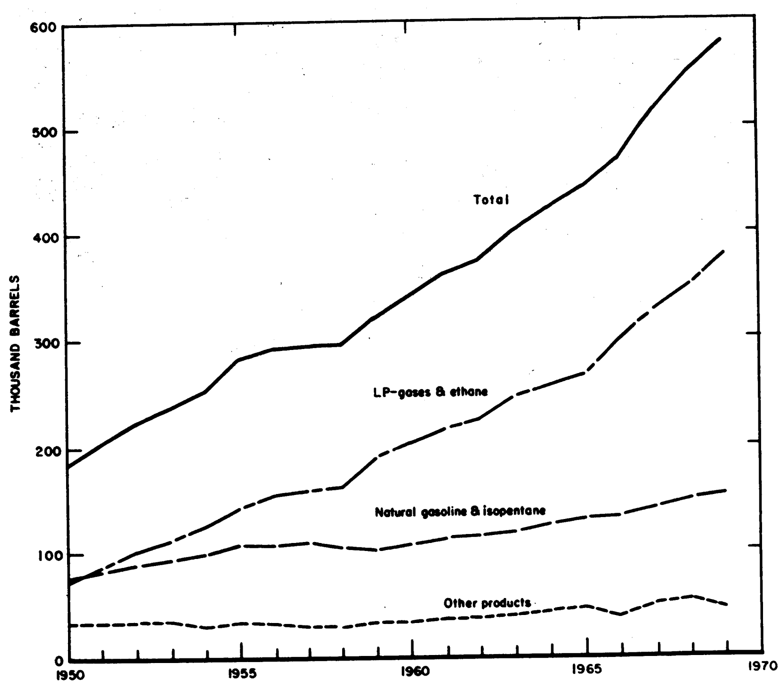

Figure 1.—Production of natural gas liquids in the United States.

In terms of physical volumes, there are four major categories classified under the generic terms "natural gas liquids." These are LP gases, natural gasoline, ethane, plant condensate, and other products. The "other products" category includes motor gasoline, distillate fuel oil, kerosine, specia naphthas, jet fuel, and "other." Showı below is a chart illustrating the relativ(importance of the five components of natural gas liquids.

580,241,000 BARRELS = 100 PERCENT

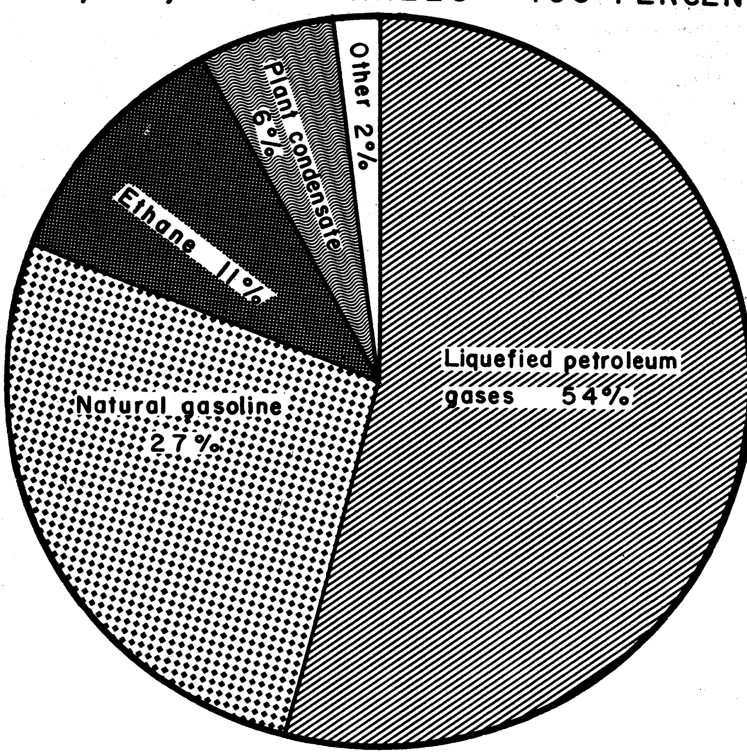

Figure 2.—The relative importance of natural gas liquids, 1969.

Ethane production is growing at the fastest rate in the natural gas liquids group and in 1969 accounted for 11 percent of the total volume. In 1969, ethane production, from natural gas processing plants only, aggregated 63 million barrels, a volume 37.6 percent larger than the 45.8 million barrels produced in 1968. In addition there were about 9 million barrels of ethane produced at refineries in 1969. Liquefied petroleum gases accounted for 54 percent of the total output of natural gas liquids in 1969.

Production of LPG at gas processing plants increased moderately to 315.4 million barrels or about 3 percent. In addition to this output there were 114.4 million barrels of liquefied petroleum gases produced at refineries in 1969. Of this total about 67 percent was propane and 21 percent butane.

Natural gasoline constituted 27 percent of the natural gas liquids output in 1969 and production in that year advanced to 154.5 million barrels for a gain of 6.4 percent for the year.

RESERVES

Although the prolonged downtrend in well drilling was arrested in 1969, withdrawal of natural gas exceeded additions to proved natural gas reserves by a wide margin, so that there was a net decrease in reserves. Proved reserves of natural gas liquids at the end of 1969 aggregated 8,143,174,000 barrels, which was 454.9 million barrels or 5.3 percent below the 1968 level.

Estimates by the American Gas Association's (AGA) Committee on Natural Gas Reserves indicated that declines in the proved reserves of 12 States, including California, Louisiana, and Texas more than offset increases in Michigan, Montana, Mississippi, Nebraska, Oklahoma, and Wyoming. While the drop in reserves is disturbing in itself it should be recognized that these reserve data make no provision for reserves in the new oil province on the North Slope of Alaska because of the nonavailability of data the committee requires to make such estimates. Data on the proved reserves of 22 States are shown in table 6.

PRODUCTIVE CAPACITY

The AGA Natural Gas Reserves Committee, also, estimated that the productive capacity of natural gas liquids in the United States was 3,161,000 barrels per day as of December 31, 1969. This estimate, about 100,000 barrels per day less than a year earlier, reflected declines in the productive capacities of Kansas, Louisiana, and Texas, which more than offset the increases in the capacities of New Mexico and Oklahoma. The productive capacities of natural gas liquids in 18 States are shown in table 7.

The productive capacity of natural gas liquids is defined as the amount of hydrocarbon liquids that would be produced coincidental with the estimated productive capacity of natural gas. At the same time it should be recognized that these estimates, which are based on the unit recoveries of natural gas at normal producing rates, are purely theoretical; first, because the estimates relate to increased production of gas from oil and gas wells operating at their productive capacities. Actually, many wells are operating at rates below these capacities because of the absence of surface facilities; also, State regulations are a restrictive factor.

Capacity and throughput of gas at natural gas processing plants have expanded markedly over the past 5 years. Between 1964 and 1969, for example, the capacity of gas processing plants has grown from 55.7 billion cubic feet daily to 67.9 billion, an increase of 22 percent. At the same time daily throughput rose from 42.1 billion cubic feet per day to 56.2 billion or an overall growth of 33.5 percent, according to the Oil and Gas Journal's annual surveys.

Virtually all of this growth in throughput occurred in Kansas, Louisiana, New Mexico, Oklahoma, and Texas and, to a lesser extent, in Florida, Michigan, Montana, North Dakota, and Wyoming. Conversely, there have been decreases in the volumes of natural gas processed in Arizona, Arkansas, California, Missisippi, Colorado, Kentucky, Nebraska, Ohio, and West Virginia. Comparisons of operating capacities and throughputs as of the end of 1964 and of 1969, in billions of cubic feet, are as follows:

	1964	1969	Percent change
Number of plants	839	839	------
Capacity	55.7	67.9	+22.0
Throughput	42.1	56.2	+33.5

In recent years, however, there has been a decided slowing in the addition of new capacity to gas-processing plants. The near 68 billion cubic feet per day reported for the end of 1969 was only about 2 percent higher than in 1968. Throughput of gas processed averaged 56 billion cubic feet per day, as compared with 53 billion in 1968, an increase of 5.6 percent. The steep er rise in throughput reflects technological improvements in processing but the slowdown in additions to capacity are a direct result of the sharply reduced rate of natural gas discovery. Allowing for a lag between a rise in the price of natural gas and a revival in exploratory effort to search for new gas, it appears reasonable to expect a renewed interest in building new plant capcity over the near term.

DEMAND AND USES

The volume of natural gas liquids shipped to refineries for blending and processing increased nominally in 1969 to 264.6 million barrels or about 2 percent above the 1968 levels. Included in the natural gas liquids-for-blending category are natural gasoline, LPG, and condensate. Condensate used at refineries for blending purposes declined to 34.4 million barrels, a volume 6.9 percent below shipments to refineries in 1968. Refinery inputs of LPG increased in 1969, in the use of isobutane and the butane-propane mixes.

Natural gasoline accounted for nearly six out of each 10 barrels of blending materials used at refineries in 1969. During the year, 153.7 million barrels were used by refiners, as indicated in the tabulation below. Data on the production, shipments, and stocks at natural gas processing plants is available, by months, in table 1. Also shown in this table are data on 9.7 million barrels of finished petroleum products. More than half of this segment consists of motor gasoline. Production, shipments, and inventories on jet fuel, distillate fuel oil, kerosine, and special naphthas as well as gasoline are shown also in table 1.

	1968	1969	Percent change
Natural gasoline	145,275	153,698	+5.8
Plant condensate	38,548	34,427	−10.7
LPG	72,652	72,764	+0.1
Total	256,475	260,889	+1.8

Excluding use at refineries domestic demand for butane and propane for fuels and chemicals and ethane for chemicals aggregated nearly 326.2 million barrels in 1969 as compared with 264.2 million the preceding year. A year to year comparison in millions of barrels, is as follows:

	1968	1969	Increase Volume	Increase Percent
Ethane	45.7	63.1	17.4	+38.0
Propane	178.4	209.7	31.3	+17.5
Butane	40.1	53.4	13.3	+33.2
Total	264.2	326.2	62.0	+23.5

Ethane is used primarily as a chemical feedstock from which ethylene is produced. Over the 10-year period, 1960 through 1969 inclusive, the recovery of ethane from natural gas at gas processing plants has grown from 19.9 million barrels annually to 63.0 million barrels in 1969. At the same time ethylene production from all sources has increased from 5,860 million pounds in 1960 to nearly 13,150 million pounds by 1968. Final figures for 1969 are not yet available from the United States Tariff Commission.

Reflecting a severe winter, coupled with a strong demand for propane in the manufacture of chemicals, demand for propane in 1969 rose to 286.2 million barrels or 13 percent. The major chemical use for propane is as a feedstock for ethylene.

Residential and commercial use includes private households and nonmanufacturing organizations such as retail stores, restaurants, hotels, and service companies. The category includes space heating, water heating, and cooking and accounts for 6 out of every 10 barrels of propane consumed. In terms of LPG use, propane accounts for 90 percent of LPG shipments for residential and commercial use. Detailed data on shipments of LPG by end use in 1969 will be available in the Bureau of Mines Mineral Industry Survey, "Shipments of Liquefied Petroleum Gases and Ethane in 1969."

Isobutane was in strong demand in 1969. Some 26.9 million barrels were produced but demand outstripped production of isobutane. Hence, it was necessary to draw on supplies in inventories. The principal use for the butanes, both normal and isobutane, is for gasoline blending. The hydrocracking and the reforming processes yield propane, normal butane, and isobutane. Hence, as capacity in these types of refining processes expand so will the production of the butanes in refineries.

Between 1966 and the end of 1969, reforming capacity has expanded from 2.2 million barrels per day to 2.7 million per day or 22.7 percent.

Refining capacity on January 1, 1969, was 11.7 million barrels per calendar day and gasoline production accounts for 5.5 million barrels per day. Of the gasoline production, cracking capacity made up 51.4 percent; reforming made up 36.9 percent; and alkylation made up 11.7 percent. An expansion in the production of lead-free gasoline could provide a strong stimulus in the demand for isobutane.

STOCKS

In sharp contrast with a year earlier, stocks at gas processing plants and refineries of liquefied petroleum gas, exclusive of ethane, dropped from 73.9 million barrel at the end of 1968 to 57.4 million by the end of 1969, a reduction of 16.5 million or 22 percent. Most of the decline, as indicated in table 10, occurred in propane where stocks dropped 12.9 million barrels or 27 percent. The combined stocks of the butanes, both normal and isobutane, which aggregated 25.5 million barrels at yearend 1968, had been reduced about 3.4 million barrels or 13 percent by the end of 1969, as indicated in table 10.

Some of the heavy drawdowns on propane reflect the severe winter which caused consumption of this gas to rise sharply. In addition a strong demand for propane as a petrochemical feedstock in 1969 was an important contributing factor as propane as well as ethane and heavier hydrocarbons can be used to obtain ethylene. Stocks of isobutane at natural gas processing plants declined from 7,736,000 to 6,854,000 barrels at the end of 1969 as demands for chemical use and refinery use outstripped production.

PRICES AND VALUE

Although the value per barrel of natural gas liquids stiffened markedly in the final quarter of 1969 a soft price structure prevailed most of the year. As a result, the overall price of the five segments in the natural gas liquids category declined from $2.04 per barrel to $1.90 or 6.9 percent. The sharpest decline occurred in LP gases and ethane, as indicated in table 12. The volumes of LP gases and ethane expanded 7.7 percent but the aggregate value of production dropped 9.6 percent as shown in table 12.

Most of price drop occurred in the LP gases as there is no spot market for ethane. Propane prices, for example, were depressed to 4.75 cents per gallon (Baton Rouge) in the peak use period—the first quarter of 1969 when the price was 1.17 cents per gallon less than a year earlier. Not until November 1969 did the price at Baton Rouge rise above 4¾ cents per gallon. Price trends of propane in the market at Baton Rouge, Oklahoma, and New York harbor and Philadelphia are shown in table 13.

In view of the firmer price structure in propane, it appears reasonable to assume that less propane and more ethane will be used to obtain ethylene in the near term.

FOREIGN TRADE

Nearly 8 million barrels of the total LP gases exported were destined for Mexico and most of these volumes were made up of butane propane mixtures as indicated in table 14.

The volume of liquefied petroleum gas imported into the United States was exceeded slightly by exports in 1969. Most of butane and propane imported (96.7 percent) originated in Canada. In addition some 400,000 barrels of LPG was imported from Venezuela. Imports aggregated nearly 12.7 million barrels, which was about 1 million barrels more than in 1968 as shown in table 10. Butane imports accounted for 7.4 million barrels and propane for nearly 5.3 million. On the export side, the volumes shipped from the United States aggregated nearly 12.8 million barrels.

Table 1.—Plant production, stocks at plants and terminals, shipments

(Thousand

Product	Jan.	Feb.	Mar.	Apr.	May
All products, total:					
Production	48,468	45,169	49,184	47,203	49,017
Stocks	58,184	52,842	51,903	56,449	64,377
Shipments	65,580	50,511	50,123	42,657	41,089
Ethane:					
Production	5,081	4,641	5,033	5,119	5,265
Stocks	2,121	2,018	1,924	2,123	2,099
Shipments	5,172	4,744	5,127	4,920	5,289
Liquefied petroleum gases:					
Production	26,716	25,181	27,455	25,993	26,622
Stocks	51,871	46,561	45,634	50,186	57,702
Shipments	43,773	30,491	28,382	21,441	19,106
Isopentane:					
Production	299	294	338	271	254
Stocks	12	38	48	31	14
Shipments	331	268	328	288	271
Natural gasoline:					
Production	12,346	11,387	12,534	12,462	13,219
Stocks	2,978	3,034	3,182	2,999	3,428
Shipments	11,952	11,331	12,386	12,645	12,790
Plant condensate:					
Production	3,110	2,875	2,987	2,584	2,848
Stocks	673	756	729	682	711
Shipments	3,278	2,792	3,014	2,631	2,819
Other products, total:					
Production	916	791	837	774	809
Stocks	529	435	386	428	423
Shipments	1,074	885	886	732	814
Motor gasoline:					
Production	533	487	491	459	481
Stocks	284	234	209	253	238
Shipments	519	537	516	415	496
Special naphthas:					
Production	46	39	42	42	45
Stocks	14	14	12	9	10
Shipments	45	39	44	45	44
Kerosine:					
Production	105	86	88	86	89
Stocks	128	118	96	98	113
Shipments	267	96	110	84	74
Distillate fuel oil:					
Production	139	120	138	121	135
Stocks	67	43	43	40	35
Shipments	137	144	138	124	140
Jet fuel:					
Production	1	------	------	------	------
Stocks	4	4	4	4	3
Shipments	21	------	------	------	1
Miscellaneous products:					
Production	92	59	78	66	59
Stocks	32	22	22	24	24
Shipments	85	69	78	64	59

from plants of natural gas processing plant products in 1969
barrels)

June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total 1969	Total 1968
46,839	48,247	48,578	47,061	49,723	49,112	51,640	580,241	550,311
70,839	77,052	80,631	81,414	77,400	69,348	58,552	58,552	75,296
40,377	42,034	44,999	46,278	53,737	57,164	62,436	596,985	537,984
4,898	5,105	5,251	5,054	5,600	5,744	6,236	63,027	45,803
2,116	2,188	1,869	1,803	2,061	2,099	2,182	2,182	2,212
4,881	5,033	5,570	5,120	5,342	5,706	6,153	63,057	45,706
25,196	25,318	25,694	25,360	27,007	26,646	28,242	315,430	305,459
64,202	69,831	73,760	75,034	70,812	62,711	51,799	51,799	68,928
18,696	19,689	21,765	24,086	31,229	34,747	39,154	332,559	293,101
235	256	283	284	301	313	329	3,457	2,660
7	6	8	7	9	12	10	10	44
242	257	281	285	299	310	331	3,491	2,640
12,967	13,952	13,615	12,858	13,245	12,782	13,105	154,472	145,214
3,375	3,701	3,738	3,290	3,351	3,322	3,358	3,358	2,584
13,020	13,626	13,578	13,306	13,184	12,811	13,069	153,698	145,275
2,773	2,803	2,927	2,744	2,788	2,820	2,874	34,133	38,494
671	739	689	653	617	616	547	547	841
2,813	2,735	2,977	2,780	2,824	2,821	2,943	34,427	38,548
770	813	808	761	782	807	854	9,722	12,681
468	587	567	627	550	588	656	656	687
725	694	828	701	859	769	786	9,753	12,714
439	469	476	449	464	483	514	5,745	6,211
256	278	259	310	261	278	308	308	270
421	447	495	398	513	466	484	5,707	6,206
43	41	42	40	39	37	36	492	473
11	10	9	8	6	11	11	11	13
42	42	43	41	41	32	36	494	466
92	105	96	98	93	86	97	1,121	1,027
130	168	197	187	208	218	249	249	290
75	67	67	108	72	76	66	1,162	1,095
134	129	133	112	119	132	129	1,541	1,308
43	46	48	48	42	45	50	50	65
126	126	131	112	125	129	124	1,556	1,272
3	2	2	3	3	1	3	18	277
6	8	10	12	15	16	19	19	24
------	------	------	1	------	------	------	23	267
59	67	59	59	64	68	75	805	3,385
22	77	44	62	18	20	19	19	25
61	12	92	41	108	66	76	811	3,408

Table 2.—Natural gas liquids and ethane produced, value at plants in the United States in 1969, by States

(Thousand barrels and thousand dollars)

State	No. of operating companies [1]	LP gases and ethane			Natural gasoline and isopentane			Plant condensate		
		Quantity	Value	Dollars per barrel [2]	Quantity	Value	Dollars per barrel [2]	Quantity	Value	Dollars per barrel [2]
Arkansas	4	1,279	$2,098	1.64	564	$1,703	3.02	97	$257	2.65
California and Alaska	15	8,308	17,779	2.14	12,424	38,142	3.07	530	1,802	3.40
Colorado	5	1,782	2,762	1.55	1,076	2,798	2.60	-------	---------	----
Illinois and Kentucky	4	13,358	24,712	1.85	869	2,763	3.18	-------	---------	----
Kansas	13	19,574	26,229	1.34	4,798	11,707	2.44	57	141	2.48
Louisiana	41	71,867	96,302	1.34	36,285	108,492	2.99	9,751	31,496	3.23
Michigan	4	1,197	2,561	2.14	909	2,445	2.69	12	36	2.98
Mississippi and Alabama	7	622	908	1.46	571	1,582	2.77	45	138	3.07
Montana and Utah	7	2,050	2,850	1.39	745	2,034	2.73	-------	---------	----
Nebraska	2	408	738	1.81	128	387	3.02	-------	---------	----
New Mexico	14	24,920	30,402	1.22	8,825	23,739	2.69	189	524	2.77
North Dakota	3	1,951	2,868	1.47	508	1,346	2.65	-------	---------	----
Oklahoma	36	27,304	34,403	1.26	13,359	35,401	2.65	1,098	3,085	2.81
Pennsylvania	3	35	78	2.23	22	61	2.78	-------	---------	----
Texas	76	194,599	237,411	1.22	73,664	216,572	2.94	21,021	65,375	3.11
West Virginia and Florida	6	4,775	9,741	2.04	942	2,609	2.77	1,050	2,163	2.06
Wyoming	14	4,428	7,085	1.60	2,240	6,205	2.77	283	846	2.99
Total	254	378,457	498,927	1.32	157,929	457,986	2.90	34,133	105,863	3.10

State	No. of operating companies [1]	Finished gasoline and naphtha			Other products [3]			Total		
		Quantity	Value	Dollars per barrel [2]	Quantity	Value	Dollars per barrel [2]	Quantity	Value	Dollars per barrel [2]
Arkansas	4	-------	-------	----	31	$89	2.86	1,971	$4,147	2.10
California and Alaska	15	-------	-------	----	-------	-------	----	21,262	57,723	2.71
Colorado	5	-------	-------	----	-------	-------	----	2,858	5,560	1.95
Illinois and Kentucky	4	-------	-------	----	-------	-------	----	14,227	27,475	1.93
Kansas	13	-------	-------	----	-------	-------	----	24,429	38,077	1.56
Louisiana	41	7,087	$30,049	4.24	442	1,397	3.16	125,432	267,736	2.13
Michigan	4	-------	-------	----	-------	-------	----	2,118	5,042	2.38
Mississippi and Alabama	7	-------	-------	----	16	35	2.19	1,254	2,663	2.12
Montana and Utah	7	-------	-------	----	-------	-------	----	2,795	4,884	1.75
Nebraska	2	-------	-------	----	-------	-------	----	536	1,125	2.10
New Mexico	14	35	112	3.21	4	13	3.36	33,973	54,790	1.61
North Dakota	3	-------	-------	----	-------	-------	----	2,459	4,214	1.71
Oklahoma	36	73	215	2.95	91	230	2.53	41,925	73,334	1.75
Pennsylvania	3	-------	-------	----	-------	-------	----	57	139	2.44
Texas	76	1,722	6,578	3.82	221	517	2.34	291,227	526,453	1.81
West Virginia and Florida	6	-------	-------	----	-------	-------	----	6,767	14,513	2.14
Wyoming	14	-------	-------	----	-------	-------	----	6,951	14,136	2.03
Total	254	8,917	36,954	4.14	805	2,281	2.83	580,241	1,102,011	1.90

[1] A producer operating in more than one State is counted once in arriving at U.S. total.
[2] Represents average unit value of sales throughout the year.
[3] Includes kerosine, jet fuel, distillate fuel, etc.

Table 3.—Production of natural gas liquids and ethane at natural gas processing plants in the United States in 1969

(Thousand barrels)

States by petroleum districts	Ethane	Liquefied petroleum gases: Propane	Butane	Butane-propane mixture	Isobutane	Total	Natural gasoline and isopentane	Plant condensate	Finished gasoline and naphtha	All other products [1]	Total
District 1:											
Georgia, Florida, and West Virginia	(2)	2,684	1,238	-------	119	4,041	(2)	1,050	-------	-------	6,767
Pennsylvania	-------	25	10	-------	-------	35	22	-------	-------	-------	57
Total	-------	2,709	1,248	-------	119	4,076	22	1,050	-------	-------	6,824
District 2:											
Michigan	-------	771	413	-------	13	1,197	909	12	-------	-------	2,118
Kansas	-------	12,613	5,518	-------	1,443	19,574	4,798	57	-------	-------	24,429
Nebraska	-------	250	158	-------	-------	408	128	-------	-------	-------	536
North Dakota	-------	1,192	759	-------	-------	1,951	508	-------	-------	-------	2,459
Oklahoma	454	17,422	7,122	896	1,410	26,850	13,359	1,098	73	91	41,925
Other States [3]	[2] 8,855	4,082	635	-------	520	5,237	[2] 1,811	-------	-------	-------	14,227
Total	9,309	36,330	14,605	896	3,386	55,217	21,513	1,167	73	91	85,694
District 3:											
Alabama and Mississippi	-------	268	166	188	-------	622	571	45	-------	16	1,254
Arkansas	-------	796	306	-------	177	1,279	564	97	-------	31	1,971
Louisiana											
Gulf	16,917	28,640	10,036	160	9,904	48,740	34,836	8,744	2,479	366	112,082
Inland	1,117	2,806	1,275	431	581	5,093	1,449	1,007	4,608	76	13,350
Total	18,034	31,446	11,311	591	10,485	53,833	36,285	9,751	7,087	442	125,432
New Mexico	1,893	12,787	9,198	427	615	23,027	8,825	189	35	4	33,973
Texas:											
Gulf	12,647	16,275	5,016	988	3,867	26,146	16,735	4,101	423	49	60,101
West	7,669	40,973	18,308	732	1,601	61,614	20,689	4,797	2	9	94,780
East (field)	122	2,805	1,650	55	107	4,617	1,608	22	-------	19	6,388
Panhandle	937	14,531	10,796	30	1,615	26,972	10,823	346	-------	-------	39,078
Other	12,416	24,500	10,308	2,318	4,333	41,459	23,809	11,755	1,297	144	90,880
Total	33,791	99,084	46,078	4,123	11,523	160,808	73,664	21,021	1,722	221	291,227
Total	53,718	144,381	67,059	5,329	22,800	239,569	119,909	31,103	8,844	714	453,857
District 4:											
Colorado	-------	1,084	653	-------	45	1,782	1,076	-------	-------	-------	2,858
Montana and Utah	-------	1,177	790	77	6	2,050	745	-------	-------	-------	2,795
Wyoming	-------	2,835	1,559	-------	34	4,428	2,240	283	-------	-------	6,951
Total	-------	5,096	3,002	77	85	8,260	4,061	283	-------	-------	12,604
District 5	-------	6,830	557	409	512	8,308	12,424	530	-------	-------	21,262
Total United States	63,027	195,346	86,471	6,711	26,902	345,430	157,929	34,133	8,917	805	580,241

[1] Includes jet fuel, kerosine, distillate, and other.
[2] PAD district 1 data included with PAD district 2, other States.
[3] Other States includes Florida, Georgia, Illinois, Kentucky, and West Virginia for ethane and natural gasoline and isopentane only.

Table 4.—Production of natural gasoline by vapor pressure and PAD districts in the United States in 1969

(Thousand barrels)

Reid vapor pressure	PAD District					Total
	1	2	3	4	5	
12 pounds and less	466	1,961	60,574	1,004	204	64,209
Over 12 pounds including 14 pounds	468	5,959	17,232	891	199	24,749
Over 14 pounds including 18 pounds	-------	5,467	3,799	787	304	10,357
Over 18 pounds including 22 pounds	22	115	235	-------	1,830	2,202
Over 22 pounds including 26 pounds	-------	1,060	12,744	446	2,004	16,254
Over 26 pounds	8	5,995	21,882	933	7,883	36,701
Total	964	20,557	116,466	4,061	12,424	154,472

Table 5.—Liquefied petroleum gas and ethane (LRG) produced at refineries for fuel and chemical use in 1969

(Thousand barrels)

States by petroleum district	Ethane	Propane	Butane	Butane-propane mixture	Total
District 1:					
New Jersey	-------	5,004	883	-------	5,887
Pennsylvania	-------	7,788	101	-------	7,889
Other States [1]	-------	3,092	762	-------	3,854
Total	-------	15,884	1,746	-------	17,630
District 2:					
Illinois	-------	4,908	324	-------	5,232
Indiana	-------	1,283	243	-------	1,526
Kansas	122	3,397	305	84	3,908
Kentucky	-------	824	109	-------	933
Michigan	-------	1,418	99	3	1,520
Other states [2]	-------	1,421	66	302	1,789
Ohio	-------	3,967	49	-------	4,016
Oklahoma	-------	3,204	983	1,384	5,571
Total	122	20,422	2,178	1,773	24,495
District 3:					
Alabama and Mississippi	-------	1,297	26	26	1,349
Arkansas	-------	642	72	-------	714
Louisiana:					
Gulf	2,745	11,249	2,141	4,212	20,347
Inland	-------	79	68	31	178
Total	2,745	11,328	2,209	4,243	20,525
New Mexico	-------	145	185	3	333
Texas:					
Gulf	5,512	17,494	13,696	4,256	40,958
West	-------	986	487	-------	1,473
East	-------	272	3	-------	275
Panhandle	132	1,006	487	-------	1,625
Other	-------	121	26	-------	147
Total	5,644	19,879	14,699	4,256	44,478
Total	8,389	33,291	17,191	8,528	67,399
District 4:					
Colorado	-------	91	192	-------	283
Montana	-------	390	22	-------	412
Utah	-------	452	38	-------	490
Wyoming	-------	187	568	8	763
Total	-------	1,120	820	8	1,948
District 5:	648	6,026	4,293	1,082	12,049
Total United States	9,159	76,743	[3] 26,228	11,391	123,521

[1] Includes Delaware, New York, Virginia and West Virginia.
[2] Includes Minnesota, Missouri, Nebraska, North Dakota, Tennessee, and Wisconsin.
[3] Includes 1,706,000 barrels of isobutane used for petrochemical feedstock.

Table 6.—Estimated proved recoverable reserves of natural gas liquids [1] in the United States

(Thousand barrels)

State	Reserves as of Dec. 31, 1968	Changes in reserves during 1969			Reserves as of December 31, 1969		
		Extensions and revisions [2]	Discoveries of new fields and new pools	Preliminary net production	Non-associated with oil	Associated-dissolved	Total
Alaska	---------	468	---------	70	---------	398	398
Arkansas	13,096	(41)	1,750	1,644	9,466	3,695	13,161
California [3]	203,268	3,121	300	20,757	7,364	178,568	185,932
Colorado	22,601	(563)	8	2,121	6,648	13,277	19,925
Illinois	1,895	(33)	---------	390	3	1,469	1,472
Indiana	44	4	---------	8	8	32	40
Kansas	270,556	17,451	191	18,937	261,173	8,088	269,261
Kentucky	52,464	---------	---------	3,481	48,983	---------	48,983
Louisiana	2,667,520	113,135	27,640	237,997	2,163,039	407,259	2,570,298
Michigan	3,592	1,436	216	1,188	1,375	2,681	4,056
Mississippi	19,578	1,589	1,090	2,212	13,161	6,884	20,045
Montana	9,783	1,253	---------	1,155	1,691	8,190	9,881
Nebraska	2,085	722	---------	539	1,071	1,197	2,268
New Mexico	604,163	43,034	773	48,295	372,424	227,251	599,675
North Dakota	61,563	(7,430)	---------	2,529	---------	51,604	51,604
Ohio	523	(515)	---------	8	---------	---------	---------
Oklahoma	448,023	51,488	6,847	40,664	333,088	132,606	465,694
Pennsylvania	1,064	---------	---------	90	974	---------	974
Texas	4,005,373	(45,485)	29,191	337,140	2,055,157	1,596,782	3,651,939
Utah	40,495	604	---------	2,310	1,337	37,452	38,789
West Virginia	83,627	3,295	---------	5,688	81,234	---------	81,234
Wyoming	84,968	23,986	15	8,557	52,350	48,062	100,412
Miscellaneous [4]	1,827	5,488	---------	182	6,352	781	7,133
Total	8,598,108	213,007	68,021	735,962	5,416,898	2,726,276	8,143,174

[1] Comprises natural gasoline, LPG, and condensate.
[2] Parenthesis denote decrease.
[3] Includes offshore reserves.
[4] Alabama only.

NOTE: Total remaining recoverable natural gas liquids reserves in the Gulf of Mexico are estimated to be 840,329,000 barrels; of which 740,773,000 barrels are nonassociated and 99,556,000 barrels are associated-dissolved.

Source: Committee on Natural Gas Reserves, American Gas Association.

Table 7.—Estimated productive capacity of natural gas liquids in the United States, December 31, 1969

(Thousand barrels per day)

State	Productive capacity			State	Productive capacity		
	Non-associated	Associated or dissolved	Total		Non-associated	Associated or dissolved	Total
Arkansas	4	3	7	New Mexico	113	95	208
California [1]	4	66	70	North Dakota	-------	8	8
Colorado	2	5	7	Oklahoma	214	75	289
Illinois	-------	1	1	Texas [1]	844	592	1,436
Kansas	151	9	160	Utah	1	6	7
Kentucky	10	-------	10	West Virginia	21	-------	21
Louisiana [1]	778	109	887	Wyoming	20	10	30
Michigan	2	1	3	Miscellaneous [2]	2	1	3
Mississippi	4	4	8				
Montana	1	3	4	Total	2,172	989	3,161
Nebraska	1	1	2				

[1] Includes offshore.
[2] Includes Alabama, Arizona, Florida, Iowa, Maryland, Minnesota, Missouri, South Dakota, Tennessee, and Washington.

Source: Committee on Natural Gas Reserves, American Gas Association.

Table 8.—Natural gas liquids[1] used as refinery input in the United States in 1969, by Bureau of Mines refinery districts, and by months

(Thousand barrels)

District	Jan.	Feb.	Mar.	Apr.	May	June	July
East Coast	468	438	263	260	289	247	298
Appalachian	18	8	10	21	11	11	11
Indiana, Illinois, Kentucky, etc.	2,054	1,752	1,299	1,203	1,267	1,173	1,301
Minnesota, Wisconsin, North Dakota, and South Dakota	388	364	322	226	226	287	296
Oklahoma, Kansas, Missouri	1,735	1,624	1,595	1,534	1,439	1,495	1,664
Texas:							
Inland	1,691	1,484	1,747	1,768	1,807	1,946	2,006
Gulf Coast	10,461	8,615	9,919	9,647	10,593	10,491	10,106
Total	12,152	10,099	11,666	11,415	12,400	12,437	12,112
Louisiana-Arkansas:							
Louisiana Gulf Coast	3,073	2,677	2,651	2,604	2,376	2,116	2,523
Arkansas and Louisiana Inland	382	392	411	405	421	364	426
Total	3,455	3,069	3,062	3,009	2,797	2,480	2,949
New Mexico	82	83	96	68	93	104	125
Other Rocky Mountain	504	464	492	439	434	417	466
West Coast	1,975	1,883	2,028	1,816	2,020	1,830	2,013
Total United States	22,831	19,784	20,833	19,991	20,976	20,481	21,235

District	Aug.	Sept.	Oct.	Nov.	Dec.	Total
East Coast	323	531	682	712	606	5,117
Appalachian	11	10	24	17	15	167
Indiana, Illinois, Kentucky, etc.	1,284	1,449	1,990	1,887	2,278	18,937
Minnesota, Wisconsin, North Dakota, and South Dakota	358	354	343	395	482	4,041
Oklahoma, Kansas, Missouri	1,729	1,841	1,963	2,009	2,331	20,959
Texas:						
Inland	1,937	1,951	2,085	1,886	2,049	22,357
Gulf Coast	10,671	10,722	11,380	11,461	11,135	125,201
Total	12,608	12,673	13,465	13,347	13,184	147,558
Louisiana-Arkansas:						
Louisiana Gulf Coast	2,374	2,718	2,622	3,226	3,795	32,755
Arkansas and Louisiana Inland	427	421	396	388	414	4,847
Total	2,801	3,139	3,018	3,614	4,209	37,602
New Mexico	104	104	89	106	89	1,143
Other Rocky Mountain	469	465	522	537	575	5,784
West Coast	1,843	1,919	2,098	1,942	1,913	23,280
Total United States	21,530	22,485	24,194	24,566	25,682	264,588

[1] Comprises natural gasoline, LPG, and condensate.

Table 9.—Refinery input of LPG by product and PAD district

(Thousand barrels)

LPG product	PAD District 1	2	3	4	5	United States
1967						
Propane	------	5	838	90	1,083	2,016
Butane	2,040	13,858	14,628	1,658	5,336	37,520
Isobutane	79	4,800	20,437	678	662	26,656
Butane-propane mix	------	1,947	144	154	238	2,483
Total	2,119	20,610	36,047	2,580	7,319	68,675
1968						
Propane	------	3	575	10	999	1,587
Butane	1,992	14,322	17,882	2,097	5,203	41,496
Isobutane	92	4,775	20,418	434	1,349	27,068
Butane-propane mix	------	1,792	35	403	271	2,501
Total	2,084	20,892	38,910	2,944	7,822	72,652
1969						
Propane	9	2	681	15	925	1,632
Butane	2,378	13,501	18,316	2,526	3,622	40,343
Isobutane	71	5,694	18,988	504	2,519	27,776
Butane-propane mix	------	1,996	237	494	286	3,013
Total	2,458	21,193	38,222	3,539	7,352	72,764

Table 10.—Production, stocks, and demand of liquefied petroleum gases at gas processing plants and refineries

(Thousand barrels)

	Ethane		Propane		Butane		Butane-propane mixtures		Isobutane		Total	
	1968	1969	1968	1969	1968	1969	1968	1969	1968	1969	1968	1969
Production:												
At gas processing plants	45,803	63,027	184,409	195,346	78,903	86,471	12,367	6,711	29,780	26,902	351,262	378,457
At refineries:												
For fuel use	-------	-------	56,847	57,022	9,584	13,535	4,671	5,102	-------	-------	71,102	75,659
For chemical use	9,446	9,159	17,489	19,721	12,441	10,987	6,494	6,289	1,115	1,706	46,985	47,862
Total	55,249	72,186	258,745	272,089	100,928	110,993	23,532	18,102	30,895	28,608	469,349	501,978
Net change in stocks:												
Liquefied petroleum gases:												
At gas processing plants	97	−30	7,459	−13,148	2,084	−2,811	115	−288	2,700	−882	12,455	−17,159
At refineries	-------	-------	-------	−1	65	−87	−41	79	68	−67	92	−76
Liquefied refinery gases:												
For fuel use	-------	-------	−498	136	−201	512	183	−91	-------	-------	−516	557
For chemical use	-------	-------	10	142	−37	−6	1	−1	−10	−15	−36	120
Exports	-------	-------	2,542	2,412	r 1,184	3,084	r 6,882	7,299	-------	-------	10,608	12,795
Imports	-------	-------	5,627	5,251	6,020	7,400	-------	-------	-------	-------	11,647	12,651
Used at refineries	-------	-------	1,587	1,632	41,526	40,268	2,527	3,013	27,012	27,851	72,652	72,764
Domestic demand:												
At gas processing plants	45,706	63,057	178,448	209,702	r 40,064	53,417	r 3,357	285	-------	-------	267,575	326,461
At refineries:												
For fuel use	-------	-------	57,345	56,886	9,785	13,023	4,488	4,538	-------	-------	71,618	74,447
For chemical use	9,446	9,159	17,479	19,579	12,478	10,993	6,020	3,268	1,125	1,721	46,548	44,720
Total	55,152	72,216	253,272	286,167	r 62,327	77,433	r 13,865	8,091	1,125	1,721	385,741	445,628
Stocks:												
Liquefied petroleum gases:												
At gas processing plants	2,212	2,182	44,523	31,375	16,141	13,330	528	240	7,736	6,854	71,140	53,981
At refineries	-------	-------	5	4	357	270	12	91	273	206	647	571
Liquefied refinery gases:												
For fuel use	-------	-------	2,947	3,083	936	1,448	342	251	-------	-------	4,225	4,782
For chemical use	-------	-------	73	215	42	36	1	-------	32	17	148	268
Total	2,212	2,182	47,548	34,677	17,476	15,084	883	582	8,041	7,077	76,160	59,602

r Revised.

Table 11.—Stocks of natural gas liquids and ethane in the United States

(Thousand barrels)

Date	LP gases and ethane		Natural gasoline and isopentane		Other finished products and plant condensate		Total at plants and terminals	Total at refineries	Grand total
	At plants and terminals	At refineries	At plants and terminals	At refineries	At plants and terminals	At refineries			
Dec. 31:									
1965	29,416	587	3,116	1,629	952	166	33,484	2,382	35,866
1966	34,610	587	2,673	1,300	950	303	38,233	2,190	40,423
1967	58,685	555	2,669	2,077	1,615	141	62,969	2,773	65,742
1968	71,140	647	2,628	1,860	1,528	137	75,296	2,644	77,940
1969:									
Jan. 31	53,992	794	2,990	1,894	1,202	242	58,184	2,930	61,114
Feb. 28	48,579	798	3,072	2,001	1,191	200	52,842	2,999	55,841
Mar. 31	47,558	666	3,230	2,040	1,115	236	51,903	2,942	54,845
Apr. 30	52,309	619	3,030	2,035	1,110	142	56,449	2,796	59,245
May 31	59,801	503	3,442	1,798	1,134	186	64,377	2,487	66,864
June 30	66,318	610	3,382	2,046	1,139	137	70,839	2,793	73,632
July 31	72,019	641	3,707	2,088	1,326	211	77,052	2,940	79,992
Aug. 31	75,629	546	3,746	2,442	1,256	241	80,631	3,229	83,860
Sept. 30	76,837	464	3,297	2,292	1,280	211	81,414	2,967	84,381
Oct. 31	72,873	516	3,360	2,102	1,167	212	77,400	2,830	80,230
Nov. 30	64,810	592	3,334	1,670	1,204	159	69,348	2,421	71,769
Dec. 31	[1] 53,981	571	3,368	1,557	1,203	232	58,552	2,360	60,912

[1] Includes 47,513,000 barrels in underground storage.

Table 12.—Values and volumes of natural gas liquids and ethane produced in the United States

	Thousand barrels		Percent change	Thousand dollars		Percent change	Dollars per barrel		Percent change
	1968	1969		1968	1969		1968	1969	
LP gases and ethane	351,262	378,457	+7.7	552,200	498,927	−9.6	1.57	1.32	−15.9
Natural gasoline and isopentane	147,874	157,929	+6.8	411,589	457,986	+11.3	2.78	2.76	−0.7
Plant condensate	38,494	34,133	−11.3	115,175	105,863	−8.1	2.99	3.10	+3.7
Finished gasoline and naphthas	6,684	8,917	+33.4	26,577	36,954	+39.0	3.98	4.14	+4.0
Other products	5,997	805	−86.6	18,232	2,281	−87,5	3.04	2.83	−6.9
Total	550,311	580,241	+5.4	1,123,773	1,102,011	−1.9	2.04	1.90	−6.9

Table 13.—Average monthly prices, liquefied petroleum gas (propane) in the United States [1]

(Cents per gallon)

	Jan.	Feb.	Mar.	Apr.	May	June	July
New York harbor and Philadelphia:[2]							
1969	7.25	7.25	7.25	6.96	6.75	6.75	6.75
Oklahoma:							
1968	5.69	5.49	4.68	4.13	3.77	3.75	3.75
1969	4.25	4.25	4.25	3.63	3.25	3.25	3.25
Baton Rouge:							
1968	6.25	6.11	5.39	4.75	4.34	4.25	4.25
1969	4.75	4.75	4.75	4.13	3.75	3.75	3.75

	Aug.	Sept.	Oct.	Nov.	Dec.	Average for year
New York harbor and Philadelphia:[2]						
1969	6.75	6.78	7.50	7.54	7.50	7.09
Oklahoma:						
1968	3.75	3.75	3.75	3.75	4.05	4.19
1969	3.25	4.07	4.25	4.53	4.75	3.92
Baton Rouge:						
1968	4.25	4.25	4.25	4.25	4.55	4.74
1969	3.75	4.57	4.75	4.97	5.25	4.41

[1] Producers' net contract prices (after some discounts and summer-fill allowances) for propane, tank cars/transport trucks.
[2] Prior to 1969, New York and Philadelphia listed separately. See 1968 Platt's Oil Price Handbook, 45th edition, for separate listings 1964–68.

Source: Platt's Oil Price Handbook.

Table 14.—LP gases [1] exported from the United States, by countries

(Thousand barrels and thousand dollars)

Country	1968				1969			
	Butane	Propane	Butane-propane mixtures	Total	Butane	Propane	Butane-propane mixtures	Total
Argentina	225	237	-------	462	766	131	27	924
Bahamas	(2)	54	(2)	54	(2)	86	(2)	86
Belgium-Luxembourg	4	7	14	25	(2)	-------	27	27
Brazil	377	-------	(2)	377	617	-------	-------	617
Canada	277	17	116	410	566	19	253	838
Chile	(2)	22	26	48	(2)	-------	29	29
France	(2)	114	(2)	114	13	(2)	-------	13
Guatemala	3	-------	11	14	3	11	5	19
Japan	(2)	-------	1	1	2	509	3	514
Mexico	245	731	6,701	7,677	171	889	6,937	7,997
Portugal	-------	-------	-------	-------	6	7	4	17
Spain	45	5	(2)	50	931	37	(2)	968
United Kingdom	1	1,343	1	1,345	2	698	1	701
Other	3	10	12	25	5	13	14	32
Total	1,180	2,540	6,882	10,602	3,082	2,400	7,300	12,782
Total value	$3,325	$9,865	$19,298	$32,488	$7,030	$7,071	$20,196	$34,297

[1] Data include LR gases.
[2] Less than ½ unit.

Nickel

By Horace T. Reno [1]

Prolonged labor strikes at the mines of the principal nickel producers in Canada cut the nickel supply and further increased the worldwide imbalance between supply and demand. As a result the price of primary nickel in world markets was raised 25 cents per pound, and the prices paid for merchant nickel and nickel contained in scrap advanced to 5 to 7 times the price of primary nickel. Free world nickel production reached an estimated 361,000 tons, Communist countries produced about 147,000 tons; the total world output was approximately 508,000 tons. The International Nickel Co. of Canada Ltd. (Inco) estimated free world nickel consumption at 410,000 tons, and Communist countries consumed an estimated 120,000 to 130,000 tons. The difference between production and demand was met by drawing from Government and industrial stocks. For the fourth year since 1965, use of nickel in the world was restricted by the available supply.

Most nickel producers engaged in plant expansion programs designed to increase free world nickel production capacity to over 550,000 tons annually by 1972. New mines, concentrating plants, and processing plants were being bulit in Canada, New Caledonia, Australia, and in the Dominican Republic. Almost all mines producing from nickeliferous laterites installed new facilities.

Legislation and Government Programs.—According to the July–December 1969 Statistical Supplement Stockpile Report to the Congress prepared by the General Services Administration, 66,376 short tons of nickel plus cobalt was in the defense materials inventory as of December 31, 1969. Of this quantity 48,780 short tons was in the strategic stockpile, 1,220 tons was in the Defense Production Act (DPA) stocks, and 16,376 tons was held in stock for the U.S. Mint. The Government raised the stockpile objective for nickel on May 13 from 20,000 to 55,000 tons. Therefore after that date, nickel stocks in the strategic stockpile were less than the objective. On June 13, Public Law 91–25 extended the suspension of the tariff on metal scrap which included nickel scrap. The Business and Defense Service Administration (BDSA) of the U.S. Department of Commerce set aside primary nickel for defense purposes, equal to 25 percent of the producers average monthly shipments during the last 6 months of 1967. In addition, BDSA strengthened its control over the supply of nickel in the last half of the year when it became apparent that the labor strike at mines in Canada would limit nickel imports into the United States. On July 11, BDSA discontinued issuing nickel export licenses. On July 25, BDSA limited users of defense rated orders to "quantities of primary nickel needed for current use in defense orders and not for inventory replacement," and on September 11 the Administration revised its export control on nickel to specify that "validated licenses will be required to export nickel-bearing stainless steel ingots and iron and steel scrap, including scrap metals in crude forms containing 1 percent or more nickel to countries not previously requiring validated licenses."

[1] Physical scientist, Division of Ferrous Metals.

Table 1.—Salient nickel statistics
(Short tons)

	1965	1966	1967	1968	1969
United States:					
Mine production	16,188	15,036	15,287	17,294	17,056
Plant production:					
Primary	13,510	13,237	14,615	15,154	15,616
Secondary	19,407	26,777	20,731	14,061	18,775
Exports	20,935	26,387	31,537	33,681	34,758
Imports for consumption	163,000	141,000	143,000	147,950	129,332
Consumption	172,084	187,833	173,798	159,306	141,737
Stocks Dec. 31: Consumer	14,047	31,288	31,007	27,466	16,590
Price cents per pound	79–77¾	77¾–85¼	85¼–94	94–103	103–128
World: Production	468,346	454,457	494,835	546,496	530,495

DOMESTIC PRODUCTION

The Hanna Mining Co. at Riddle, Oreg., was the sole producer of primary nickel in the United States. Nickel salts were produced as a byproduct at copper and other metal refineries; part of the byproduct nickel originated from scrap. Several major mining companies explored for nickel in the United States, principally in Minnesota, Wyoming, and the Pacific Northwest States. However, no significant developments were reported.

Table 2.—Primary nickel produced in the United States
(Short tons, nickel content)

	1965	1966	1967	1968	1969
Byproduct of metal refining	844	1,006	1,579	2,030	2,520
Domestic ore	12,666	12,231	13,036	13,124	13,096

Table 3.—Nickel recovered from nonferrous scrap processed in the United States, by kind of scrap and form of recovery
(Short tons)

Kind of scrap	1968	1969	Form of recovery	1968	1969
New scrap:			As metal	1,165	1,514
Nickel-base	1,733	2,170	In nickel-base alloys	2,006	2,221
Copper-base	2,828	3,486	In copper-base alloys	5,217	6,746
Aluminum-base	600	630	In aluminum-base alloys	1,050	997
			In ferrous and high-temperature		
Total	5,161	6,286	alloys [1]	4,172	6,965
			In chemical compounds	451	332
Old scrap:					
Nickel scrap	7,802	11,331	Total	14,061	18,775
Copper-base	748	778			
Aluminum-base	350	380			
Total	8,900	12,489			
Grand total	14,061	18,775			

[1] Includes only nonferrous nickel scrap added to ferrous and high-temperature alloys.

CONSUMPTION AND USES

Despite the prolonged nickel shortage, domestic consumption of nickel, exclusive of scrap, was only 11 percent less than that in 1968. However, it was 16 percent less than the 5-year average, 1964–68. Consumption of old and new nickel scrap was 64 percent more than that in 1968. Overall U.S. nickel consumption in 1969 was thus only 5 percent less than comsumption in 1968. Primary nickel consumed to make stainless and heat-resistant steels was down about 11 percent compared with 1968 as the output of high-nickel stainless steels continued to decline.

The Bureau of Mines has changed the format for canvassing and reporting U.S. nickel consumption. Nickel used in superalloys is reported separately for the first time. Although the new format sacrifices several historical series, the disadvantage of doing so should be outweighed by the advantage of having significant data on the use of nickel in materials of the aerospace age.

Table 4.—Stocks and consumption of new and old nickel scrap in the United States in 1969

(Gross weight, short tons)

Class of consumer and type of scrap	Stocks beginning of year	Receipts	Consumption New	Consumption Old	Consumption Total	Stocks, end of year
Smelters and refiners:						
Unalloyed nickel	108	1,560	1,108	470	1,578	90
Monel metal	507	3,892	582	3,061	3,643	756
Nickel silver [1]	564	5,643	738	4,954	5,692	515
Cupronickel [1]	98	381	------	428	428	51
Miscellaneous nickel alloys	------	4,961	51	4,900	4,951	10
Nickel residues	21	6,974	2,453	2,799	5,252	1,743
Total	636	17,387	4,194	11,230	15,424	2,599
Foundries and plants of other manufacturers:						
Unalloyed nickel	394	13,637	72	6,888	6,960	7,071
Monel metal	10	268	92	152	244	34
Nickel silver [1]	1,999	11,656	11,475	100	11,575	2,080
Cupronickel [1]	5,060	320	4,088	150	4,238	1,142
Nickel residues	335	858	297	706	1,003	190
Total	739	14,763	461	7,746	8,207	7,295
Grand total:						
Unalloyed nickel	502	15,197	1,180	7,358	8,538	7,161
Monel metal	517	4,160	674	3,213	3,887	790
Nickel silver [1]	2,563	17,299	12,213	5,054	17,267	2,595
Cupronickel [1]	5,158	701	4,088	578	4,666	1,193
Miscellaneous nickel alloys	------	4,961	51	4,900	4,951	10
Nickel residues	356	7,832	2,750	3,505	6,255	1,933
Total	1,375	32,150	4,655	18,976	23,631	9,894

[1] Excluded from totals because it is copper-base scrap, although containing considerable nickel.

Table 5.—Nickel (exclusive of scrap) consumed in the United States, by forms

(Short tons)

Form	1965	1966	1967 [1]	1968 [1]	1969 [1]
Metal	146,357	132,573	124,639	115,839	99,096
Ferronickel	-------	29,674	25,228	15,170	17,804
Oxide powder and oxide sinter	23,047	22,845	19,349	24,362	19,133
Matte	3	-------	-------	-------	-------
Salts [2]	2,677	2,741	4,582	3,935	2,647
Other	-------	-------	-------	-------	3,057
Total	172,084	187,833	173,798	159,306	141,737

[1] Metallic nickel salts consumed by plating industry are estimated.
[2] Figures do not cover all consumers for 1965-66.

Table 6.—U.S. consumption of nickel (exclusive of scrap), by uses and forms, 1969

(Short tons)

Use	Commercially pure unwrought nickel	Ferronickel	Nickel oxide	Nickel sulfate and other nickel salts	Other forms	Total of figures shown
Steel:						
Stainless and heat-resisting	18,700	8,335	12,395	-----	28	39,458
Alloys (excludes stainless)	10,125	8,582	5,157	W	W	23,864
Superalloys	12,709	W	W	-----	W	12,709
Nickel-copper and copper-nickel alloys	5,341	W	15	-----	118	5,474
Permanent magnet alloys	W	W	W	-----	-----	-----
Other nickel and nickel alloys	26,047	140	W	W	78	26,265
Cast irons	3,183	403	387	W	1,615	5,588
Electroplating [1]	16,487	W	28	2,398	329	19,242
Chemicals and chemical uses	462	-----	174	153	W	789
Other uses [2]	6,042	344	977	96	889	8,348
Total reported by companies canvassed and estimated	99,096	17,804	19,133	2,647	3,057	141,737

W Withheld to avoid disclosing individual company confidential data.
[1] Based on monthly estimated sales to platers.
[2] Includes batteries, ceramics, and other alloys containing nickel.

Table 7.—Nickel (exclusive of scrap) in consumer stocks in the United States, by forms

(Short tons)

Form	1967	1968 r	1969
Metal	24,383	19,385	12,566
Ferronickel	2,462	2,603	1,888
Oxide powder and oxide sinter	3,759	4,321	998
Salts	403	502	524
Other	------	655	614
Total	31,007	27,466	16,590

r Revised.

PRICES

The price of electrolytic nickel remained unchanged at US$1.03 per pound until November 24, 1969, when (INCO) announced a price increase on nickel cathodes of 25 cents per pound to $1.28 per pound. Prices for other forms of nickel were adjusted accordingly. The following day, the other major nickel producers of the world followed suit. Prices for merchant nickel and nickel contained in scrap rose rapidly during the Canadian strike and reached a peak of $6.65 to $7.15 per pound for merchant nickel, and $5.80 to $6.40 for nickel contained in scrap. At yearend merchant electrolytic nickel was quoted at $5.80 to $6.40 per pound f.o.b. shipping point, nominal. Scrap nickel prices ranged from $2 to $4 per pound in the latter part of December.

FOREIGN TRADE

U.S. foreign trade in nickel in 1969, although seriously curtailed by the strike in Canada, was only 10 percent less than that in 1968. Canadian imports were down 18 percent, but delivery of nickel processed before the strike, that in transit, and a marked increase in imports of nickel scrap and of ferronickel modified the impact of decreased trade with Canada. Of the 15,696 tons of ferronickel imported for consumption in the United States, 10,365 tons came from New Caledonia, 4,754 tons came from Greece, 248 tons from Brazil, 161 tons from Sweden, 114 tons from France, and the remaining 54 tons came from Mexico, the United Kingdom, Japan, and the Republic of South Africa.

Table 8.—U.S. exports of nickel and nickel alloy products, by class

Class	1967		1968		1969	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Unwrought	7,453	$14,347	6,498	$14,211	1,851	$5,631
Bars, rods, angles, shapes, and sections	2,595	8,697	2,880	7,277	5,052	12,405
Plates, sheets, and strip	1,997	9,292	2,308	9,784	4,218	16,582
Anodes	232	558	107	326	91	347
Wire	565	2,530	624	2,652	746	3,630
Powder and flakes	533	2,144	337	1,598	398	2,517
Foil	6	26	51	92	14	83
Catalysts	3,441	9,387	3,340	7,299	3,592	7,531
Tubes, pipes, blanks, and fittings therefor, and hollow bars	823	3,417	774	3,646	768	3,887
Waste and scrap	13,892	20,331	16,762	24,788	18,028	29,455
Total	31,537	70,729	33,681	71,673	34,758	82,068

Table 9.—U.S. imports for consumption of nickel products, by class

Class	1967 Short tons	1967 Value (thousands)	1968 Short tons	1968 Value (thousands)	1969 Short tons	1969 Value (thousands)
Ore	-------	-------	42	$2	30	$2
Unwrought	113,860	$193,848	108,158	201,312	99,652	209,468
Oxide and oxide sinter	6,208	8,130	6,388	8,911	4,013	6,524
Slurry [1]	22,984	39,892	35,099	63,674	23,714	54,784
Bars, plates, sheets, and anodes	172	536	245	669	113	628
Rods and wire	428	1,435	392	1,287	540	2,171
Shapes, sections, and angles	1	1	-------	-------	5	30
Pipes, tubes, and fittings	107	442	146	627	10	45
Powder	3,716	7,319	2,936	6,106	2,708	6,452
Flakes	(2)	(2)	53	109	65	136
Waste and scrap	1,104	1,240	r 1,974	r 2,575	3,188	8,084
Ferronickel	9,020	3,482	r 10,553	r 5,450	15,696	9,507
Total (gross weight)	157,600	256,325	165,986	290,722	149,734	297,831
Nickel content (estimated)	143,000	XX	147,950	XX	129,332	XX

r Revised. XX Not applicable.
[1] Nickel-containing material in powder, slurry, or any form, derived from ore by chemical, physical, or any other means, and requiring further processing to recover nickel or other metals.
[2] Less than ½ unit.

Table 10.—U.S. imports for consumption of new nickel products,[1] by countries

(Short tons)

Country	Metal 1968 (Gross weight)	Metal 1969 (Gross weight)	Oxide and oxide sinter 1968 (Gross weight)	Oxide and oxide sinter 1969 (Gross weight)	Slurry and other [2] 1968 Gross weight	Slurry and other [2] 1968 Nickel content	Slurry and other [2] 1969 Gross weight	Slurry and other [2] 1969 Nickel content
Canada	97,101	86,242	6,383	4,008	31,921	26,363	19,458	16,376
Finland	26	43	-----	-----	-----	-----	-----	-----
France	33	20	1	-----	-----	-----	-----	-----
Germany, West	10	27	-----	1	-----	-----	-----	-----
Netherlands	27	112	-----	-----	-----	-----	-----	-----
Norway	9,518	11,224	-----	-----	-----	-----	-----	-----
South Africa, Republic of	239	246	-----	-----	3,178	1,443	3,806	1,836
Southern Africa, n.e.c.	-----	45	-----	-----	-----	-----	450	207
Sweden	116	28	-----	-----	-----	-----	-----	-----
U.S.S.R.	r 402	1,109	-----	-----	-----	-----	-----	-----
United Kingdom	681	372	4	4	-----	-----	-----	-----
Other countries	r 5	184	-----	(3)	-----	-----	-----	-----
Total	r 108,158	99,652	6,388	4,013	35,099	27,806	23,714	18,419

r Revised.
[1] Ore: 1968, 42 short tons from Japan; 1969, 30 short tons from Peru.
[2] Nickel-containing material in powder, slurry, or any form, derived from ore by chemical, physical, or any other means, and requiring further processing to recover nickel or other metals.
[3] Less than ½ unit.

WORLD REVIEW

The nickel industry in 1969 was marked by worldwide activity from exploration of mineral deposits to refining of metal. Most interest was in developing Australian and New Caledonia deposits. The nickel industry of Canada, although hampered by long labor strikes against the two principal producing companies, developed new mining and processing capacity. Exploitation of low-grade nickel, laterite deposits was advanced markedly in the Dominican Republic, Indonesia, and the Philippines.

Australia.—Australia's nickel production practically doubled for the second year in a row. Most of the primary nickel produced in Australia in 1969 came from the Western Mining Company's Silver Lake shaft at Kambalda, but the Scotia mine of Great Boulder Gold Mines Ltd. produced nickel in the last quarter of the year.

Western Australia's nickel boom continued unabated throughout the year, but the major mining companies apparently worked more to consolidate their position at deposits already discovered rather than to prospect in new areas. The same was true in Queensland at Greenvale, where Freeport of Australia Ltd. and Metals Exploration N.L. investigated the economic feasibility of exploiting the nickeliferous laterites explored in 1967 and 1968.

Table 11.—World production of nickel, by countries

(Short tons)

Country [1]	1965	1966	1967	1968	1969 p
North America:					
Canada [2]	267,308	r 238,598	r 248,647	263,542	212,414
Cuba:					
Content of oxide e	20,200	17,500	r 21,500	20,950	20,400
Estimated content of sulfide	9,900	11,100	r 12,500	16,200	18,400
Dominican Republic (content of ferronickel)	-------	-------	37	324	-------
United States:					
Byproduct of copper refining	844	1,006	1,579	2,030	2,520
Nickel recovered from domestic ore	12,666	12,231	13,036	13,124	13,096
South America:					
Brazil (content of ferronickel)	1,228	r 1,070	1,181	1,186	e 1,200
Europe:					
Finland:					
Content of nickel sulfate	180	204	176	195	e 187
Content of concentrates	3,295	3,254	3,812	3,666	e 3,748
Greece: nickel recovered from ore	-------	-------	e 2,535	e 4,189	e 6,614
Norway (content of concentrate)	-------	-------	166	e 198	e 248
Poland (content of ore) e	1,214	1,400	1,650	1,653	1,653
U.S.S.R. (content of ore) e	90,000	95,000	105,000	110,231	115,743
Africa:					
Morocco (content of cobalt ore) e	397	430	410	-------	15
Rhodesia, Southern (content of ore)	e 770	e 770	e 770	1,102	8,818
South Africa, Republic of (content of matte and refined nickel) e	3,300	6,000	6,000	6,063	6,063
Asia:					
Burma (content of speiss)	e 55	e 75	3 e 30	40	28
Indonesia (content of ore)	3,935	4,335	5,642	8,663	7,716
Oceania:					
Australia (content of concentrates)	-------	-------	2,308	5,122	11,901
New Caledonia (recoverable) [4]	53,054	61,484	67,856	88,018	99,731
Total [5]	r 468,346	454,457	r 494,835	546,496	530,495

e Estimate. p Preliminary. r Revised.

[1] Nickel is also produced in Albania and East Germany, but production data are not available.

[2] Refined nickel and content of oxides and salts produced plus recoverable nickel in matte and concentrates exported.

[3] Fiscal year October through September. Figures are for first 9 months of year noted and 3 months of previous year.

[4] Nickel-cobalt content of metallurgical plant products plus recoverable nickel-cobalt in exported ores.

[5] Total is of listed figures only.

Great Boulder Gold Mines Ltd. and North Kalgurli Ltd. reported a significant deposit of sulfide ore containing about 2 percent nickel in Carr Boyd Rocks area north of Kalgoorlie and nickel in arsenic ores in the old Mount Martin gold mine south of Kalgoorlie. Western Mining Corp. explored laterite deposits in the Ora Banda-Kunanalling-Broad Arrow area north of its Kambalda operations, and Anaconda Australia Inc., Conzinc Riotinto of Australia Ltd., and New Broken Hill Consolidated Ltd. reported an ore body of about a million tons containing 1.2 percent nickel and minor copper to a depth of 1,000 feet in the Higginsville-Widgiemooltha area. This deposit was north of those previously reported at Higginsville. All these new discoveries strengthen the theory of a nickel province superimposed on the Western Australian gold belt that extends from Norseman in an arc north to Wiluna.

A nickel discovery by Poseidon N.L. some 200 miles north of Kalgoorlie extended the known nickel-bearing area in conformance with the theoretical. This alone would make news. The impact of the discovery on the London Stock Exchange made the headlines around the world as the price of Poseidon stock went from $3 to $119 a share. The sensational price rise was symbolic of the worldwide interest in Australia's fledgling nickel industry. Moreover, it was probably an indication of the course of the industry's future, if the world markets can absorb the potential nickel output as planned by the concerns that operated in 1969.

Botswana.—Botswana Roan Selection Trust Ltd. announced that its subsidiary Bamangwato Concessions Ltd. had developed enough nickel-copper reserves in the Pikwe-Selebi area 60 miles southeast of Francistown to support a mining-smelting complex. The International Bank for Reconstruction and Development issued a $2.5 million credit for engineering design and preliminary work for the necessary infrastructure. Roan Selection Trust Ltd., American Metal Climax, and the Botswana Government will participate in the project.

Canada.—Canadian nickel production was almost 20 percent less than that in 1968, as the two largest producing companies were shut down by labor strikes. INCO was struck July 10, and Falconbridge Nickel Mines Ltd. was struck August 21. The INCO strike ended on November 17 and Falconbridge strike ended on November 22.

Despite the setback caused by the strikes, the nickel industry of Canada made notable advances in 1969. Nickel prospecting and exploration crews were active in the Sudbury district of Ontario, in Manitoba, Quebec, and Saskatchewan, and to a lesser extent throughout the Territories. Sheridan Geophysics Ltd., through New Hosco Mines, brought the Renzy Mines open pit nickel-copper mine in southern Quebec into production at approximately 500 tons of 1 percent nickel-copper per month. In order to open the mine, the company had to drain a million gallons of water from Lake Renzy and move approximately 450,000 cubic yards of overburden. Falconbridge Nickel Mines Ltd. conducted a comprehensive feasibility study of the New Quebec Raglan Mines project in northern Quebec approximately 1,000 miles north of Montreal.

Both INCO and Falconbridge worked on new facilities to increase the efficiency and productivity of their operations. INCO completed the 7,138-foot Creighton shaft, the deepest shaft in the Western Hemisphere, and was in the process of bringing 6 mines in its Ontario division and two mines in its Manitoba division into production. It began building the Clarabelle mill, which will have capacity to process 35,000 tons of ore per day and will be the company's fifth mill in the Sudbury district.

Falconbridge Nickel Mines Ltd. was active on a somewhat smaller scale. Its Strathcona mine reached full production early in the year, and the company began installing facilities to bring its Manibridge mine in Manitoba into production.

Canadian nickel producers and their 1969 production or delivery to customers as given in their annual reports to stockholders were as follows:

Company	Type of operation	Thousand pounds
The International Nickel Co. of Canada Ltd.	Delivery	309,940
Falconbridge Nickel Mines Ltd.	Delivery	80,647
Sherritt Gordon Mines Ltd.	Production	23,074
Consolidated Canadian Faraday Ltd.	Production	2,705
Giant Mascot Mines Ltd.	Recovery	3,496

The Canadian Government established controls on exports of nickel in all forms, except scrap, to all destinations effective December 5. Controls on scrap became effective December 19. The controls were established to insure adequate supply and distribution of nickel to Canadian consumers and to insure that normal channels of trade are utilized fully to supply traditional consumers of exported nickel.

Cuba.—Nickel was produced at the Nicaro and Moa Bay laterite leaching plants in Oriente Province of Cuba. Reportedly, neither nickel oxide nor sulfide production exceeded that of 1968 and may have been substantially less.

Dominican Republic.—Falconbridge Dominicana C. por A. began constructing a plant to produce ferronickel from the laterite deposits it has been exploring since 1956. Falconbridge Dominicana is a subsidiary of Falconbridge Nickel Mines Ltd. of Canada. However, Falconbridge sold Armco Steel Corporation of the United States 20 percent of its shareholdings in Dominicana in 1959. The construction project is being financed with $41 million from Canadian and United States commercial banks, $80 million from U.S. insurance companies, and the equivalent of $25 million from the International Bank for Reconstruction and Development, together with a subordinated loan of $34 million from the insurance companies. Falconbridge Dominicana C. por A. is capitalized for 1,500,000 shares, 65.7 percent of which was held by Falconbridge. The Dominican Government held an option to purchase 47,664 shares at $10 per share.

Greece.—Larco produces all of the primary nickel in Greece. Larco's output has more than doubled since 1967, its first year of full operation. In 1969 the company was in the process of again doubling its capacity.

Guatemala.—Exploraciones y Explotaciones Mineras Izabal, S.A., owned 80 percent by INCO and 20 percent by The Hanna Mining Co., did not reach agreement with the Guatemalan Government to construct a 60-million-pound-per-year nickel plant, although plans for the plant and for mine development were completed early in the year.

India.—The Geological Society of India announced that a deposit containing about 15 million metric tons of low-grade nickel was discovered in the Cuttack district of Orissa State. Tests by the National Metallurigical Laboratory indicated that the ore contained 0.72 percent recoverable nickel.

Indonesia.—The Indonesian Government contracted with P.T. Pacific Nikkel to explore for nickel on Waigeo Island off the Sentani area of West Irian (formerly Dutch New Guinea). Pacific Nikkel is owned 43 percent by United States Steel Corp., 22 percent by Koninklijke Nederlandsche Hoogovens en Staalfabrieken, 15 percent by Newmount Mining Corp., and 10 percent each by Wm. H. Müller and Co. N.V. and Sherritt Gordon Mines Ltd. The exploration contract is similar to one made last year with P.T. International Nickel Indonesia.

New Caledonia.—Following through on its announced intention of permitting competition in the nickel mining industry of New Caledonia, the French Government approved the organization of Compagnie Française Industrielle et Minière du Pacifique (COFIMPAC) to exploit nickel deposits in competition with Société Le Nickel. COFIMPAC is owned 40 percent by INCO and 60 percent by Société Auxiliaire et Minière du Pacifique (SAMIPAC), a French holding company. COFIMPAC located substantial nickel deposits in the northern section of New Caledonia, but at yearend had not yet come to a decision on exploiting them.

American Metal Climax, Inc. (AMAX), and Société Minière et Métallurgique de Peñarroya S.A., anticipating French Goverment approval, formed Penamax G.I.E. to exploit New Caledonian nickel resources.

Société Le Nickel, New Caledonia's only integrated nickel producer until 1969, asked the French Government to approve a project to establish a metallurgical complex in the northern part of New Caledonia. Ore would be supplied by independent mining enterprises. The metallurigical plant would produce ferronickel from silicate ores.

Philippines.—Marinduque Mining and Industrial Corp.'s nickel laterite project on Nonoc Island apparently was running behind schedule. A feasibility study and certain engineering aspects of the project had not been completed by midyear. However, a pilot plant test of the ore by Sherritt Gordon Mines Ltd. of Canada was completed successfully.

United Kingdom.—The United Kingdom's experience with the nickel industry during the year paralleled that of Canada. The Canadian labor strike, which intensified the worldwide shortage of nickel, was felt almost immediately in the U.K. because of the large refining facilities there. The workers at Inco's Clydach, South Wales, refinery struck the plant on September 19. Moreover, the British Government strengthened its export controls on nickel in iron and steel alloys in October and released part of its strategic stockpile of nickel in November. The Clydach workers were still on strike at yearend.

TECHNOLOGY

Bureau of Mines nickel research projects were again designed to reclaim nickel from waste materials and incidentally to contribute to control of evironmental pollution. Bureau chemists developed a solvent extraction method for recovering nickel and zinc from phosphate wastes.[2] The process was demonstrated on a laboratory scale. Several million gallons of phosphate waste is generated each year in phosphating sheet steel to provide a base for paint, enamel, or lubricating oil or to protect the steel against corrosion. Application of the Bureau's process to waste treatment would not only save the contained metals but would also prevent the waste from polluting the streams and rivers into which it is normally discharged.

Bureau of Mines researchers described a bench-scale hydrometallurgical process for recovering nickel, cobalt, molybdenum, and chromium from small fragments of super-

[2] Powell, H. E., L. L. Smith, and A. A. Cochran. Solvent Extraction of Nickel and Zinc From a Waste Phosphate Solution. BuMines Rept. of Inv. 7336, 1970, 14 pp.

alloy scrap.[3] The scrap was dissolved in chlorinated, dilute hydrochloric acid. Then silicon and tungsten were removed by carbon absorption; molybdenum, iron, and cobalt were removed successfully by solvent extraction; and then chromium and nickel were removed in that order by selective precipitation. Nickel was precipitated as a carbonate which could be converted to nickel oxide suitable for metallurgical use.

Judging by the number of patents issued, industrial researchers continued to seek better methods of extracting nickel from its ores. The work apparently was divided about equally among acidic and basic laterites. However, a froth flotation reagent said to improve selectivity of nickel sulfide ores, among others, was patented. High nickel demand and limited supply, intensified by labor strikes in the Canadian and Australian mines, led to an intensified search for nickel substitutes. Despite the shortage, metallurgists developed several new nickel-base superalloys.

A heat exchange system to utilize heat in mine exhaust air to raise the temperature of the intake air was installed at the Strathcona Mine of the Falconbridge Nickel Mines Ltd.[4] The Strathcona Mine is in the Sudbury district of Ontario where the average January temperature is 5° F and temperatures of 30° below zero are common. Therefore, the intake air must be heated before it is introduced into the mine. The heat exchange system theoretically recovers 16.1 million Btu per hour.

The Agricultural Department of INCO reported increasing success in growing grasses and grains on its mill tailings. The group tested alfalfa, sweet clover, and oats in experimental plots and established flourishing crops of grass in some areas by using rye to protect the grass during the first 2 years of growth.[5]

Sherritt Gordon Mines Ltd.'s ammonia leach process, which has been used successfully since 1954 to recover nickel from sulfide concentrates, is to be used in modified form to treat lateritic ores under a licensing agreement with the Marinduque Mining and Industrial Corp. Marinduque will construct a plant in the Philippines for treating laterite ore on the Surigao Mineral Reservation. Western Mining Corp. is installing the same Sherritt Gordon process for use at its refinery at Kwinana, Western Australia.[6]

In further work to eliminate or modify pollution from its operations, INCO designed an exhaust chimney 1,250 feet high that, in conjunction with electrostatic precipitators, will prevent sulfur dioxide from destroying vegetation in the area of its smelter complex at Copper Cliff, Ontario.

Researchers found ways to replace about half the nickel used in plating processes with an equal weight of cobalt. During normal times the substitution would not be profitable because cobalt normally costs more than nickel. However, with platers forced to pay $6 per pound or more to obtain nickel and with cobalt available at about $2 per pound, the substitution process went from research laboratory to commercial application within a short time. On industrial shapes plated in the research laboratories the cobalt-nickel plating appeared as bright as that of pure nickel.

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[3] Brooks, P. T., G. M. Potter, and D. A. Martin. Chemical Reclaiming of Superalloy Scrap. Bumines Rept. of Inv. 7316, 1969, 28 pp.

[4] McCallum, V. I. Design of Mine Air Heating Plant at Strathcona Mine Falconbridge Nickel Mines Ltd. Canadian Min. J., v. 90, No. 10, October 1969, pp. 62–65.

[5] Pit and Quarry. International Nickel Agriculturists Grow Grass on Fields of Rock After Agstone Neutralizes Acidity. V. 61, No. 9, March 1969, p. 155.

[6] Rosenzweig, Mark D. Hydrometallurgical Process Yields Pure Nickel. Chem. Eng. v. 76, No. 7, April 1969, pp. 108–110.

Nitrogen

By Walter C. Lorenz [1]

Increases in United States crop production per acre during the last 20 years have been greatly influenced by the quantity and quality of fertilizers used, particularly nitrogen compounds. Nitrogen use in fertilizers continued to grow in the United States and throughout the world during 1969. U.S. consumption of nitrogen in fertilizers during the year increased 3 percent.

Domestic production of anhydrous ammonia increased 5 percent in 1969. The annual production of urea and ammonium phosphate increased by 12 and 9 percent, respectively; the production of ammonium nitrate, ammonium sulfate, and nitric acid decreased 3, 4, and 2 percent, respectively.

World production of agricultural nitrogen rose again in 1969 to 30.6 million short tons, from 27.9 million during the previous year. However, technical nitrogen production, worldwide, decreased slightly to 6.8 million short tons, from 6.9 million in 1968.

Table 1.—Salient nitrogen statistics

(Thousand short tons of contained nitrogen)

	1965	1966	1967	1968	1969 p
United States:					
Production as ammonia	7,465	8,904	10,205	10,130	10,611
Production as high purity nitrogen gas	2,829	3,511	4,057	4,480	4,879
Exports of nitrogen compounds	459	707	828	1,428	1,415
Imports for consumption of nitrogen compounds	496	566	691	669	735
Consumption [1]	6,526	r 7,812	r 9,216	r 9,682	9,939
World: Production [1]	24,031	27,565	31,627	35,427	39,556

p Preliminary. r Revised. [1] Estimated, excludes nitrogen gas.

Table 2.—Nitrogen production in the United States

(Thousand short tons of contained nitrogen)

	1965	1966	1967	1968	1969 p
Anhydrous ammonia: Synthetic plants [1]	7,295	8,722	r 10,029	9,968	10,456
Ammonia compounds, coking plants:					
Ammonia liquor	13	11	12	14	12
Ammonium sulfate	147	162	156	142	135
Ammonium phosphates	10	9	8	6	7
Total	7,465	8,904	r 10,205	10,130	[2] 10,611
Nitrogen gas [1]	2,829	3,511	4,057	4,480	4,879

p Preliminary. r Revised.
[1] Bureau of the Census Current Industrial Report.
[2] Data may not add to totals shown because of independent rounding.

Table 3.—Major nitrogen compounds produced in the United States

(Thousand short tons, gross weight)

Compounds	1968	1969 p
Ammonium nitrate	5,737	5,593
Ammonium sulfate	2,002	1,931
Ammonium phosphate	4,129	4,492
Nitric acid	6,362	6,254
Urea	2,428	2,709

p Preliminary.
Sources: Bureau of the Census and Tariff Commission.

DOMESTIC PRODUCTION

The production of nitrogen compounds during 1969 increased 5 percent over the previous year. Nitric acid decreased 3 percent, anhydrous ammonia increased 5 percent, ammonium nitrate decreased 7 percent, ammonium sulfate decreased 3 percent, ammonium phosphate output in-

[1] Chemical engineer, Eastern Field Operation Center, Pittsburgh, Pa.

creased 9 percent, and urea increased 12 percent.

Production rates for ammonium sulfate were cut back because of increasing inventories. The reduction was attributed to yearend cutbacks in exports to India and Pakistan by the U.S. Agency for International Development (AID), and an increased use of higher analysis nitrogen compounds by domestic and foreign consumers.

Recent nitrogen plant closings and startups followed past trends of discontinuing operations of small, marginal plants and the starting of new, large, modern ones.

Production of high-purity nitrogen in 1969 was 7 percent higher than it was for the previous year.

Table 4.—Recent nitrogen plant closings and startups
(Capacities in short tons per year)

Company	Location	Closings			Startups		
		Type of plant	Date closed	Capacity closed	Type of plant	Date started	Capacity started
Air Products & Chemical, Inc.	E. Fishkill, N. Y.				Nitrogen gas	1969	(2.4 bcf)
American Cyanamid Co.	Fortier, La.				Malamine urea	1971	80,000
American Oil Co.	Huntington, Ind.				Anhydrous ammonia	Sept 1969	30,000
Do	Texas City, Tex.				do	June 1969	300,000
Central Farmers Fertilizer Co.	N. Orleans, La.				do	June 1969	350,000
Chevron Chemical Co.	Kennewick, Wash.				Nitric acid Ammonia	June 1969	62,500 365,000
Hills Chemical, Inc.	Borger, Tex.				Anhydrous ammonia	1970	246,300
International Minerals & Chemical Co.	Cordova, Ill.	Anhydrous ammonia	1969	100,000			
Monsanto's Chemical Co.	El Dorado, Ark.	Ammonia Urea	1969 1969				
U.S. Industrial Chemical Co.	Danville, Ill.						
Do	Tuscola, Ill.						
D. M. Weatherly Co.	St. Helens, Oreg.						
Wycon Chemical Co.	Cheyenne, Wyo.				Ammonia Nitrates Nitric acid	 1969 1969	 25,400
Vistron Corp.	Lima, Ohio				Ammonium nitrate Ammonia Urea	1969 1970 1970	50,000 140,000

CONSUMPTION AND USES

The most important use for nitrogen in the United States was for fertilizers. The nitrogenous compounds consumed in this manner were ammonia (liquid or gas), ammonium nitrate, ammonium sulfate, ammonium phosphate, potassium nitrate, ammonium polyphosphate, and urea. According to the U.S. Department of Agriculture the total nitrogen consumption for fiscal year 1969 was 6,833,000 tons compared with 6,788,000 tons in 1968. Poor weather and a possible decrease in domestic acreage was responsible for this low growth rate. The 1969 domestic consumption of nitrogen in tons, for the year ending June 30, by regions, was as follows: New England, 41,000; Middle Atlantic, 230,000; South Atlantic, 758,000; East North Central, 1,234,000; West North Central, 2,060,000; East South Central, 491,000; West South Central, 980,000; Mountain, 376,000; Pacific, 604,000; and other United States, 50,000. The average percentage of nitrogen content in mixed fertilizers was 9.0 percent, which was a gain of 0.75 percent from an average of 8.8 percent in 1968.

By the end of 1969, inventories of nitrogenous fertilizers were 6 percent lower than they were at the end of 1968.

PRICES

Agricultural nitrogen prices tended to remain firm as consumption increased slightly and inventory reductions occurred during the year. The December ending inventory for nitrogen products as a group was down 8 percent from 1968. However, two products showed sizable increases—ammonium sulfate, up 30 percent, and urea, up 18 percent.

Anhydrous ammonia, bulk wholesale prices, ranged between $50 and $92 per ton. The American Oil Company established a retail price of $75 per ton in the high plains area of West Texas, effective August 15, 1969.

The diammonium phosphate price schedule for June 30, 1969, was $60 per ton f.o.b. bulk rail cars, Florida and Tennessee. The microammonium phosphate bulk price was $63 per ton.

Sun Oil Co. increased wholesale prices for agricultural grade anhydrous ammonia on September 30, 1969 to $50 per ton f.o.b. Marcus Hook, Pa.

Table 5.—Price quotations for major nitrogen compounds in 1969

(Per short ton)

Compound	Jan. 6	Dec. 22
Ammonium nitrate, fertilizer grade, 33.5 percent nitrogen, bulk, carload lots, f.o.b. works	$45–47	$45
80 pound bags (same basis)	50–55	52
Ammonium sulfate, standard grade, bulk, carload lots, f.o.b. works	23–31	23–37
Bags, cwt., works	37	37
Anhydrous ammonia, fertilizer, tanks, freight equalized east of Rockies	50–92	50
Aqueous ammonia 29.4 percent NH_3	87–95	65
Sodium nitrate, domestic, agricultural, bulk, carload lots, f.o.b. works	47	47
Bags, cwt., f.o.b. works	51	51
Sodium nitrate, imported, commercial, bulk, carload lots, f.o.b. port warehouse	44	45.50
Bags, cwt., f.o.b. port warehouse	48	49.50
Urea:		
Industrial 46 percent nitrogen, bags, carlots, delivered freight equalized	92	94
Agricultural 46 percent nitrogen, bulk, carlots, delivered freight equalized	63	92
Agricultural 45 percent nitrogen, bulk, carlots, works	61	61
Diammonium phosphate, fertilizer grade, 18-46-0 bulk, carlots, f.o.b. works	60–94	54–60

Source: Oil, Paint and Drug Reporter.

FOREIGN TRADE

Nitrogen exports in 1969 were more than double that imported. Nitrogenous fertilizer materials accounted for 93 percent gross weight of the nitrogen exported; industrial chemicals comprised the remaining 7 percent.

The gross weight of nitrogenous fertilizers exported in 1969 were 15 percent less than that shipped in 1968; the dollar decrease was 16 percent. Even though the gross weight decreased in 1969, the nitrogen content increased slightly, which indicated sales of more concentrated materials.

Urea exports for 1969 showed a gain of 29 percent over the 1968 total; however, the value in dollars rose 38 percent.

The U.S. Government's domestic and foreign policy has a profound effect on markets and fertilizer supplies. The export market is directly affected by the AID—supported fertilizer sales, especially to developing countries in Asia, Exports in 1969 were equal to the annual production of six 1,000-ton-per-day ammonia plants operating at capacity.

Imports of fertilizer materials increased 8 percent in 1969.

WORLD REVIEW

World output of nitrogenous fertilizers for the 1969 fiscal year ending June 30 increased by 14 percent over the previous year, while consumption rose by 13 percent, according to the German nitrogen marketing syndicate Ruhr-Stickstoff AG of Bochum.

A fast growth in West European synthetic ammonia capacity was instrumental in the increase of 5.5 million tons nitrogen of ammonia capacity in the world at large in the fiscal year.

At the end of the 1969 fiscal year, the synthetic ammonia capacity in the world was 45.3 million tons of nitrogen, as stated in Ruhr-Stickstoff report; this represents a doubling of the capacity in a 5-year period.

Table 6.—U.S. exports and imports for consumption of major nitrogen compounds

(Thousand short tons and thousand dollars)

Compounds	1968			1969		
	Gross weight	Nitrogen content	Value	Gross weight	Nitrogen content	Value
EXPORTS						
Industrial chemicals: Anhydrous ammonia and chemical grade aqua (ammonium content)	80	66	$3,592	265	217	$6,830
Fertilizer materials:						
Ammonium nitrate	89	30	4,022	112	38	5,723
Ammonium phosphates and other nitrogenous phosphatic-type fertilizer materials	1,270	229	76,308	942	170	50,744
Ammonium sulfate	1,395	293	48,844	812	171	28,383
Anhydrous ammonia and aqua (ammonia content)	720	590	22,889	857	703	26,241
Nitrogenous chemical materials, n.e.c.	26	8	1,810	30	9	2,122
Sodium nitrate	1	(1)	86	(1)	(1)	52
Urea	461	212	28,921	596	274	39,944
Total	4,042	1,428	186,472	3,614	1,582	160,039
IMPORTS						
Industrial chemicals: Ammonium nitrate	(1)	(1)	2	(1)	(1)	6
Fertilizer materials:						
Ammonium nitrate	227	76	11,344	233	78	11,716
Ammonium nitrate-limestone mixtures	7	1	210	(1)	(1)	1
Ammonium phosphates	247	47	17,264	273	52	18,391
Ammonium sulfate	131	28	4,352	138	29	4,576
Calcium cyanamide or lime nitrogen	17	4	1,709	14	3	878
Calcium nitrate	42	7	990	50	8	1,195
Nitrogen solutions	72	22	3,232	91	27	3,976
Anhydrous ammonia	401	329	18,500	447	367	20,577
Potassium nitrate or saltpeter, crude	16	2	656	11	1	449
Potassium nitrate, sodium nitrate mixtures	28	4	1,009	37	6	1,370
Sodium nitrate	205	33	6,715	184	29	5,252
Urea	248	114	15,471	285	131	18,561
Other	11	2	767	16	3	981
Total	1,652	669	82,221	1,779	734	[2] 87,923

[1] Less than ½ unit. [2] Data may not add to total shown because of independent rounding.

The leading nitrogenous fertilizer importer in fiscal 1969, was Communist China, followed by India, the United States, Indonesia, and Turkey.

The United States continued to be the leading exporter of nitrogenous fertilizers, a fact which was attributed to AID programs.

Algeria.—SONATRACH, the State-owned gas and oil concern, has brought several plants on stream at Arzew with capacities of 330,000 tons per year of ammonia, 132,000 tons per year of nitric acid, 165,000 tons per year of ammonium nitrate, and 132,000 tons per year of urea. Until these plants began operation in 1969, all nitrogen products in Algeria had been imported, mainly from France.

About 203,000 tons per year of ammonia will be available from the Arzew complex for export.

The start of the nitrogenous fertilizer complex at Arzew represents a turning point in Algerian industry and agriculture.[2]

Australia.—During 1969, Eastern Nitrogen, Ltd., started up a fertilizer complex at Kooragang Island, Newcastle, New South Wales, Australia. The synthetic ammonia capacity is 175,000 tons per year. The ammonia nitrate capacity is 144,000 tons per year. Eastern Nitrogen is 51 percent owned by Imperial Chemical Industries of Australia and New Zealand, Ltd., 23 percent by Sulphide Corporation Pty. Ltd., 10 percent by King Ranch Pty. Ltd., 6 percent by Mitsui and Co., and the remaining 10 percent by various Australian institutions.

In August 1969, Austral-Pacific Fertilizer, Ltd., started a 580-ton-per-day synthetic ammonia plant.[3]

Early in 1969, Kwinana Nitrogen, Ltd.,[4] started and brought into full production a fertilizer complex of 100,000 tons per year

[2] Chemical Week. V. 104, No. 17, April 26, 1969, pp. 76–77.
[3] European Chemical News. V. 16, No. 410, Dec. 12, 1969, p. 6.
[4] Chemical Age (London). V. 99, No. 2602, May 3, 1969, p. 24.

Table 7.—World production and consumption of fertilizer nitrogen compounds, years ended June 30, by principal countries r

(Thousand short tons of contained nitrogen)

Country	Production e			Consumption e		
	1966–67	1967–68	1968–69	1966–67	1967–68	1968–69
Argentina	1	3	23	31	29	38
Australia	48	61	105	119	151	176
Austria	257	268	280	99	111	128
Belgium	351	397	441	174	170	193
Brazil	7	9	10	75	134	159
Bulgaria	327	390	556	298	358	408
Canada	526	627	717	305	358	397
Ceylon	---	---	---	43	61	57
Chile	165	137	133	40	31	41
China, mainland	860	937	1,036	1,955	1,791	2,304
Colombia	38	44	52	45	50	56
Cuba	6	11	13	159	220	239
Czechoslovakia	277	288	289	289	333	333
Denmark	50	65	53	237	261	281
Finland	88	88	125	111	110	144
France	1,308	1,308	1,590	1,079	1,279	1,334
Germany:						
East	379	370	387	477	434	563
West	1,655	1,718	1,762	980	1,047	1,028
Greece	129	129	153	163	169	185
Hungary	184	212	279	234	261	335
India	340	427	585	936	1,252	1,382
Indonesia	46	47	48	121	128	181
Ireland	38	50	44	54	58	69
Israel	25	28	26	28	31	31
Italy	1,036	1,179	1,168	535	536	571
Japan	1,972	2,243	2,318	919	1,160	1,268
Korea:						
North	123	143	163	123	143	163
South	96	262	358	295	342	342
Malawi, Southern Rhodesia, Zambia	---	---	2	51	73	66
Mexico	176	191	216	341	328	380
Netherlands	754	936	1,047	372	379	389
Norway	359	410	411	68	76	77
Pakistan	103	115	166	283	298	326
Peru	19	23	20	41	58	52
Philippines	23	55	49	72	93	99
Poland	509	655	837	518	620	750
Portugal	127	132	142	85	112	116
Rumania	291	410	464	228	350	364
South Africa, Republic of	85	99	160	108	144	159
Spain	366	481	536	466	536	622
Sweden	132	153	163	181	200	211
Switzerland	31	40	39	34	35	35
Taiwan	192	195	222	204	193	216
Trinidad	332	405	262	6	7	7
Turkey	36	36	33	121	152	182
U.S.S.R	3,131	3,806	4,604	2,928	3,405	3,807
United Arab Republic	179	172	132	298	299	254
United Kingdom	787	885	953	753	824	886
United States	6,268	6,872	6,985	6,354	6,588	6,833
Vietnam, South	---	---	---	60	66	72
Yugoslavia	116	125	130	218	249	269
Other:						
North America [1]	53	72	67	127	142	165
South America	15	17	30	47	54	67
Europe	8	14	28	26	32	50
Asia	67	125	149	235	301	348
Africa	4	7	21	176	212	238
Oceania	---	---	---	12	14	17
World total	[2] 24,495	[2] 27,872	30,582	24,337	26,848	29,463
Estimated losses (in transit, bagging, etc.)	---	---	---	365	403	442

e Estimated. r Revised.

[1] Includes Central America.

[2] Data may not add to total shown because of independent rounding.

Source: Nitrogen (London). No. 63 January-February 1970, pp. 13, 14.

synthetic ammonia, 90,000 tons per year nitric acid, and 110,000 tons per year ammonium nitrate.

Australia's increased nitrogen capacity during 1969 has made the country self-sufficient in fertilizers.

Belgium.—Ammoniaque Synthetique et Derivees SA, of Willebrock was constructing a 110,000-ton-per-year nitric acid plant. The plant will produce 53 and 58 percent acid and is expected to start up in 1971. [5]

Brazil.—Companhia Ultrafértil S.A. was constructing a 455-ton-per-day ammonia plant at Piassaguera, which is scheduled for completion in 1970.

Petróleo Brasileiro S.A. was developing its Conjunto Petroquimica da Bahia operation to process natural gas to produce 200 tons of ammonia and 250 tons of urea per day. The plant location is at Camaceri, Bahia.

Burma.—Two urea plants were under construction, the Sale Chemical Fertilizer plant, Chauk, scheduled for full operation in December 1970 with an annual capacity of 75,000 tons of urea; a second to be operated by Kyunchaung Chemical Fertilizer plant, with annual capacity of 77,000 tons of urea and scheduled for full operation February 1971. [6]

Czechoslovakia.—A nitrogenous fertilizer plant designed by Frederick Uhdo for Duslo NP, of Sala, Czechoslovakia was scheduled for operation at the beginning of 1972. The plant will have a capacity of 210,000 tons per year of ammonia, and 210,000 tons per year of urea. Duslo NP already has plants at Sala producing ammonia and urea, each with capacities of 100,000 tons per year. [7]

Egypt.—The Helwan and Assiut fertilizer plants of the Chemical Industries Organization were producing 220,000 tons per year of nitrofertilizers. The Talkha plant will start in 1972 and have an annual capacity of 518,000 tons.

Finland.—Rikkihappo Oy brought on stream during June 1969 a 132,000-ton-per-year monoammonium phosphate unit. This plant is expected to be expanded by 220,000 tons per year during 1970. The monoammonium phosphate produced at this plant was used for compounding in other plants operated by the company.

A new ammonia plant in Finland was on stream at Ouln for Typpi Oy. The plant was designed by Humphrey's & Glasgow Ltd., with a capacity of 825 tons per day. The Typpi Oy plant ammonia synthesis loop was designed to operate at a pressure of 300 atmosphere.

Nitrogen was being used in greater quantities for grassland in Finland. Forest fertilization was receiving attention. Typpi Oy has promoted the use of urea. Work on the company's fourth ammonia plant and urea plant was completed in 1969. [8]

France.—Sté Normande de l'Azote SNA's ammonia and urea plant was completed and put on stream in 1969. The plant has a capacity of 298,000 tons of nitrogen per year and 291,000 tons per year of urea. The ammonia unit operated under the Haldor Topse process and the urea plant under the Stamicarbon NV process.

Pechiney-St. Gobain's fertilizer complex at Grand Quevilly put their (58 percent HNO_3) nitric acid expansion plant on stream. Plant capacity was 771 tons per day of nitric acid and it operated under the Pechiney-St. Gobain and Pintsch-Barnag process. [9]

Germany, West.—UEBA-Chemie at Gelsenkirchen, are constructing an ammonia plant with capacity of 425,000 tons per year; completion was scheduled for late-in 1971.

Badische Anilin und Soda-Fabrik AG ordered a 375,000-ton-per-year urea plant to be erected in Ludwigshafen for operation during 1971.

Erdolchemie G.m.b.H. increased ammonia capacity to 330,000 tons per year, nitric acid to 243,000 tons per year, and ammonium sulfate to 28,000 tons per year at their Cologne complex. [10]

Greece.—Northern Greece Chemical Industries SA, owned by Pechiney-St. Gobain, National Bank of Greece, and the Bodossakis industrial group, placed an 87,000-ton-per-year nitric acid plant and a 93,000-ton-per-year ammonium nitrate plant on stream, at Thessaloniki, during October 1969. [11]

Hungary.—Production of nitrogenous fertilizers rose 23 percent in Hungary in

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[5] Chemical Age (London). V. 100, No. 2633, Jan. 2, 1970, p. 6.
[6] Nitrogen (London). No. 63, January-February 1970, pp. 7, 8.
[7] Work cited in footnote 6.
[8] Page 6 of work cited in footnote 6.
[9] Pages 5–6 of work cited in footnote 6.
[10] Work cited in footnote 9.
[11] Work cited in footnote 6.

1969, to 1.6 million tons, according to figures released in Budapest.[12]

India.—Late in 1969, AID reported a gradual increase in fertilizer use during the 1969 growing season. India announced an intention to import $280 million worth of urea, ammonium sulfate, calcium ammonium nitrate, and other fertilizers for the 1969–70 growing season.

An $82 million fertilizer complex in Kanpur, India came on stream late in 1969. The plant operated by Indian Explosive, Ltd., had a capacity of 200,000 tons per year of synthetic ammonia, and 450,000 tons per year of urea. The complex was the largest nitrogenous fertilizer plant on one site in India, and increases the country's nitrogen capacity by almost 20 percent. Indian Explosive, Ltd., is a foreign-dominated firm 51 percent owned by Britain's Imperial Chemical Industries, Ltd., 12.75 percent by the Government of India, 10 percent by the International Finance Corp., and the remaining 26.25 percent by the Indian public.[13]

During 1968 in Punjat State, an aerial fertilizer application, was one of the first attempts in India to employ this advanced agricultural technique to improve food production. The aerial application method has been employed successfully on rice fields in other Asian countries.

Italy.—Montedison S.p.A. was planning a 449,000-ton-per-year ammonia unit, and an expansion of its ammonium nitrate plant at Porto Marthera.

Soc. Industriale Catanese SpA placed a new 330,000-ton-per-year ammonia unit at Priolo on stream, as well as a 181,000-ton-per-year urea unit.[14]

Consumption of nitrogen fertilizers increased 8 percent over that of 1968.

Compound	Nitrogen analysis, percent	Consumption, percent
Ammonium sulfate	21	+11
Do	27	−14
Ammonium nitrate	21	−19
Do	27	+ 5
Calcium nitrate	16	− 8.5
Calcium cyanamide	16	− 6
Urea	46	+46

Netherlands.—Nitrogenous fertilizer production increased 12 percent in the 1969 fiscal year, according to the Dutch Ministry of Agriculture and Fisheries in Amsterdam.

This increase was lower than expected, since planned expansion of capacities was not fully realized. The Netherlands Government expects production of nitrogen fertilizer to use another 10 to 15 percent during the current 1969–70 fertilizer year.

Netherlands fertilizer exports increased 52 percent during the 1968–69 year; about 50 percent of the export volume went to Communist China, predominately in the form of urea. Total exports from Netherlands were 70 percent of total production of nitrogen fertilizers during the 1968-69 year.[15]

Poland.—The capacity of the Pulawy Nitrogen works will be increased to 1.1 million tons per year of ammonia, 694,000 tons per year of urea, and 1.2 million tons per year of ammonium nitrate. Startup has been scheduled in 1971–72. Production of nitrogenous fertilizers for 1969 in Poland was 1.0 million tons.[16]

Qatar.—Qatar Fertilizer Co. at Umm Said was constructing a fertilizer complex, which included a 385,000 ton-per-year ammonia plant, and a 365,000 ton-per-year urea plant. The complex was designed and engineered by Power-Gas Corp. Ltd. The ammonia plant will use natural gas as feedstock.[17]

Spain.—New nitrogenous fertilizer plants placed on stream in 1969 increased Spain's fertilizer production capacity by 310,000 tons per year. Plants started in September included one operated by Fostorico Español SA at Huelva, with a capacity of 150,000 tons per year ammonium phosphate, and a plant operated by Abonos del Sudeste SA at Cartagena, with capacity to produce 85,000 tons per year nitric acid and 75,000 tons per year of ammonium nitrosulphate.

The quantities of nitrogen fertilizers used in Spain during the last 6 months of 1969 were 10 percent higher than for the same period in 1968, according to the Ministerio de Agricultura. During 1969, 552,000 tons of available nitrogen were used, compared with 528,000 tons in 1968. Just 10 years ago only 75,800 tons of available nitrogen fertilizer was used. The increased nitrogen consumption reflects the recent

[12] Chemical Age (London). V. 100, No. 2644, Mar. 20, 1970, p. 24.
[13] European Chemical News. V. 16, No. 410, Dec. 12, 1969, p. 6.
[14] Work cited in footnote 6.
[15] Chemical Age (London). V. 100, No. 2639, Feb. 13, 1970, p. 20.
[16] Chemical Age (London). V. 99, No. 2530, Dec. 12, 1969, p. 20.
[17] European Chemical News. V. 16, No. 389, July 18, 1969, p. 12.

rapid growth of the fertilizer industry in Spain.

Refinería de Petroleos de Escombreras, SA commissioned an ammonia plant, late in 1969, which had a capacity of 874 tons per day synthetic ammonia.[18]

Turkey.—A ot Sanarjii TAS of Kuetahya accepted from the designer Pintsch Barnaq AG of West Germany a (100 percent) nitric acid plant with a 716-ton-per-day capacity. This was the largest nitric acid plant in Turkey and one of the largest in the world outside of the United States or West Europe.[19]

United Kingdom.—Prolonged bad weather during 1968 and early 1969 seriously affected England's fertilizer industry. Added to the adverse climate conditions, the farmers suffered a sharp drop in purchasing power because of crop failures and credit squeezes. In 1969, the industry had an overcapacity of 20 percent for the year as a whole. The result was a 15-percent drop in prices. Numerous firms were forced out of the business or to dispose of unprofitable operations.

Imperial Chemical Industries, Ltd., commissioned a 365,000-ton-per-year prilled ammonium nitrate plant at Billingham. This brings the total "Nitrain" capacity in the United Kingdom to over 700,000 tons per year.

Stavely Chemicals Ltd., announced the commissioning of a plant for the production of a range of substituted ureas, such as methyl and ethyl urea. The plant is located at Chesterfield.[20]

Yugoslavia.—Production of nitric acid in Yugoslavia increased from 375,000 tons in 1968 to 538,000 tons in 1969. Nitrogenous fertilizers increased from 282,000 tons in 1968 to 1.0 million tons in 1969, though ammonia nitrate output actually dropped from 9,600 tons to 9,500 tons.[21]

[18] Page 6 of work cited in footnote 6.
[19] Page 5 of work cited in footnote 6.
[20] Chemical Age (London). V. 100, No. 2636, Jan. 23, 1970, p. 17.
[21] Chemical Age (London). V. 100, No. 2645, Mar. 27, 1970, p. 10.

TECHNOLOGY

The coating of urea with molten sulfur to seal pellets against absorbing moisture has been successfully carried out by the Tennessee Valley Authority (TVA).[22]

A new process innovation for making liquid ammonium polyphosphates was developed by Swift Agricultural Chemical Corp., through a direct reaction (U.S. pat. 3,464,808) of anhydrous ammonia with orthophosphoric acid, producing solutions and suspensions of ammonium polyphosphates. Two plants were operating, producing up to 8 tons per hour of 12-40-0 grade.

A new process for the production of nitric acid which reduces pollution, designed by Chemical Construction Co. and Britain's Humphrey & Glasgow Ltd., eliminates waste-heat boilers in the ammonia-oxidation-water absorption route to nitric acid.

A new fertilizer mixture which combines various sources of nitrogen, phosphorus, and potassium in a polymeric compound was developed and produced by O.M. Scott & Sons, Co., Marysville, Ohio. The polyform fertilizer offers important reductions in weight and bulk.

Georgia Institute of Technology, working with the Perlite Institute, Inc., developed an economic process for the manufacture of a lightweight fertilizer, containing perlite, by a wet granulation process.

This year ammonia was being transported by long-distance pipeline for the first time. The Mid-America Pipeline, which extends 850 miles from Texas to Iowa, was put into operation in the spring of 1969. The Gulf Central Pipeline, which extends 1,700 miles from Louisiana to Missouri for distribution of ammonia to the middle west farming States, was started during the summer of 1969.

Research at Michigan State University revealed that ammonia can be used instead of urea as a nitrogen additive for cattle feed. Ammonia is about one-third the price of urea, and unlike humans, ruminants can use simple nitrogen to form amino acids, the basic of protein.[23]

A new process for the production of monoammonium phosphate has recently been developed by the Swift Agricultural and Chemical Corp. of Chicago. The reaction between liquid ammonia and 50 percent phosphoric acid takes place at atmospheric pressure and the product is a finely divided solid phosphate which can be used directly in mixed fertilizers.[24]

[22] Fertilizer Feed and Pesticides Journal. V. 66, No. 4, Apr. 1969, p. 6.
[23] Chemical Week. V. 105, No. 6, Aug. 9, 1969, p. 34.
[24] Page 9 of work cited in footnote 12.

Peat

By Keith S. Olson [1]

Peat production in the United States decreased nearly 8 percent in quantity in 1969, reversing a 3-year trend of increased output. Commercial sales declined nearly 9 percent in quantity and more than 2 percent in value. Michigan was again the largest peat-producing State. Imports of peat increased 4 percent over those of 1968, remaining at about one-half the domestic output. The total amount of peat available for consumption, consisting of commercial sales plus imports, decreased to the lowest level in 6 years. World production of peat was estimated at 219 million tons, an increase of nearly 5 percent over that of 1968. The Soviet Union supplied an estimated 96 percent of the world peat output.

DOMESTIC PRODUCTION

The major decline in peat production was due to lesser demand for material used for soil improvement, with a decrease of 12 percent in quantity from that of 1968. Twenty-three States produced peat in 1969 compared with 25 in 1968. Of the States reporting production, increased peat output in Florida, Illinois, and seven other States was more than offset by decreases in Michigan, New Jersey, Washington, and 10 other States. Production remained unchanged in one State. Michigan was the largest peat-producing State with 33 percent of the Nation's output. The number of active operations decreased from 135 in 1968 to 128 in 1969. Average output per plant was 4,470 tons, compared with 4,585 tons in 1968. Operations producing less than 5,000 tons of peat in 1969 accounted for 76 percent of the number of plants but only 24 percent of the total output. Four plants each produced more than 25,000 tons and represented nearly 29 percent of the total output.

Reed-sedge peat comprised more than 58 percent of the domestic output in 1969, humus peat 24 percent, and moss peat more than 17 percent. In 1968, reed-sedge peat represented 55 percent of the total, moss peat 28 percent, and humus peat 17 percent. About 46 percent of the total output was cultivated during the year. Nearly

[1] Industry economist, Bureau of Mines, Minneapolis, Minn.

Table 1.—Salient peat statistics

	1966	1967	1968	1969
United States:				
Number of operations	144	131	135	128
Production ... short tons	611,085	617,172	618,995	572,122
Commercial sales ... do	605,858	619,687	619,161	565,760
Value of sales ... thousands	$6,501	$6,768	$7,230	$7,055
Average per ton	$10.73	$10.92	$11.68	$12.47
Imports ... short tons	293,843	280,842	287,600	299,997
Available for consumption [1] ... do	899,701	900,529	906,761	865,757
World: Production ... thousand short tons	224,041	218,546	208,423	p 218,584

p Preliminary.
[1] Commercial sales plus imports.

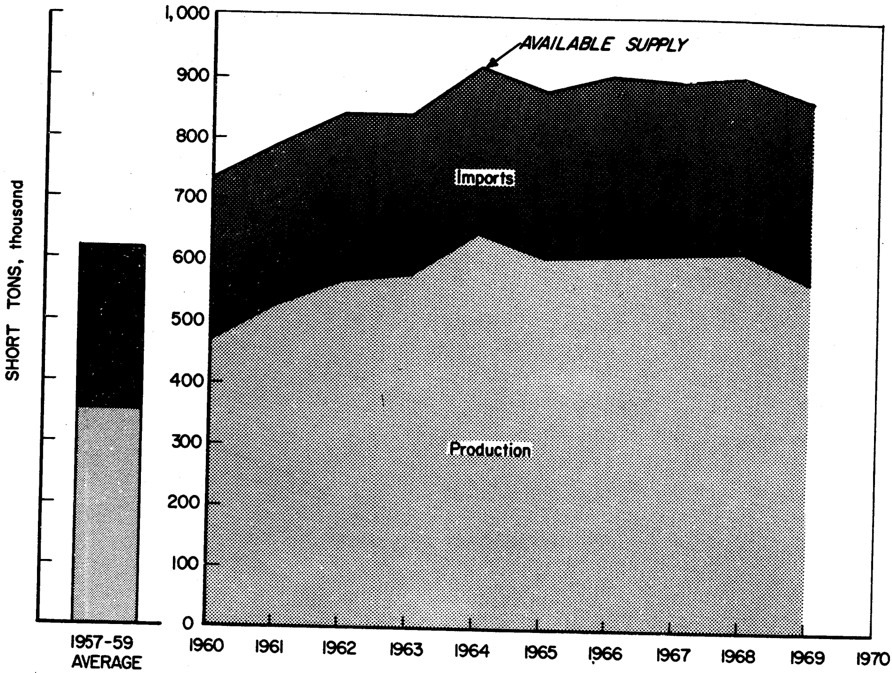

Figure 1.—Production, imports, and available supply of peat in the United States.

82 percent of the peat was processed; most of this was only shredded, and lesser amounts were only kiln-dried or kiln-dried and shredded. The remainder was sold after air-drying only. Equipment used to harvest peat included front-end loaders, draglines, bulldozers, power shovels, and specialized harvesting machines used at a few of the larger operations. Processing equipment included shredders, hammer-mills, pulverizers, grinders, screens, artificial dryers, and hydraulic presses.

Table 2.—Peat produced in the United States in 1969, by kinds

(Short tons)

Kind	Unprepared	Processed: Shredded	Processed: Kiln-dried only	Processed: Shredded and kiln-dried	Total
Moss	14,791	78,129	1,744	4,350	99,014
Reed-sedge	21,077	310,542	2,610	-----	334,229
Humus	67,503	67,607	450	3,319	138,879
Total	103,371	456,278	4,804	7,669	572,122

Table 3.—Production and commercial sales of peat in the United States in 1969, by States

State	Active plants	Production (short tons)	Commercial sales		
			Short tons	Value	
				Total (thousands)	Average per ton
California	3	11,395	11,395	$106	$9.30
Colorado	15	26,103	26,103	160	6.13
Florida	11	55,265	55,265	359	6.49
Georgia	2	W	W	W	W
Idaho	1	1,000	1,000	W	W
Illinois	8	67,330	67,330	958	14.22
Indiana	6	27,554	38,214	515	13.47
Iowa	2	W	W	W	W
Maine	[1] 2	5,269	150	W	W
Maryland	2	5,407	4,481	78	17.37
Massachusetts	1	W	W	W	W
Michigan	22	189,447	186,278	2,724	14.62
Minnesota	[1] 8	16,470	12,026	249	20.74
Montana	1	W	W	W	W
New Jersey	4	46,367	46,367	551	11.89
New Mexico	1	446	446	4	10.00
New York	5	14,990	14,352	178	12.42
Ohio	[2] 11	8,350	10,848	116	10.73
Pennsylvania	[1] 10	39,613	34,613	407	11.76
South Carolina	1	W	W	W	W
Vermont	1	180	180	4	21.11
Washington	9	32,684	32,684	134	4.11
Wisconsin	2	1,985	1,761	155	88.00
Total	128	572,122	565,760	7,055	12.47

W Withheld to avoid disclosing individual company confidential data; included in total.
[1] Includes 1 plant which had production, but no sales.
[2] Excludes 2 plants which had sales, but no production.

Table 4.—Relative size of peat operations in the United States

Size	1968				1969			
	Active plants		Production		Active plants		Production	
	Number	Percent of total	Short tons	Percent of total	Number	Percent of total	Short tons	Percent of total
Under 500 tons	30	22.2	6,533	1.0	29	22.7	5,245	0.9
500 to 999 tons	17	12.6	11,035	1.8	17	13.3	11,424	2.0
1,000 to 4,999 tons	59	43.7	135,980	22.0	51	39.8	118,210	20.7
5,000 to 14,999 tons	20	14.8	176,980	28.6	22	17.2	185,846	32.5
15,000 to 24,999 tons	5	3.7	93,717	15.1	5	3.9	88,320	15.4
Over 25,000 tons	4	3.0	194,750	31.5	4	3.1	163,077	28.5
Total	135	100.0	618,995	100.0	128	100.0	572,122	100.0

CONSUMPTION AND USES

About 86 percent of the total peat was sold for general soil improvement. Other uses for peat included packing material for flowers and shrubs, potting soils, seed inoculant, mushroom beds, earthworm culture, and mixed fertilizers. Major outlets for peat were nurseries, greenhouses, landscape gardeners, contractors, and retail stores. No sales of peat for fuel or energy uses were reported in the United States. Sales of peat in bulk form accounted for 52 percent in quantity and 32 percent in value of all domestic peat sales. The remainder was sold in packaged form. Compared with 1968, bulk sales decreased 2 percent in quantity and 4 percent in value. Sales of packaged peat were down nearly 15 percent in quantity and 1 percent in value. Sales of packaged peat for general soil improvement decreased nearly 16 percent in quantity and 3 percent in value. Nearly 82 percent in quantity and 77 percent in value of the packaged peat of domestic origin sold in 1969 was reed-sedge peat, most of which was produced in Michigan. Other States with large sales of packaged peat in descending order of tonnage were Illinois, Indiana, New Jersey, and New York. A complete and meaningful tabulation of bulk and packaged peat by State cannot be published without disclosing individual company confidential data.

Table 5.—Commercial sales of peat in the United States in 1969, by kinds and uses

(Thousand short tons and thousand dollars)

Use	Moss		Reed-sedge		Humus	
	Quantity	Value	Quantity	Value	Quantity	Value
Bulk:						
Soil improvement	56	$522	90	$716	80	$546
Other uses	10	68	14	112	41	268
Total [1]	66	590	104	828	121	815
Packaged:						
Soil improvement	32	675	214	3,244	13	217
Other uses	2	35	10	446	4	205
Total	34	710	224	3,690	17	422
Total:						
Soil improvement	88	1,197	304	3,960	93	763
Other uses	12	103	24	558	45	474
Grand total [1]	100	1,299	328	4,519	138	1,237

[1] Data may not add to totals shown because of independent rounding.

Table 6.—Commercial sales of peat in the United States in 1969, by uses

(Thousand short tons and thousand dollars)

Use	In bulk		In packages		Total [1]	
	Quantity	Value	Quantity	Value	Quantity	Value
Soil improvement	226	$1,784	259	$4,136	485	$5,920
Potting soils	15	110	12	476	26	585
Packing flowers, shrubs, etc.	39	274	1	23	40	297
Seed inoculant	(2)	4	2	186	2	191
Mushroom beds	2	16	---	-----	2	16
Earthworm culture	1	10	(2)	1	1	11
In mixed fertilizers	9	34	---	-----	9	34
Total [1]	291	2,233	274	4,822	566	7,055

[1] Data may not add to totals shown because of independent rounding.
[2] Less than ½ unit.

PRICES AND SPECIFICATIONS

Prices for peat at individual operations varied greatly depending upon the locality, kind of peat, type of packaging, and amount of processing. The overall average value for peat was $12.47 per ton, exceeding the previous record high of $11.68 per ton set in 1968. Peat sold in bulk form averaged $7.66 per ton, compared with $7.84 per ton in 1968. Packaged peat averaged $17.58 per ton in 1969, compared with $15.25 per ton in 1968. Average value of imported peat, which includes the price paid by importers, less transportation and various other charges, was $45.84 in 1969, an increase of $1.28 per ton from that of 1968.

Although the average value of imported peat is shown as being nearly three times that of domestically produced packaged peat, the two are not directly comparable. The values are established at different marketing levels, and imported peat has different physical properties from that produced in the United States. Each 100 pounds of imported air-dried peat usually contains a considerably greater volume of material than the same weight of domestically packaged peat.

Major classifications for peat in the United States are moss, reed-sedge, and humus. Moss peat is formed from sphagnum, hypnum, or other mosses. Reed-sedge peat originated principally from reeds, sedges, and other swamp plants. Peat which is too decomposed for identification of its botanical sources is classified as humus peat. The labeling of peat sold in the United States is under the regulation of the Federal Trade Commission.

The American Society for Testing and Materials has released standard classifications for peat and related products effective April 25, 1969.[2]

FOREIGN TRADE

Imports of peat increased about 4 percent in quantity and 7 percent in value over those of 1968, exceeding the previous record established in 1966. Major reason for the gain was an increase of about 25,000 tons in imports from Canada which supplied 95 percent of the nearly 300,000 tons of peat imported into the United States. The remaining imports were from Europe except for small amounts imported from Taiwan and Mexico. Imports from Europe declined 31 percent, owing chiefly to a decrease in imports of peat from West Germany, which supplied about 3 percent of the total imports. Other leading sources of imported peat in descending order of quantity were Poland, Ireland, and Sweden. Peat imports are classified in two categories—fertilizer grade, which accounted for 99 percent in quantity and in value of the total imports, and poultry and stable grade, which comprised the remainder. Fertilizer-grade peat enters the United States duty free, whereas a duty of $0.25 per long ton is levied on poultry and stable-grade peat.

Peat entering the United States through the Buffalo and Ogdensburg, N.Y., Detroit, Mich., Pembina, N. Dak., St. Albans, Vt., and Seattle, Wash., customs districts represented 89 percent of the total peat imports.

[2] American Society for Testing and Materials, Committee D-29. ASTM Designation: D-2607-69. Apr. 25, 1969.

Table 7.—U.S. imports for consumption of peat moss, by grades and by countries

Country	Poultry and stable grade		Fertilizer grade		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1968						
Brazil	-----	---	55	$4	55	$4
Canada	1,428	$87	258,771	11,580	260,199	11,667
Denmark	-----	---	81	5	81	5
Germany, West	259	12	13,439	551	13,698	563
Ireland	38	1	1,024	44	1,062	45
Netherlands	-----	---	459	16	459	16
Poland	-----	---	5,528	228	5,528	228
Sweden	-----	---	579	32	579	32
Switzerland	-----	---	44	2	44	2
Trinidad and Tobago	-----	---	5,821	250	5,821	250
United Kingdom	-----	---	74	4	74	4
Total	1,725	100	285,875	12,716	287,600	12,816
1969						
Canada	2,117	96	282,952	13,014	285,069	13,110
Czechoslovakia	-----	---	25	2	25	2
Denmark	26	1	-------	-------	26	1
Finland	2	(1)	-------	-------	2	(1)
Germany, West	152	10	9,805	397	9,957	407
Ireland	40	2	1,293	67	1,333	69
Mexico	-----	---	14	(1)	14	(1)
Norway	-----	---	11	8	11	8
Poland	296	12	2,791	116	3,087	128
Portugal	-----	---	49	3	49	3
Sweden	-----	---	327	18	327	18
Taiwan	-----	---	1	(1)	1	(1)
United Kingdom	-----	---	96	6	96	6
Total	2,633	121	297,364	13,631	299,997	13,752

[1] Less than ½ unit.

Table 8.—U.S. imports for consumption of peat moss in 1969, by grades and by customs district

Customs district	Poultry and stable grade		Fertilizer grade		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Baltimore, Md.	-----	---	1,096	$55	1,096	$55
Boston, Mass.	-----	---	284	14	284	14
Buffalo, N.Y.	20	$1	29,578	1,303	29,598	1,304
Charleston, S. C.	-----	---	245	11	245	11
Chicago, Ill.	-----	---	26	1	26	1
Detroit, Mich.	226	14	52,747	2,718	52,973	2,732
Duluth, Minn.	618	20	1,816	86	2,434	106
Great Falls, Mont.	-----	---	8,610	445	8,610	445
Honolulu, Hawaii	14	1	41	2	55	3
Houston, Tex.	-----	---	440	18	440	18
Los Angeles, Calif.	26	1	1,498	72	1,524	73
Miami, Fla.	11	1	525	23	536	24
Mobile, Ala.	-----	---	1,851	79	1,851	79
New Orleans, La.	26	1	2,413	91	2,439	92
New York, N. Y.	40	2	1,876	82	1,916	84
Norfolk, Va.	2	(1)	1,041	39	1,043	39
Ogdensburg, N. Y.	-----	---	70,366	2,927	70,366	2,927
Pembina, N. Dak.	781	38	12,605	500	13,386	538
Philadelphia, Pa.	351	15	603	26	954	41
Portland, Maine	8	(1)	6,829	302	6,837	302
Portland, Oreg.	60	5	47	2	107	7
St. Albans, Vt.	188	8	53,488	2,193	53,676	2,201
San Francisco, Calif.	-----	---	471	16	471	16
San Juan, P. R.	-----	---	170	9	170	9
Savannah, Ga.	-----	---	414	16	414	16
Seattle, Wash.	262	14	46,828	2,536	47,090	2,550
Tampa, Fla.	-----	---	1,456	65	1,456	65
Total	2,633	121	297,364	13,631	299,997	13,752

[1] Less than ½ unit.

Table 9.—Peat moss imported for consumption from Canada and West Germany in 1969, by grades and by customs district

Customs district	Canada				West Germany			
	Poultry and stable grade		Fertilizer grade		Poultry and stable grade		Fertilizer grade	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Baltimore, Md.	-----	-----	-----	-----	-----	-----	554	$23
Boston, Mass.	-----	-----	33	$1	-----	-----	-----	-----
Buffalo, N.Y.	20	$1	29,578	1,303	-----	-----	-----	-----
Charleston, S.C.	-----	-----	-----	-----	-----	-----	206	8
Chicago, Ill.	-----	-----	26	1	-----	-----	-----	-----
Detroit, Mich.	226	14	52,747	2,718	-----	-----	-----	-----
Duluth, Minn.	618	20	1,816	86	-----	-----	-----	-----
Great Falls, Mont.	-----	-----	8,596	445	-----	-----	-----	-----
Honolulu, Hawaii	14	1	40	2	-----	-----	-----	-----
Houston, Tex.	-----	-----	-----	-----	-----	-----	290	12
Los Angeles, Calif.	-----	-----	-----	-----	26	$1	1,218	49
Miami, Fla.	-----	-----	-----	-----	11	1	200	9
Mobile, Ala.	-----	-----	-----	-----	-----	-----	1,851	79
New Orleans, La.	-----	-----	-----	-----	-----	-----	1,498	54
New York, N.Y.	-----	-----	-----	-----	-----	-----	660	24
Norfolk, Va.	-----	-----	-----	-----	-----	-----	589	22
Ogdensburg, N.Y.	-----	-----	70,366	2,927	-----	-----	-----	-----
Pembina, N. Dak.	781	38	12,605	500	-----	-----	-----	-----
Philadelphia, Pa.	-----	-----	-----	-----	55	3	491	22
Portland, Maine	8	(1)	6,829	302	-----	-----	-----	-----
Portland, Oreg.	-----	-----	-----	-----	60	5	47	2
St. Albans, Vt.	188	8	53,488	2,193	-----	-----	-----	-----
San Francisco, Calif.	-----	-----	-----	-----	-----	-----	471	16
San Juan, P.R.	-----	-----	-----	-----	-----	-----	170	9
Savannah, Ga.	-----	-----	-----	-----	-----	-----	362	15
Seattle, Wash.	262	14	46,828	2,536	-----	-----	-----	-----
Tampa, Fla.	-----	-----	-----	-----	-----	-----	1,198	53
Total	2,117	96	282,952	13,014	152	10	9,805	397

[1] Less than ½ unit.

WORLD REVIEW

Worldwide peat production in 1969 was estimated at nearly 219 million short tons, an increase of 5 percent over that of 1968.

Peat production in the U.S.S.R. was estimated at 209 million short tons, or 96 percent of the world total. An estimated 68 percent of the Soviet peat output was used for agricultural purposes including general soil improvement and in manufacturing fertilizers. The remainder was used principally as fuel in generating electric power and in briquet form for domestic and industrial uses.

The second largest peat-producing country in 1969 was Ireland with an estimated output of 5.6 million tons. Nearly all of the peat produced in Ireland was used for fuel in heating and in generating electricity. A substantial part of Ireland's peat output is exported each year. The third-ranking peat producer in the world was West Germany with an estimated output of 1.6 million tons. About two-thirds of the peat produced in West Germany was used for agricultural purposes and the remainder for fuel. The United States was fourth in peat output with less than 0.5 percent of world production. Peat production data for East Germany, a major producer of peat, were not available.

Table 10.—World production of peat, by countries [1]

(Thousand short tons)

Country	1967	1968	1969 p
Argentina, agricultural use	2	NA	NA
Canada, agricultural use	281	293	314
Denmark, fuel	11	e 6	e 6
Finland:			
Agricultural use	137	e 138	e 138
Fuel e	110	110	110
France, agricultural use	91	e 88	e 88
Germany, West:			
Agricultural use	1,202	e 1,102	e 1,102
Fuel	362	480	e 476
Hungary, agricultural use e	72	72	72
Ireland:			
Agricultural use	41	45	e 44
Fuel	5,175	6,325	e 5,512
Israel, agricultural use e	22	22	22
Japan e	77	77	77
Korea, South, agricultural use	34	9	NA
Netherlands e	440	440	440
Norway:			
Agricultural use	9	e 9	e 9
Fuel	r 4	e 4	e 4
Poland, fuel	45	31	22
Sweden:			
Agricultural use	r 127	110	e 110
Fuel	r 28	e 28	e 28
U.S.S.R.:			
Agricultural use e	143,300	143,300	143,300
Fuel	66,359	55,115	e 66,138
United States, agricultural use	617	619	572
Total [2]	r 218,546	208,423	218,584
Fuel peat (included in total)	r 72,094	62,099	72,296

e Estimate. p Preliminary. r Revised. NA Not available.

[1] In addition, Austria, Canada, Iceland, Italy, and Spain produced a negligible quantity of fuel peat. No data were available on East Germany, a major producer.

[2] Total is of listed figures only.

TECHNOLOGY

A method for determining standards for peat was described.[3] Indicators of peat quality taken into consideration were weight per volume, pore volume, water-holding capacity, and air space. Techniques of measurement included measuring the effect of premoistening by various methods on peat standards.

Results of a study on the feasibility of reducing production and distribution costs of Minnesota peat to a competitive level, other peat research, and the potential for further research were published.[4]

[3] Peat & Plant News (Helsinki, Finland). Fixing Peat Standards. V. 2, No. 1, First Quarter, 1969, pp. 3–8.

[4] Minnesota, Department of Iron Range Resources and Rehabilitation. 1966–1968 Biennial Report. January 1969, pp. 9–11.

Perlite

By Donald E. Eilertsen [1]

Crude perlite was produced in eight States at 20 mines (mostly New Mexico) in 1969, and the output was exceeded only by that of 1967. Expanded perlite, however, was produced at 99 plants in more than 30 States and the output was the largest ever reported. The quantity of expanded perlite that producers sold or used exceeded 400,000 tons for the first time.

DOMESTIC PRODUCTION

Crude perlite was produced by 15 companies at 20 mines in eight States in 1969, and the quantity mined (613,000 tons) was exceeded only by that of 1967. New Mexico continued to lead the States in output of crude perlite (532,000 tons). Other States which produced crude perlite, in descending order, were Arizona, Nevada, California, Colorado, Idaho, Utah, and Oregon. The total quantity of crude perlite that producers sold and used (471,000 tons) was the largest on record.

Table 1.—Crude and expanded perlite produced and sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Crude perlite						Expanded perlite		
	Quantity mined	Sold		Used at own plant to make expanded material		Total quantity sold and used	Quantity produced	Sold or used	
		Quantity	Value	Quantity	Value			Quantity	Value
1965	502	231	$1,731	161	$1,621	392	343	344	$15,391
1966	548	193	1,799	211	2,108	404	394	394	16,403
1967	638	190	1,802	223	2,171	413	351	350	15,115
1968	558	202	1,975	226	2,246	428	339	336	15,265
1969	613	205	2,087	266	3,013	471	405	402	22,100

Expanded perlite was produced by 83 firms in 99 plants in more than 30 States in 1969; only 86 plants produced expanded perlite in 1968. The output (405,000 tons) was the largest ever reported, and likewise, the quantity that producers sold or used (402,000 tons) was a new record. Illinois led the country in production of expanded perlite and also in the quantity that producers used and sold.

[1] Physical scientist, Intermountain Field Operation Center, Denver, Colo.

Table 2.—Expanded perlite produced and sold by producers in the United States

State	1968 Quantity produced (short tons)	1968 Sold or used Quantity (short tons)	1968 Sold or used Value (thousands)	1968 Sold or used Average value per ton	1969 Quantity produced (short tons)	1969 Sold or used Quantity (short tons)	1969 Sold or used Value (thousands)	1969 Sold or used Average value per ton
California	r 15,880	r 15,410	$1,116	r $72.44	16,980	16,410	$1,296	$79.02
Florida	9,700	8,590	598	69.63	10,410	9,420	676	71.73
Illinois	(1)	(1)	2,919	(1)	(1)	(1)	3,119	(1)
Kansas	900	930	80	86.42	900	930	80	86.52
Maryland	7,080	6,320	457	72.39	7,250	6,740	454	67.44
New York	5,120	5,120	295	57.52	4,560	4,550	297	65.26
Ohio	7,750	7,750	(1)	(1)	7,990	7,990	472	59.02
Oregon	540	540	40	74.37	510	510	44	86.55
Pennsylvania	12,170	12,290	869	70.68	12,580	12,860	877	68.19
Texas	(2)	(2)	(2)	(2)	34,880	34,870	2,262	64.88
Other Eastern States [3]	193,840	193,210	4,756	38.20	249,120	247,680	9,321	[4] 50.22
Other Western States [5]	86,110	86,330	4,134	47.89	59,640	60,220	3,202	53.17
Total [6]	r 339,100	r 336,480	15,265	r 45.37	404,820	402,170	22,100	54.95

r Revised
[1] Included with "Other Eastern States."
[2] Included with "Other Western States."
[3] Includes Georgia, Illinois (quantity only), Indiana, Kentucky, Maine, Massachusetts, Michigan, Mississippi, New Hampshire, New Jersey, North Carolina, Ohio (1968 value only), Tennessee, and Wisconsin.
[4] Based on quantity of 247,678 tons and value of $12,439,571 ($9,320,847 "Other Eastern States" plus $3,118,724 for Illinois).
[5] Includes Arizona, Colorado, Idaho, Iowa, Louisiana, Minnesota, Missouri, Nebraska, Nevada, Utah, and Washington.
[6] Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

The disposition of expanded perlite according to uses as reported by producers is shown in table 3; insulation board, filter aid, building plasters, and concrete aggregate were major uses. Some of the "Other uses" for expanded perlite were paint additives, texturing, refractories, roof insulation, charcoal base, and formed products.

Table 3.—Disposition and end-use of expanded perlite
(Percent)

Use	1968	1969
Insulation board	(1)	(1)
Plaster aggregate	r 21	16
Filter aid	r 20	18
Concrete aggregate	9	11
Masonry and cavity fill insulation	3	1
Horticultural aggregates	3	3
Fillers	r 1	1
Low temperature insulation	(1)	2
Formed products	(1)	1
Other	r 43	47

r Revised.
[1] Included in "Other."

PRICES

Producers of crude perlite sold crushed, cleaned, and sized perlite to expanding plants at an average price of $10.19 per short ton compared with $9.78 per ton in 1968. The portion used by producers in their own expanding plants was valued at an average of $11.30 per ton compared with $9.95 per ton in 1968. The weighted average of both categories was $10.82 per ton in 1969 compared with $9.87 per ton in 1968.

According to expanders of perlite, sold or used expanded perlite had an average value of $54.95 per ton compared with $45.37 per ton in 1968. Average values by States, however, ranged from $30 to $111 per ton.

WORLD REVIEW

Bulgaria.—Output of expanded perlite is being increased in Bulgaria. A new plant was being built at Kurdjali to make refractory aggregates from expanded perlite using ceramic bonds. The plant will be able to produce 5,000 cubic meters of clay-bonded "ceramoperlite" annually. Additional facilities were also being installed to produce bitumen-bonded expanded perlite for use in construction materials.[2]

Greece.—Most of the European supply of perlite comes from the island of Milos, famous for many archeological discoveries including the statue "Venus de Milo" in 1820. The island has gneiss and mica schists bedrock overlain by quartz-like rocks of variable thickness and crowned by volcanic tuff. Silver and Baryte Ores Mining Co. have mined deposits on Milos for barytes, bentonite, and kaolin ores for many years, and for perlite since 1954. Three types of perlite are mined on the island and reserves are estimated at 100 million tons. Milos perlite is porous, absorbs heat readily, expands easily, and requires no preheating before expansion. Reportedly modern furnaces using this material can yield recoveries of 93 to 97 percent expanded perlite with a minimum of fines and dust.

Hellenic Chemical Products & Fertilisers Co., Ltd., of Athens, also has deposits of perlite on Milos and plans to exploit them.[3]

Production of crude perlite in Greece in 1969 was estimated at 165,350 short tons.[4]

Iceland.—The Government of Iceland, long interested in exploiting perlite deposits on its eastern coast, continued to determine the feasibility of such an undertaking. The Johns-Manville Corp. of the United States offered the Government technical assistance in establishing a perlite industry, but reportedly decided against any equity capital.[5]

Mexico.—Perlite output totaled 11,170 tons in 1969.[6]

Philippines.—A large surface and subsurface deposit of perlite containing 9.9 million tons was discovered near Legaspi City on Luzon. The discovery, extending over 16 mining claims in Lamba and Maslog barrios, is held by Trinity Lodge Mining Corp. The firm also reported that it knows of another deposit containing 33 million tons of perlite in an adjacent area at Polique Bay.[7]

United Kingdom.—Six companies produce expanded perlite and all used imported raw materials. The firms are as follows:

Johns-Manville (G. B.) Ltd., at Hessle, Yorkshire.

Perlite Industries Ltd., at Belper, Derbyshire.

Lime-lite Division of Lime-Sand Mortar Ltd., at Buxton, Derbyshire.

British Gypsum, Ltd., at Kirby Thore and Cocklakes, Cumberland; Gotham, Nittinghamshire; Fauld, Staffordshire; Erith, Kent; and Robertsbridge, Sussex.

Perlite Division of European Oil and Chemical Trading Co., presumably in Scotland and a newcomer to the industry.

British Ceca Co., Ltd., at Strood, Kent.

Expanded perlite has many diverse uses; about 70,000 tons of the material is used annually in the manufacture of plasters. Chinchilla breeders use a small amount of expanded perlite as dust baths to yield better pelts.[8]

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[2] Industrial Minerals (London). Bulgaria—Perlite Production Expanded. No. 16, January 1969, pp. 33–34.

[3] Industrial Minerals (London). Perlite on the Continent. No. 20, May 1969, pp. 16–17.

[4] U.S. Embassy, Athens, Greece. State Dept. Airgram A–163, May 1, 1970, p. 3 encl. 1.

[5] Bureau of Mines. Mineral Trade Notes. V. 66, No. 4, April 1969, p. 27.

[6] U.S. Embassy, Mexico D. F. State Dept. Airgram A–215, Apr. 28, 1970, p. 6, encl. 1.

[7] Bureau of Mines. Mineral Trade Notes. V. 66, No. 5, May 1969, p. 27.

[8] Industrial Minerals (London). Perlite in Britain. No. 20, May 1969, pp. 18–19.

Crude Petroleum and Petroleum Products

By James G. Kirby [1] and Betty M. Moore [2]

The total demand [3] for petroleum products increased 5.5 percent, or at an average rate of 749,000 barrels daily, to 14,366,000 barrels daily in 1969. Domestic crude oil and lease condensate production increased only 1.3 percent while imports of crude oil and refined petroleum products increased 11.1 percent. Crude oil production declined in 19 of the 31 oil-producing States. The 142,000-barrel daily increase in crude oil production for 1969 was the lowest gain since 1964. A drilling accident at an offshore well in the Santa Barbara Channel created pollution problems that curtailed drilling in that offshore area of California. This area had held considerable promise of offsetting the declining production rate of onshore fields in the State, but as it was, production declined for the first time since 1964.

Demand by product.—*Gasoline.*—While the growth rate of domestic demand for motor gasoline was below that of 1968, it still achieved a 5.1-percent gain in 1969 and averaged 5,526,000 barrels daily. Factory sales of passenger cars declined 6.8 percent in 1969, but apparently scrappage of automobiles declined and average consumption rates of gasoline per vehicle increased. For the 11th consecutive year the demand for aviation gasoline declined.

Distillate Fuel Oil.—Although the weather during the first quarter of 1969 was colder than in the previous year and much colder than normal, the demand for distillate fuel oil during that quarter showed no increase over the same period in 1968. Demand rallied in the second quarter and continued at a high level for the balance of the year and as a result the increase in the demand for distillate for the year was 3.2 percent.

Residual Fuel Oil.—Over 88 percent of the 152,000-barrel per day increase in the domestic demand for residual fuel oil was in the East coast market. The unavailability of natural gas and of coal with a sulfur content low enough to comply with air pollution standards required electric utility companies to increase their use of residual fuel oil for the generation of electricity by 173,000 barrels daily in 1969. The total domestic demand for residual fuel oil in the United States in 1969 averaged 1,978,000 barrels daily, of which 1,404,000 barrels daily was for use in PAD district 1.

Kerosine.—After a slight rally in 1968 the demand for kerosine declined 6,000 barrels daily in 1969 to an average for the year of 275,000 barrels daily. This includes kerosine used in space heating and uses other than that used as jet aircraft fuel.

Jet Fuels.—The 3.7-percent gain in the domestic demand for jet fuel in 1969 was the lowest reported since 1958, when sepa-

[1] Industry economist, Division of Fossil Fuels.
[2] Statistical assistant, Division of Fossil Fuels.
[3] Certain terms as used in this chapter are more or less unique to the petroleum industry. Principal terms and their meanings are—

Total demand.—A derived figure representing total new supply plus decreases or minus increases in reported stocks. Because there are substantial secondary and consumers' stocks that are not reported to the Bureau of Mines, this figure varies considerably from consumption.

Domestic demand.—Total demand less exports.

New supply of all oils.—The sum of crude oil production plus production of natural gas liquids, plus benzol (coke-oven) used for motor fuel, hydrogen, and other hydrocarbons, plus imports of crude oil and other petroleum products.

Total disposition of primary supply.—The sum of the new supply of all oils plus the processing gain at the refinery, plus or minus the adjustment for unaccounted for crude oil and the change in stocks of all oils.

Transfers.—Crude oil conveyed to fuel-oil stocks without processing, or reclassification of products from one product category to another.

All oils.—Crude petroleum, natural gas liquids, and their derivatives.

Table 1.—Salient statistics of crude petroleum, refined products, and natural gas liquids in the United States

(Thousand 42-gallon barrels unless otherwise indicated)

	1965	1966	1967	1968	1969 p
Crude petroleum:					
Domestic production (including lease condensate)	2,848,514	3,027,763	3,215,742	3,329,042	3,371,751
World production	11,058,462	12,019,964	12,889,252	14,104,250	15,220,221
U.S. proportion ------ percent	26	25	25	24	22
Exports [1]	1,097	1,477	26,541	1,802	1,436
Imports [2]	452,040	447,120	411,649	472,323	513,849
Stocks, end of year	220,289	238,391	248,970	272,193	265,227
Runs to stills	3,300,842	3,447,193	3,582,594	3,774,360	3,880,098
Value of domestic product at wells:					
Total ------ thousands	$8,158,298	$8,726,423	$9,375,727	$9,794,826	$10,426,680
Average per barrel	$2.86	$2.88	$2.92	$2.94	$3.09
Total producing oil wells Dec. 31	589,203	583,302	565,289	553,920	542,227
Total oil wells completed during year (successful wells)	18,761	16,780	15,329	14,342	14,368
Refined products:					
Exports [1]	67,191	70,923	85,519	r 82,742	83,916
Imports [3]	448,732	492,042	514,342	r 567,046	640,679
Stocks, end of year [4]	580,188	602,291	629,399	649,439	655,984
Completed refineries, yearend	286	281	291	284	281
Daily crude-oil capacity	10,493	10,760	11,533	11,740	12,074
Natural gas liquids:					
Production	441,556	468,635	514,456	550,311	580,241
Stocks, end of year	35,867	40,423	65,742	77,940	60,912
All oils:					
Total demand	4,193,746	4,397,469	4,593,270	r 4,873,776	5,126,379
Exports	68,288	72,400	112,060	r 84,544	85,352
Domestic demand	4,125,458	4,325,069	4,481,210	r 4,789,232	5,041,027

p Preliminary (except for crude production and value). r Revised.
[1] U.S. Department of Commerce data.
[2] Bureau of Mines data for crude oil and unfinished oils.
[3] U.S. Department of Commerce data, except for unfinished oils.
[4] Stocks of refined products also include stocks of unfinished oils, natural gasoline, plant condensate, and isopentane.

rate records were first kept on this fuel. The market for kerosine-type fuel, used mostly by commercial aircraft, continued to expand in 1969 and averaged 693,000 barrels daily, an increase of 13.8 percent. Naphtha-type jet fuel, used mostly by military aircraft, declined 14.2 percent to an average of 297,000 barrels daily as a result of a cutback in military purchases.

Liquefied Gases.—The domestic demand for liquefied gases (including ethane) averaged 1,221,000 barrels daily in 1969, an increase for the year of 15.8 percent. More detail on liquefied gases can be found in the "Natural Gas Liquids" chapter.

Other Products.—Included in this category are refinery still gas, asphalt, petrochemical feedstocks, petroleum coke, lubricating oils, special naphtha, road oil, wax, and miscellaneous products. The total demand for these products in 1969 was 1,743,000 barrels daily, including a domestic demand of 1,610,000 barrels daily and exports of 133,000 barrels daily. This compares with a total demand of 1,669,000 barrels daily in 1968 and a domestic demand of 1,544,000 and exports of 125,000 barrels daily. The demand for petroleum coke increased 8.8 percent in 1969 and showed strong gains in both the domestic and export markets, while demand for lubricating oil increased slightly in the domestic market but exports declined. Refineries used 160.4 million barrels of still gas for fuel in 1969, an increase of 7.3 percent for the year.

Shipments to U.S. Territories and Possessions.—Domestic demand as defined in this chapter, refers to demand in all States of the United States. Shipments from the United States to territories and possessions are included with exports. Any foreign receipts into these territories and possessions are not included in the total imports shown.

Shipments from territories and possessions to foreign countries are excluded from exports. Shipments to the United States are included in imports.

Scope of Report.—The data presented in this chapter are limited to the United States to permit a breakdown and balancing of supply and demand of operations by States and districts. The composition of the districts used by the Bureau of Mines is explained in the next section.

The increasing volume of natural gas liquids recovered from natural gas has

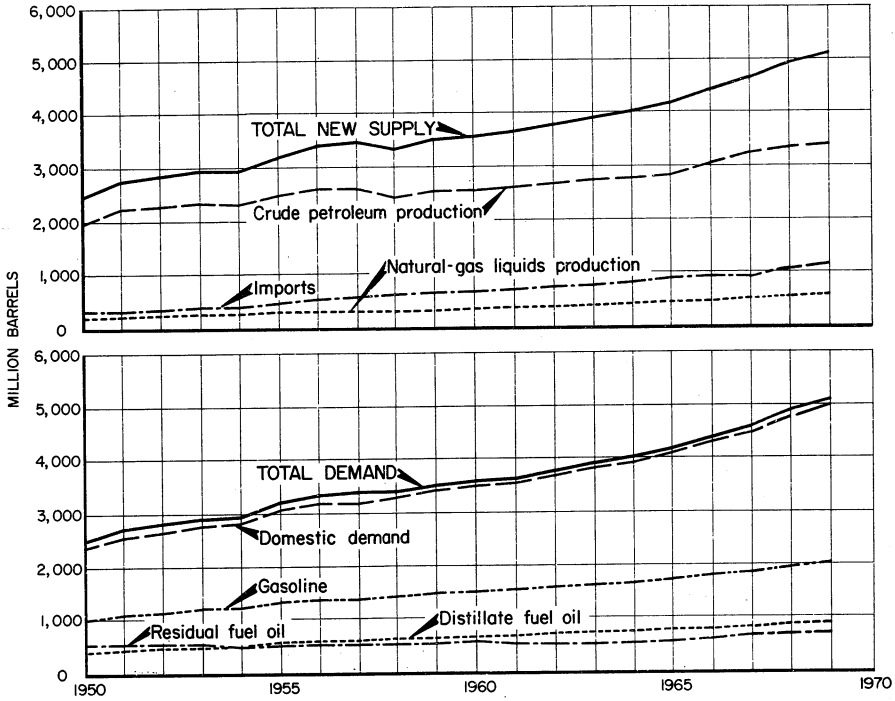

Figure 1.—Supply and demand of all oils in the United States.

made it desirable to present data on these liquids with crude oil data, as these liquids are blended with refinery products and are similar to materials recovered from refinery gases. These natural gas liquids are recovered at natural-gas processing plants away from the oil refineries.

Most of the data were compiled from detailed reports submitted on a voluntary basis by the various companies and include production, stocks, and refinery operations. These data are also published monthly.

The Bureau of Mines uses production data on crude oil compiled by State agencies for those States which compile the information. Where such data are not available, monthly questionnaires are sent to all pipeline companies operating within the State. The crude oil production figures include field condensates.

Individual refineries reported monthly receipts, input, stocks at the beginning and the end of the month, refinery production, and deliveries. Data on both product stocks at refineries and pipeline and bulk terminal stocks are collected.

Annual canvasses and State agencies provide supplemental information on the value of crude petroleum at wells, the number of producing wells, sales of fuel oils, asphalt and road oils by uses, and refinery capacity.

The import data on crude oil and unfinished oils are those reported by the refineries, whereas other product imports and all export data are taken from records of the U.S. Department of Commerce.

The table showing world crude oil production by countries is based on reports from companies operating in these countries, from reports published by these countries, or from data supplied by the U.S. Department of State.

Districts.—The Bureau of Mines reports production of crude petroleum and natural gas liquids and the number of wells drilled by States. Louisiana, New Mexico, and Texas are also reported by districts.

New Mexico has two widely separated producing areas. The Southeastern district is comprised of mainly Lea, Eddy, Chaves, and Roosevelt Counties. The Northwestern district is comprised of mainly San Juan, Rio Arriba, Sandoval, and McKinley Counties.

The Bureau of Mines producing districts in Texas correspond, with one exception, to the groupings of the Texas Railroad Commission districts as follows:

Bureau of Mines districts	*Railroad Commission districts*
Gulf Coast	Nos. 2 and 3.
West Texas	Nos. 7C, 8, and 8a.
East Proper	Part of No. 6 (East Texas field in Cherokee, Smith, Upshur, Rush, and Gregg.)
Panhandle	No. 10.
Rest of State:	
North	Nos. 7B and 9.
Central	No. 1.
South	No. 4.
Other East Texas	Nos. 5 and 6 (exclusive of East Proper.)

Separate production data are shown for the Louisiana Gulf Coast, including the offshore area.

The Bureau of Mines groups refinery operations into another set of districts called refining districts. These refining districts correspond with the groupings originated by the Petroleum Administration for War during World War II called PAW districts (later changed to PAD districts).

PAD district	*Refining districts*
I	*East Coast*—District of Columbia, Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New Jersey, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, and Florida; the following counties of New York: Cayuga, Tompkins, Chemung, and all counties east and north thereof; and the following counties of Pennsylvania: Bradford, Sullivan, Columbia, Montour, Northumberland, Dauphin, York, and all counties east thereof.
I	*Appalachian No. 1*—West Virginia and those parts of Pennsylvania and New York not included in the East Coast district.
II	*Appalachian No. 2*—The following counties of Ohio: Erie, Huron, Crawford, Marion, Delaware, Franklin, Pickaway, Ross, Pike, Scioto, and all counties east thereof.
II	*Indiana-Illinois-Kentucky*—Indiana, Illinois, Kentucky, Tennessee, Michigan, and that part of Ohio not included in the Appalachian district.
II	*Oklahoma-Kansas-Missouri*—Oklahoma, Kansas, Missouri, Nebraska, and Iowa.
II	*Minnesota-Wisconsin-North Dakota-South Dakota*—Minnesota, Wisconsin, North Dakota, and South Dakota.
III	*Texas Inland*—Texas, except Texas Gulf Coast district.
III	*Texas Gulf Coast*—The following counties of Texas: Newton, Orange, Jefferson, Jasper, Tyler, Hardin, Liberty, Chambers, Polk, San Jacinto, Montgomery, Harris, Galveston, Waller, Fort Bend, Brazoria, Wharton, Matagorda, Jackson, Victoria, Calhoun, Refugio, Aransas, San Patricio, Nueces, Kleberg, Kenedy, Willacy, and Cameron.
III	*Louisiana Gulf Coast*—The following parishes of Louisiana: Vernon, Rapides, Avoyelles, Pointe Coupee, West Feliciana, East Feliciana, Tangipahoa, St. Helena, Washington, and all parishes south thereof; the following counties of Mississippi: Pearl River, Stone, George, Hancock, Harrison, and Jackson; and Mobile and Baldwin Counties, Ala.
III	*North Louisiana-Arkansas*—Arkansas and those parts of Louisiana, Mississippi, and Alabama not included in the Louisiana Gulf Coast district.
III	*New Mexico*—New Mexico.
IV	*Rocky Mountain*—Montana, Idaho, Wyoming, Utah, and Colorado.
V	*West Coast*—Washington, Oregon, California, Nevada, Alaska, Arizona, and Hawaii.

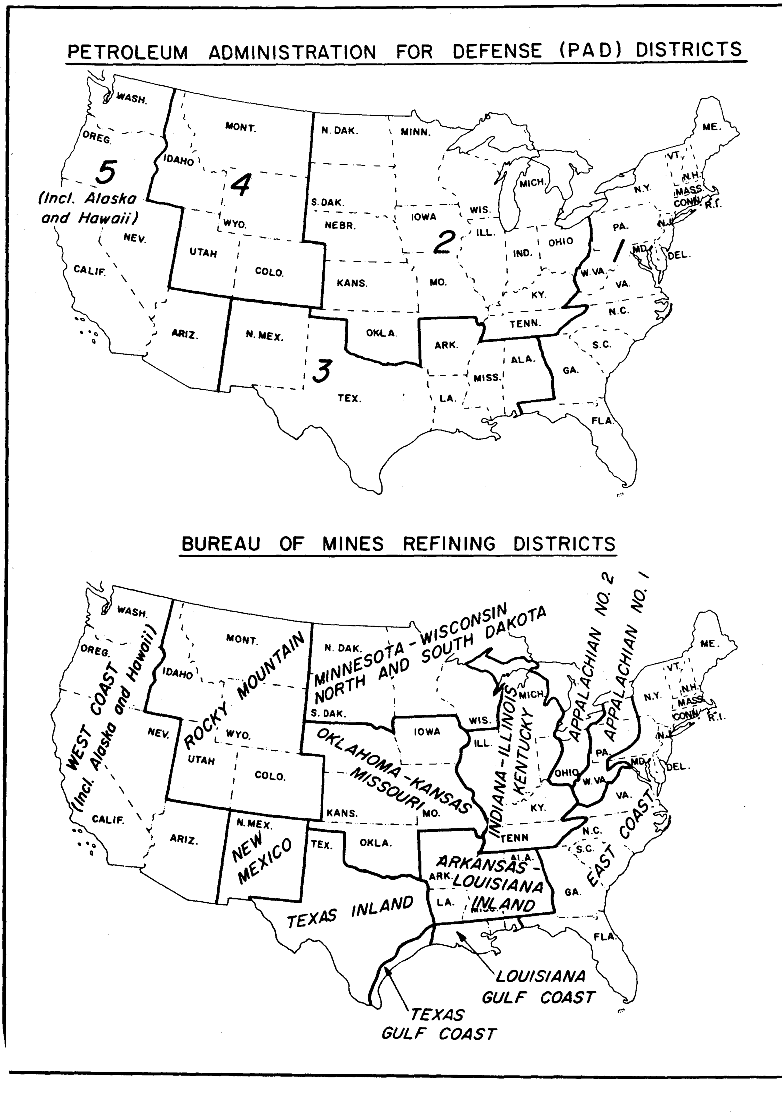

Figure 2.—Map of PAD Districts and Bureau of Mines Refining Districts.

CRUDE PETROLEUM

PRODUCTION

The total production of crude oil and lease condensate in the United States in 1969 was 3,371,751,000 barrels, 42,709,000 barrels above the 1968 level. Crude oil output reached a record high in June, when the daily production for the month averaged 9,631,000 barrels. With this high rate of production crude oil stocks also built up to the highest level since February 1958, so production was cut back to reduce the excess stock. Only 12 of the 31 oil-producing States reported gains in production in 1969. All States in PAD district III, with the exception of Arkansas, increased their production levels for the year. The daily average production in Louisiana was 74,000 above the 1968 level, and Texas production increased 50,000 barrels daily. Production declined in 19 States, with the largest declines reported in Kansas and Illinois, each having an average daily decline of 16,000 barrels.

Crude oil production goals failed to materialize in district V in 1969. A substantial increase in production had been planned from wells in the Santa Barbara channel. Early in the year an oil leak, which spread over a large coastal area, occurred at a drilling rig. Drilling was drastically curtailed as a result of various legal complications. Secondary recovery projects did get underway in the Cook Inlet of Alaska, but the resulting increase in production was about half of what had been expected. Additional data on crude oil production, by States, can be found in volume III of the 1969 Minerals Yearbook.

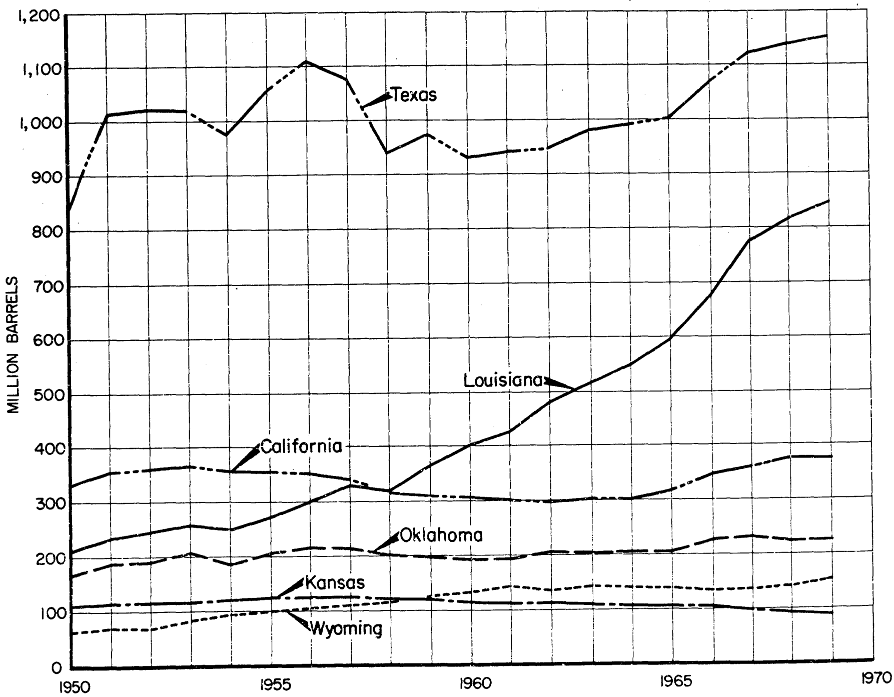

Figure 3.—Production of crude petroleum in the United States, by principal producing States.

CONSUMPTION

The total demand for crude oil in the United States in 1969 averaged 10.6 million barrels daily, of which 9.2 million barrels, or 86.7 percent, was supplied by domestic sources and 1.4 million barrels daily came from foreign sources. The demand for domestic crude oil increased 2 percent, while the demand for foreign crude oil increased 10.9 percent.

Runs to Stills.—Crude runs to stills averaged 10,630,000 barrels daily in 1969 compared with 10,312,000 in 1968. Runs of domestic crude oil increased 179,000 barrels daily to 9,217,000 barrels, and runs of foreign crude oil increased 139,000 barrels daily to 1,413,000 barrels.

Demand by States of Origin.—Distribution of domestic crude oil by refining States and districts can be analyzed from receipts of crude oil at refineries. When long-distance shipments are involved, various crude oils may be mixed in transit or storage, and identification by origin may be only approximate.

SUPPLY AND DISTRIBUTION

The total disposition of crude oil in 1969 was 3,890.8 million barrels, a 105.5-million-barrel increase for the year. Of this total, domestic crude oil including withdrawals from stocks, accounted for 3,376.4 million barrels, and imported crude oil, including withdrawals from stocks, accounted for 516.2 million barrels. The difference, a minus 1.8 million barrels, was

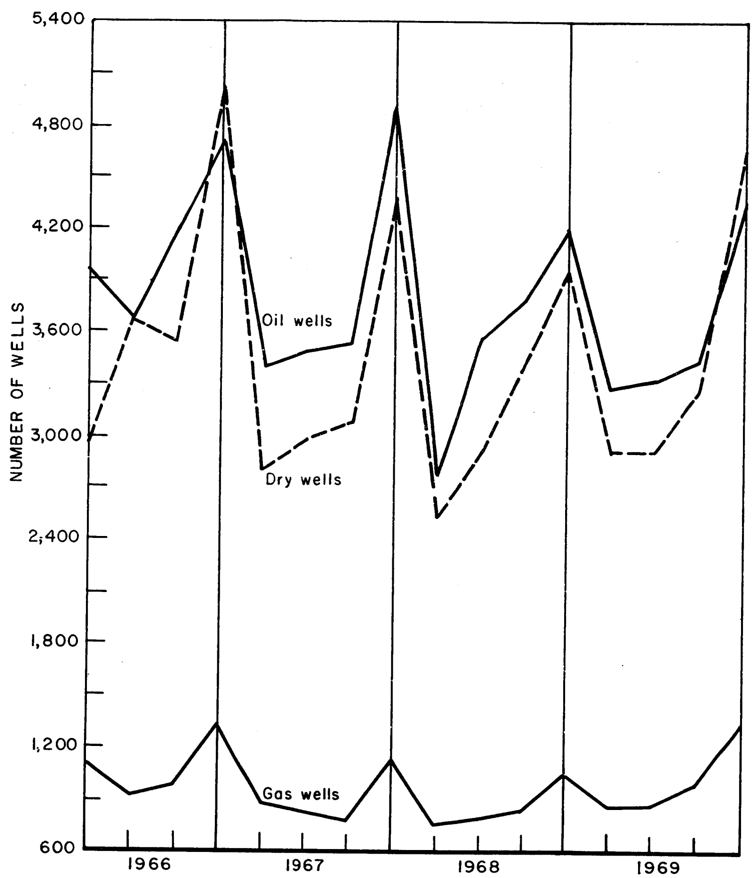

Figure 4.—Wells drilled for oil and gas in the United States, by quarters.

classed as "unaccounted for" crude oil to avoid making arbitrary adjustments in the reported supply or consumption items.

PRODUCTION CAPACITY

According to the American Petroleum Institute (API), the maximum crude oil production that could be attained in the United States as of January 1, 1970, was 11.6 million barrels daily, down 0.5 million since January 1, 1969. This estimate is based on the assumption that such production could be achieved in 90 days with existing wells, well equipment, and present surface facilities plus work changes that could be accomplished within that time.

WELLS

After 4 years of decline, drilling activity increased in 1969, and 32,173 new wells were drilled. Of these wells, 14,368 were completed as oil wells, 4,083 were completed gas wells, and 13,722 were dry holes. The average footage drilled per well in 1969 was 4,881 feet compared with 4,738 feet in 1968. A total of 1,212 wells was drilled offshore in 1969, and 619 were completed as oil wells, 216 were completed as gas wells, and 377 were dry holes. The average footage drilled per offshore well was 9,547 feet, which is more than twice the depth of the average onshore well drilled. Drilling activity increased in 21 States in 1969 but declined in 10 States. States with a sizable increase were Texas with 1,042 additional wells drilled, Wyoming with 383, Oklahoma with 373, and Colorado with 320. In California drilling for the year declined 741, Kentucky was off by 329, and Louisiana reported a decline of 304.

RESERVES

The API Committee on Petroleum Reserves estimated proved reserves of crude oil as of December 31, 1969, to be 29,632 million barrels, a decline of 1,075 million barrels for the year. The reserve estimates give no credit to the large potential reserves discovered on the North Slope of Alaska in 1968, which have been estimated as having a potential of 10 billion barrels. The committee stated, "Because of unitization negotiations and the competitive aspects of operations in progress, it was not feasible for operators to provide proprietary data upon which the committee could base an estimate of proved reserves for this area as of December 31, 1969." Texas reserves declined 746.7 million barrels during the year, and Wyoming reserves were off 104.7 million barrels. Louisiana reserves were up 81.0 million barrels for the year.

REFINED PRODUCTS

About 53 percent of the demand for petroleum products is for use in the transportation sector, 36 percent is used for heat and power, and the balance is used as raw material for the production of other products. Petroleum supplied 43 percent of the energy requirements in the United States in 1969.

Gasoline is consumed principally in highway transport, aviation, mechanized farming, and powerboating. Kerosine (other than the straight-run kerosine used as fuel in commercial jet aircraft) is used primarily in space heaters, as range oil, or for farm equipment. Distillate fuel oils, which include the light diesel fuels, are used for space heating, locomotive fuel, industrial use, vessel use, and by the military. Residual fuel oil is used primarily in electric utilities and for heavy-fuel use. Residual fuels usually sell for less than crude oil at the refineries. As it is not normally moved by pipeline, its distribution depends on low-cost water transportation and limited tank movement.

Liquefied gases, in competition with kerosine and light distillate fuel oil for domestic use, are used as fuel in internal-combustion engines and are becoming increasingly important as the initial raw material in the development of many petrochemicals.

The total demand for petroleum products averaged 14,366,000 barrels daily in 1969, including a domestic demand of 14,136,000 barrels daily and exports of 230,000 barrels daily. Compared with 1968, total petroleum product demand increased 5.5 percent, exports declined 0.4 percent, and domestic product demand increased 5.5 percent. In previous years, when discussing petroleum demand, refinery overage, which results from the volumetric excess of refined products from the refinery input because of the various refining processes, has been treated as a negative item in demand. Since this has the effect of increasing primary supply, it is now considered as a portion of supply and is no longer deducted from the overall demand.

Total supply, including processing gain (refinery overage), averaged 14,334,000 barrels daily, and stocks of all oils were reduced at an average rate of 48,000 barrels daily to meet the total demand for refined products and crude losses and exports.

GASOLINE

Despite a decline in new passenger car sales, the demand for motor gasoline continued to show a strong growth rate in 1969, and consumption averaged 5,526,000 barrels daily, an increase for the year of 5.1 percent. Aviation gasoline continued to decline in both the domestic and export markets.

The new supply of motor gasoline in 1969 was 2,024 million barrels, of which 1,731 million barrels was produced from crude oil, 270 million was from natural gas liquids, and 23 million was imported.

According to data compiled by the API based on tax data reported by the States, 2,034 million barrels of motor gasoline was consumed in the United States in 1969 compared with 1,923 million in 1968. This differs from the demand data compiled by the Bureau of Mines, which do not include changes in secondary storage. District 11 was the largest consuming area, and used 34.8 percent, while district 1 accounted for 34.7 percent. District III, which accounted for almost 40 percent of the motor gasoline produced, consumed only 12.9 percent of the total.

KEROSINE

Kerosine demand, exclusive of that used in jet fuel, was off 2.1 percent in 1969. Demand for the year averaged 275,000 barrels daily compared with 281,000 in 1968. Although the weather was much colder dur-

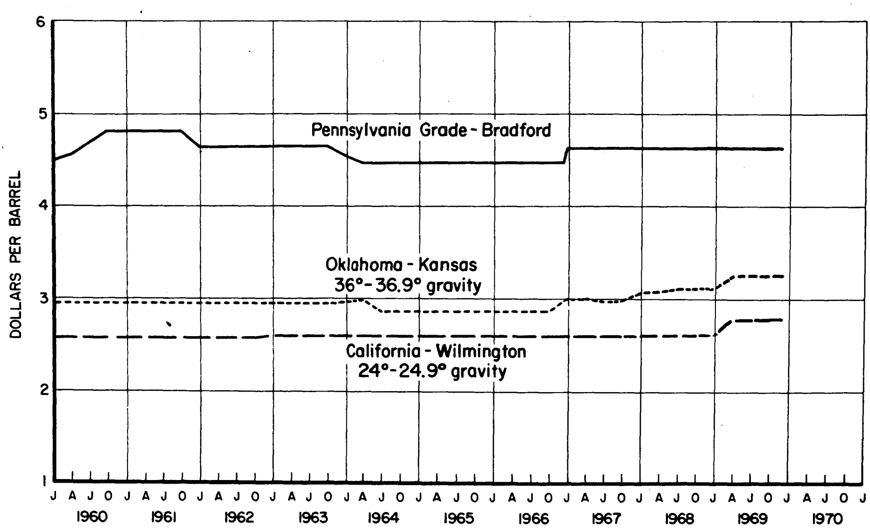

Figure 5.—Production, domestic demand, stocks, and exports of gasoline in the United States.

ing the fourth quarter of 1969 than the year before, kerosine demand was 30,000 barrels per day less. Stocks of kerosine at the end of the year were 26.8 million barrels, 3.3 million above the December 1968 level.

DISTILLATE FUEL OIL

Although the weather during the 1969 heating season was much colder than in the previous year, distillate fuel oil demand did not react in the usual manner. In the first quarter there was no increase in demand, and the fourth-quarter demand was up only 3.6 percent, while the second and third quarters showed gains of 6.4 percent and 6.2 percent, respectively. Since the fourth quarter of 1968 also showed an exceptionally high percentage increase, it appears that secondary storage, which is not included in Bureau of Mines stock data, was sufficently high during these periods not to reflect prevailing weather conditions in the demand for primary supplies. Distillate fuel oil demand for the year averaged 2,466,000 barrels daily, a gain of 3.2 percent over that of 1968.

Stocks were reduced 1.4 million at the end of 1969 to 171.7 million barrels. While imports of No. 4 distillate fuel oil increased from 19.1 million barrels in 1968 to 27.4 million in 1969, imports of lighter distillates declined from 29.1 million barrels to 23.5 million barrels for the year. No. 4 distillate fuel oil imports are treated by the Oil Imports Administration in the same manner as residual fuel oil in district I and are not included in the 12.2-percent import level. No. 4 fuel oil, being low in sulfur content, can be substituted in areas where restrictions have been placed on the use of residual fuel oils of high sulfur content.

RESIDUAL FUEL OIL

The domestic demand for residual fuel oil increased at the rate of 152,000 barrels daily in 1969, and 134,000 barrels daily of this increase was in district I. The use of residual fuel oil by electric utilities for power generation in district I increased from an average of 424,000 barrels daily in 1968 to 587,000 barrels daily in 1969. The rapid increase in residual fuel oil use by the utilities is a result of stricter regulations by communities on sulfur emission from fuels, the short supplies of coal that meet the sulfur standards, and the unavailability of natural gas for this use. Since domestic refineries do not consider it profitable to produce residual fuel oil at current price levels, the increased demand for residual fuel oil must be met by imports. The sulfur restrictions are also causing concern among suppliers, who are having to scramble to find enough low-sulfur residual fuel oil to meet the growing demand.

At yearend, stocks of residual fuel oil had declined from the December 31, 1968, level by almost 7 million barrels to 60.4 million barrels.

JET FUELS

A cutback in purchases by the military of naphtha-type jet fuels in 1969 lowered the demand for the product to 302,000 barrels daily, a decline of 14.2 percent. The demand for the kerosine-type jet fuel used in commercial jet aircraft continued strong during the year and increased by 14.1 percent to 694,000 barrels daily.

Imports of jet fuel averaged 125,000 barrels daily in 1969, of which 116,000 barrels daily was imported in bond for use as fuel for aircraft engaged in flights with destinations outside the United States. There are no custom duties on these imports, and bonded imports of such fuels are not subject to import-control regulations.

LUBRICANTS

While domestic demand for lubricants was slightly above the 1968 level, exports declined 1.6 million barrels so that total demand for the year, 65.2 million barrels, was 1.9 percent less than in 1968.

LIQUEFIED GASES, ETHANE, AND ETHYLENE

Liquefied gases are derived from two sources. Those produced at refineries are called liquefied refinery gases to distinguish them from liquefied petroleum gases produced from natural gas. The liquefied petroleum gases (LPG) are all saturated (propane, butane, etc.). The liquefied refinery gases (LRG) may contain unsaturated compounds or olefins (propylene, butylene, etc.). The olefins are used as feedstocks for chemical plants. The saturated gases may be used as chemical raw materials or as fuel.

Separate data are collected on liquefied refinery gas used as fuel and that used as raw material for petrochemical feedstocks. Liquefied gases are also used in producing gasoline and are reported in this chapter as "natural gas liquids" at refineries or as "gasoline."

The total demand for liquefied gases, excluding that blended into other products at refineries or terminals in 1969, was 386,207,000 barrels compared with 341,197,000 barrels in 1968. Domestic demand for the year increased 13.0 percent, and exports increased 20.6 percent. The demand for ethane (including ethylene) was 72,216,000 barrels in 1969 compared with 55,152,000 barrels in 1968.

More detailed information on liquefied gases may be found in the chapter on natural gas liquids.

ASPHALT AND ROAD OIL

While the overall demand for asphalt showed a 1.8-percent increase in 1969, shipments of asphalt and asphaltic products from plants were below the 1968 level by 0.8 percent. The slowdown in new building construction resulted in a 14.4-percent decline in the demand for roofing products, and other product use was down 6.1 percent. Shipments of asphalt for paving products, which represent about 76 percent of the use of asphalt, increased 3.1 percent in 1969 to 21.3 million short tons. The shipment data include, in addition to the refinery production and imports, various emulsifiers and blenders.

The demand for road oil in 1969 was 8,756,000 barrels.

OTHER PRODUCTS

Special Naphthas.—The total demand for special naphthas increased 7.4 percent in 1969 to 31.6 million barrels. This product is used primarily for paint thinners, cleaning agents, and solvents.

Waxes.—According to a survey by the API the petroleum industry reported sales of 563,987 short tons of wax for consumption in the United States in 1969, an increase of 5.6 percent for the year. Sales of wax for use in the manufacture of paper wrappers, paperboard containers, and corrugated paperboard were 296,460 short tons, down 1.2 percent from 1968 sales. The use of wax for candles, molded novelties, figurines, and decorative items increased 17.2 percent in 1969 to 79,980 short tons. Sales of wax for all other uses increased 13.2 percent in 1969 to 185,547 short tons. The API survey represents over 88 percent of the domestic demand reported by the Bureau of Mines. The 1969 domestic demand reported by the Bureau was 686,420 short tons, an increase of 12.5 percent over that of 1968.

Coke.—The total production of petroleum coke increased 8.1 percent in 1969 to 20,574 short tons. Marketable coke production was 10,401 tons, up 13.5 percent, while catalyst coke production increased 3.0 percent to 10,172 tons. Refiners used 10,625 tons of coke for fuel in 1969, including, in addition to the catalyst coke, 452 tons of marketable coke. The total demand for petroleum coke in 1969 was 20,773 tons with exports representing 22.2 percent compared with 20.3 percent in 1968.

Still Gas.—Refineries used 160,363,000 barrels (984,561 million cubic feet) of still gas as fuel in 1969 compared with 149,796,000 barrels (921,850 million cubic feet) in 1968. A total of 9,985,000 barrels of still gas was used as a petrochemical feedstock in 1969.

Petrochemical Feedstocks.—The petrochemical industry in the United States used 94,647,000 barrels of feedstocks produced at refineries (other than LRG) in 1969. This included 9,985,000 barrels of still gas, 57,569,000 of naphtha, —400°, and 27,093,000 barrels of other products for use in the manufacture of petrochemicals.

Miscellaneous Finished Products.—The petroleum industry produces a variety of miscellaneous products that are sold directly to consumers or are sold in bulk to speciality companies which package and distribute them under various trade names. Included in this category are absorption oils, insulating oils, medicinal oils, insecticides, petrochemicals, and solvents. The domestic demand for these miscellaneous oils in 1969 was 16,617,000 barrels.

Unfinished Oils.—Unfinished oils are oils that have been partially refined and will be further processed by a refinery. The rerun (net) of unfinished oil represents the receipts of domestic or foreign oil plus or minus the stock change. Unfinished oils are included with crude oil under the quotas established by the Oil Import Administration. By regulation, unfinished oil imports are restricted to 15 percent of the crude oil and unfinished oil quota in districts I–IV and to 25 percent in district V.

TRANSPORTATION AND DISTRIBUTION

CRUDE OIL

A transportation system consisting of pipelines, tankers, barges, tank cars, and tank trucks moves the crude petroleum to refineries for processing. Refineries received 76.6 percent of their crude oil supply by pipeline, 22.2 percent by water, and the remaining 1.2 percent by tank cars and tank trucks in 1969.

The eastern seaboard States (PAD district I), represent 39 percent of the domestic market for petroleum in the United States and receive a major part of their domestic supplies of crude oil and refined products (3.1 million barrels daily in 1969) from PAD district III. PAD district II, the second largest consuming sector, also receives a substantial share of crude oil and refined products from PAD district III (1.8 million barrels daily in 1969).

Data collected on receipts of domestic and foreign crude petroleum at refineries in the United States show receipts from local production (intrastrate), receipts from other States (interstate), and receipts of imported crude. These data indicate the final receipts by water, pipelines, and tank car and truck. Receipts of domestic crude by water usually are moved by pipeline from the point of production to the point of water shipment.

The total receipts of crude oil at refineries in 1969 were 3,879.0 million barrels, an increase of 96.9 million barrels for the year. Receipts from domestic sources increased 55.6 million barrels in 1969, overland receipts of foreign crude oil were 30.0 million barrels higher, and foreign receipts from overseas sources increased 11.3 million barrels.

During 1969 refineries processed 3,880.1 million barrels of crude oil, reported a net of 1.5 million barrels used for refinery fuel and losses, and withdrew 2.6 million barrels from inventories.

In 1969, refiners in PAD district I processed crude oil at the rate of 1,311,000 barrels daily, with 57.1 percent of the input being from foreign sources; 2.1 percent from crude oil produced in the district; 38.0 percent received from PAD district III, and the balance received by pipelines from PAD districts II and IV. Output from District I refineries provided less than 24 percent of the demand for petroleum products in that district.

While crude runs to stills in PAD district II increased 54,000 barrels daily in 1969 to 3,013,000 barrels daily, crude oil production declined 43,000 barrels daily. To meet crude oil demand requirements for the district, receipts from PAD district III were increased at an average rate 78,000 barrels daily to 1,309,000 barrels, and imports from Canada were stepped up to 242,000 barrels daily, 28,000 barrels above the 1968 daily average. PAD district IV supplied 302,000 barrels daily which was about the same as in 1968.

PAD districts III and IV have surplus crude oil and receive only token amounts of oil from other districts or from foreign sources.

Domestic receipts of crude oil from the Four Corners area in PAD district IV continued at the same level as in 1968, 40,000 barrels daily. To meet the crude oil requirements for the district in 1969, crude oil imports were increased from 326,000 barrels daily in 1968 to 394,000 barrels daily.

REFINED PRODUCTS

To meet the 5,507,000-barrel-per-day domestic product demand in PAD district I in 1969, 4,077,000 barrels daily of products was shipped into the district. A breakdown of these receipts of refined products in barrels daily is as follows: From foreign sources, 1,491,000; from PAD district III by pipeline, 1,410,000, by tanker, 1,061,000 and by river barge 59,000; from PAD district II, 54,000 by pipeline; and from PAD district V, 2,000 by tanker.

Demand for refined product in PAD district II averaged 3,901,000 barrels daily in 1969. Outside sources provided an average of 683,000 barrels daily of refined products to meet the district's demand. PAD district III supplied an average of 531,000 barrels daily (215,000 by river barge and 316,000 by pipeline); pipeline receipts from PAD district I averaged 113,000 barrels daily and pipelines from PAD district 4 supplied

17,000 barrels daily with imported oil supplying the remaining 22,000 barrels daily.

The demand for refined petroleum products in PAD district III averaged 2,423,000 barrels daily. While this district is a surplus producing area, there were 71,000 barrels daily of products moving into the area by pipeline from PAD district II, and imports averaged 42,000 barrels daily. The imported products were principally bonded fuels for aircraft and vessels engaged in overseas trade. The district shipped 3,178,000 barrels daily of refined products to other PAD districts.

PAD district IV is also a surplus producing area. Demand for refined products in this district averaged 367,000 barrels daily in 1969. Imports into the district averaged 8,000 barrels daily and consisted primarily of liquefied petroleum gases from Canada. Net shipments of refined products from district IV averaged 57,000 barrels daily.

Domestic demand for refined petroleum products in PAD district V averaged 1,938,000 barrels daily in 1969. Imports of refined products into the district averaged 88,000 barrels daily, and net receipts of refined products from other districts averaged 154,000 barrels daily.

PIPELINES

As of January 1, 1968, there were 209,478 miles of pipelines transporting crude oil and refined products in the United States. This represents a 1,389-mile decline from the total reported in the previous Bureau of Mines survey for January 1, 1965. The mileage of gathering lines for crude oil declined 2,917 miles during the 3-year period, and crude oil trunklines declined 1,558 miles. The January 1, 1968, survey did not include data for Capline, which started operating approximately 630 miles of 40-inch crude oil trunklines from Louisiana to Patoka, Ill., in the summer of 1968, nor did it include offtakes from that line to northern Illinois and Kentucky, which would be at least an additional 340 miles. The decline in gathering lines for crude oil between 1965 and 1968 reflects the impact of the 15,000 fewer wells producing crude oil in operation as of December 31, 1967. Larger capacity trunklines are replacing smaller lines. The total mileage of pipelines for refined products increased 3,086 miles between January 1, 1965, and January 1, 1968. The total crude oil required for pipeline fill in 1968 was 66.9 million barrels, compared with 64.9 million barrels in 1965. The pipelines for refined products required 37.7 million barrels for fill in 1968, compared with 35.8 million in 1965.

Clearance is still being withheld for the start of construction on the 800-mile Trans-Alaskan Pipeline to bring crude oil from the North Slope of Alaska to the port of Valdez for transshipment to the west coast. In addition to satisfying Federal and State government regulations that adequate precautions will be taken to insure no damage to the ecology, suits have been filed by native Alaskans claiming territorial rights and by conservation groups. It was originally estimated that the cost of the 48-inch crude oil line would be about $900 million, but with the delays, it is likely the costs will be much higher.

Plans were completed late in 1969 for a 600-mile products pipeline from the gulf coast to the Chicago area. The line, to be called the Explorer, will be a 28-inch line from Houston to Tulsa and a 24-inch line on to Chicago. Initial capacity of the line is expected to be 312,000 barrels daily.

RAIL, TANK TRUCK, BARGES, AND TANKERS

In a survey conducted by the National Petroleum Council in 1967, it was reported that as of June 1, 1967 there were 142,356 U.S.-based tank cars, having a total capacity of 1.7 billion gallons, suitable for carrying petroleum and petroleum products. The Council's survey of tank trucks and trailer units estimated that as of January 1, 1967, there were 81,300 units in service with an aggregate capacity of 497 million gallons.

There were 2,925 nonpropelled and self-propelled barges and small lake tankers suitable for transporting petroleum and petroleum products in bulk on inland waterways, the Great Lakes, and in some instances, salt water as of January 1, 1967. About 76 percent of this fleet was operating on the Mississippi River and the Gulf Intracoastal Canal. The combined capacity for this fleet was 35.5 million barrels.

The world tankship fleet at the end of 1968 numbered 3,748 vessels of 2,000 gross tons or more and totaled 126,454,000 deadweight tons. In terms of a T–2 tankship, which is defined as a 16,765-deadweight-ton vessel with a service speed of 14.5 knots per hour, this would be the equivalent of 8,202 vessels. About 7 percent, or the equivalent of 575 T–2 tankships are under United States flag registery. Under the provisions of the Jones Act, all ships involved in intercoastal trade in the United States must have been built and must be registered in the United States.

STOCKS

The total stock of all oils at the end of 1969 was 982.1 million barrels, a decrease of 17.5 million barrels for the year. Crude oil stocks declined 7.0 million barrels, stocks of refined products were down 15.1 million barrels, while stocks of unfinished oils and natural gasoline and plant condensates increased 4.7 million barrels. The heavy demand for liquefied gases resulted in a 16.5-million-barrel reduction in stocks of this product during the year and caused concern that butane and propane would be in short supply during the first quarter of 1970. However, no problems occurred. High crude runs to stills during the last half of 1969 to build up distillate fuel oil stocks also built up stocks of motor gasolines, and at the close of 1969 they were 6.7 million barrels above the level a year ago.

PRICES

Crude Oil.—Beginning February 1, 1969, crude oil purchasers on the west coast announced a 5-cent-per-barrel price increase, and on February 25 one major company announced a 20-cent-per-barrel increase for all States except California. By March 1 changes ranged from 5 to 20 cents per barrel. For the next few months, there was considerable confusion in the marketplace. Some purchasers, feeling they had been overly optimistic with their 20-cent increase, cut back to competitors' announced levels, and others, feeling they were too low, raised their offers. The situation leveled off by July, and price adjustments followed a normal pattern for the rest of the year. The overall effect on the wellhead value of crude oil for the year was an increase of 15 cents per barrel, which raised the average price for 1969 to $3.09.

Refined Products.—To compensate for the higher cost of crude oil, refiners raised the posted prices for their refined products. The March posting for regular-grade gasoline was increased 0.73 cent to 12.48 cents per gallon. The high posting did not hold, however, because of surplus supplies and by July was down to 12.09 cents. By December the price had increased to 12.29 cents. The average of posted prices of gasoline at the refineries for the year was 12.18 cents, a 0.45-cent increase. The average tank-wagon dealers' price in 1969 (excluding taxes) increased 0.6 cent per gallon, while the pump price to customers (including taxes) increased 1.13 cents per gallon. Increases in State and local taxes were responsible for 0.22 cent of the higher consumer price.

The Oil Daily publishes a daily series of dealers' tank-wagon posted prices, excluding all taxes, for kerosine and Nos.1 and 2 distillate fuel oils by cities. These are for maximum quantity deliveries. A comparison of an average of 50 cities at the beginning of 1969 with the end of 1969 showed that the price for each of the products had increased 0.8 cent per gallon. The 50 cities' average of yearend prices were—kerosine, 18.5 cents; No. 1 distillate fuel oil, 17.7 cents, and No. 2 distillate fuel oil, 16.4 cents. The average posted prices at refineries in 1969 increased 0.24 cent per gallon for kerosine, 0.33 cent for No. 1 fuel oil, and 0.24 cent for No. 2 distillate fuel oil. Refinery posted prices of residual fuel oils increased 4 to 6 cents per barrel, depending on the sulfur content.

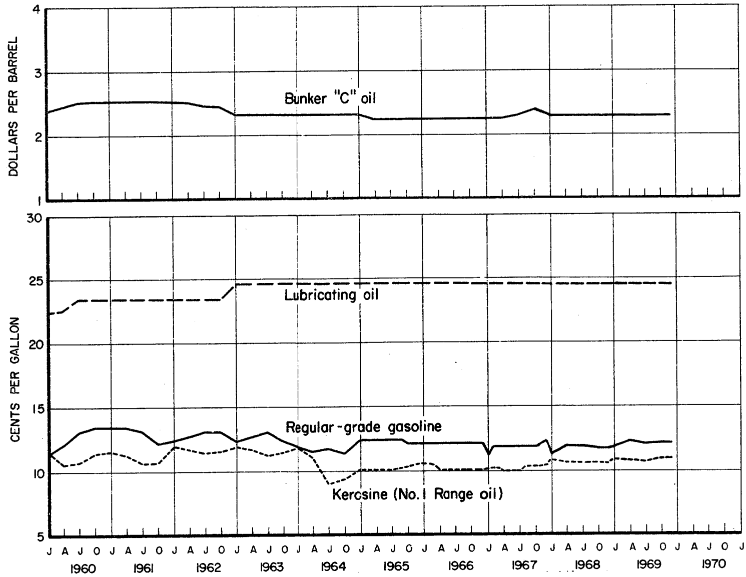

Figure 6.—Posted prices of selected grades of crude petroleum in the United States, by quarters.

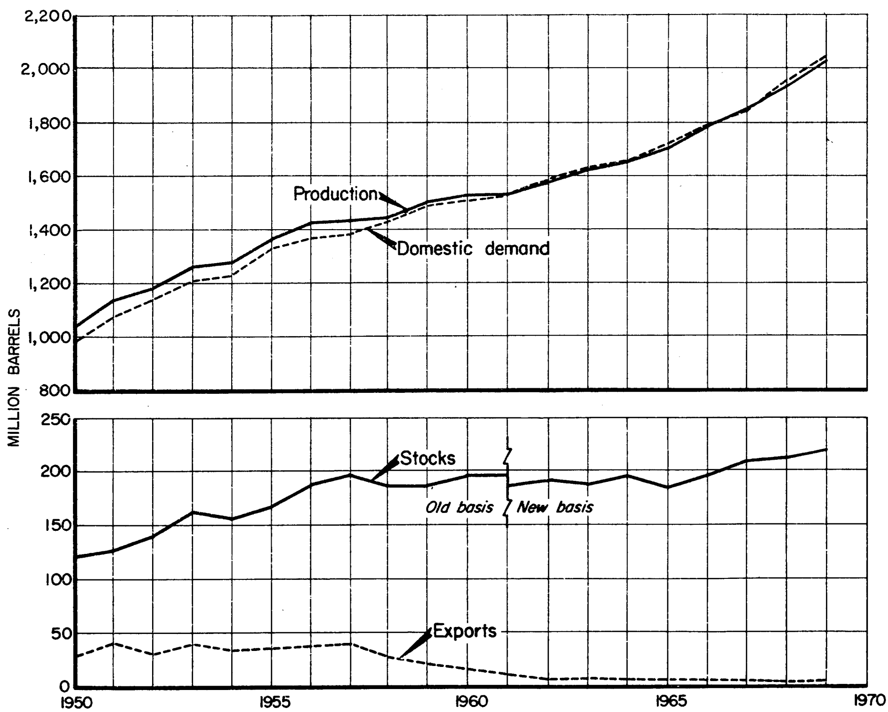

Figure 7.—Prices of Bunker "C" oil at New York Harbor, bright stock at Oklahoma refineries, No. 1 range oil at Chicago district, and regular-grade gasoline at refineries in Oklahoma, by quarters.

FOREIGN TRADE

Foreign trade statistics reported in this section were compiled from two sources. The imports of crude and unfinished oils were obtained from the petroleum refining companies. Imports of refined petroleum products and exports were compiled by the Bureau of the Census.

Total imports of crude oil and refined products in 1969 were 1,154.5 million barrels compared with 1,039.4 million in 1968. Crude oil imports increased 41.5 million barrels for the year, and 33.9 million of this represented additional imports from Canada. Imports of refined products increased 65.0 million barrels in 1969, but the increase was in bonded jet fuels and fuel oils for use as fuel by aircraft and vessels destined for overseas and for No. 4 distillate fuel oil and residual fuel oil imported into PAD district I, all of which are not restricted by import quotas.

On February 17, 1970, the President released the report of the Cabinet task force on oil import controls, culminating 11 months of intensive review. The opinions of the committee were split into two conclusions. They first found the present quota system unacceptable and urged adoption of a tariff system which would cause a reduction of wellhead crude prices in the United States. The other faction recommended retention and reform of the present quota system. The President deferred a decision on the major issues pending consultation with foreign countries and studies by congressional committees.

Exports of crude petroleum and refined products in 1969 totaled 85.4 million barrels, 800,000 barrels above the 1968 level. The principal product exported was petroleum coke, and the foreign market for coke increased 18 percent in 1969. Another product that is showing a good growth rate in the export market is liquefied petroleum gas. Exports of lubricating oils and residual oil continued to decline.

NATIVE ASPHALT

Bituminous Limestone, Sandstone, and Gilsonite.—A total of 1,918,748 short tons of native asphalt and related bitumens was produced in the United States in 1969. The value of this production was $8,561,000. States reporting production in 1969 were Alabama, Missouri, Texas, and Utah. Gilsonite, which is produced in Utah, is transported in a slurry pipeline to a refinery to southern Colorado, where it is refined into finished petroleum products.

Table 2.—Supply and demand of all oils in the United States, by months

(Thousand barrels)

1968	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
New supply:													
Domestic production:													
Crude petroleum	265,680	256,944	274,848	260,730	272,256	261,892	271,176	270,532	255,753	263,142	255,272	261,361	3,169,586
Lease condensate	14,175	13,473	14,043	12,957	13,100	12,427	12,670	12,618	12,219	13,260	13,804	14,710	159,456
Natural gas plant liquids	45,204	43,509	47,104	45,229	47,005	44,497	46,110	45,709	44,570	46,655	46,459	48,260	550,311
Imports: [1]													
Crude petroleum	30,537	28,152	35,506	32,459	37,462	40,212	45,717	43,243	42,474	45,912	40,779	49,870	472,323
Unfinished oils	1,987	2,341	1,838	2,079	2,467	2,529	3,426	2,464	2,703	2,789	2,357	2,370	29,350
Refined products	61,099	51,830	56,685	41,698	35,769	40,446	41,111	34,879	40,537	42,375	41,001	50,266	537,696
Other hydrocarbons and hydrogen refinery input	86	221	286	313	270	269	326	350	380	265	304	307	3,377
Total new supply	418,768	396,470	430,310	395,465	408,329	402,272	420,536	409,795	398,636	414,398	399,976	427,144	4,922,099
Crude petroleum unaccounted for [2]	−553	−218	+760	−403	+2,032	−520	+216	+3,506	−834	+1,609	+1,296	+247	+7,138
Processing gain	9,264	10,514	9,834	7,635	9,717	9,838	9,641	9,247	9,878	10,780	10,183	10,160	116,691
Total supply	427,479	406,766	440,904	402,697	420,078	411,590	430,393	422,548	407,680	426,787	411,455	437,551	5,045,928
Change in stocks, all oils [3]	−53,563	−26,888	+18,073	+16,879	+31,613	+29,710	+31,060	+19,552	+21,914	+9,085	−5,837	−36,137	+55,461
Total disposition of primary supply	481,042	433,654	422,831	385,818	388,465	381,880	399,333	402,996	385,766	417,702	417,292	473,688	4,990,467
Exports: [4]													
Crude petroleum	250	283	41	144	87	226	2	86	76	111	402	94	1,802
Refined products	5,375	6,327	7,732	6,842	7,538	7,460	6,955	6,816	7,386	6,510	6,611	7,190	82,742
Crude losses	343	327	343	330	354	340	358	358	342	349	335	355	4,134
Domestic demand for products:													
Gasoline:													
Motor gasoline	145,478	142,535	152,920	159,744	166,119	163,737	177,559	176,658	156,988	167,649	156,394	159,595	1,925,376
Aviation gasoline	2,564	1,976	2,655	2,973	2,848	2,630	2,962	2,651	2,794	2,455	1,957	2,159	30,624
Total	148,042	144,511	155,575	162,717	168,967	166,367	180,521	179,309	159,782	170,104	158,351	161,754	1,956,000
Jet fuel:													
Naphtha-type	8,907	9,327	10,631	11,351	11,364	10,730	9,368	11,073	10,540	12,960	10,103	10,247	126,601
Kerosine-type	17,193	17,883	17,326	17,915	16,771	18,524	19,947	20,142	19,237	20,064	18,526	19,249	222,777
Total	26,100	27,210	27,957	29,266	28,135	29,254	29,315	31,215	29,777	33,024	28,629	29,496	349,378
Ethane, including ethylene	3,829	3,963	4,080	3,968	4,459	4,465	4,531	4,794	5,010	5,112	5,382	5,559	55,152
Liquefied gases:													
LRG [5] for fuel use	6,853	6,393	5,956	5,219	6,178	5,530	6,179	6,228	5,677	5,370	5,400	6,645	71,628
LRG [5] for chemical use	3,045	2,863	3,179	3,217	3,357	3,179	3,070	3,466	3,101	2,948	2,694	2,973	37,092
LPG [6] for fuel and chemical use	28,802	23,343	19,832	13,388	13,492	12,201	14,314	13,278	13,275	19,454	22,927	27,563	221,869
Total	38,700	32,599	28,967	21,824	23,027	20,910	23,563	22,972	22,053	27,772	31,021	37,181	330,589

See footnotes at end of table.

Table 2.—Supply and demand of all oils in the United States, by months—Continued

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Kerosine	16,256	12,000	9,683	5,562	5,854	4,792	4,300	6,153	6,602	7,819	10,491	13,422	102,934
Distillate fuel oil	119,413	103,365	87,104	61,419	56,704	48,492	45,988	49,624	53,954	62,391	77,902	108,183	874,539
Residual fuel oil	82,930	66,621	62,224	50,176	43,863	47,517	45,752	43,707	48,159	50,865	56,262	70,163	668,239
Petrochemical feedstocks: [7]													
Still gas	875	786	878	792	789	774	765	846	875	864	727	873	9,844
Naphtha −400°	4,996	4,581	3,941	4,631	4,890	4,989	4,207	4,543	4,602	4,827	4,652	4,759	55,618
Other	1,920	2,072	2,377	2,053	2,655	2,008	2,605	2,905	1,764	2,563	1,957	2,595	27,474
Total	7,791	7,439	7,196	7,476	8,334	7,771	7,577	8,294	7,241	8,254	7,336	8,227	92,936
Special naphthas	2,143	2,227	2,367	1,909	2,132	2,360	2,529	2,131	2,409	2,287	2,188	2,325	27,007
Lubricants	3,796	3,853	3,871	4,304	4,534	3,698	4,324	4,059	3,985	4,388	3,755	3,900	48,467
Wax	354	352	378	346	403	339	359	359	378	409	398	285	4,360
Coke	6,692	6,143	6,426	6,435	6,027	6,196	6,503	6,644	6,273	6,796	6,044	6,140	76,319
Asphalt	4,019	4,190	5,478	9,314	13,094	16,194	19,934	19,955	17,478	17,030	8,999	5,466	141,151
Road oil	141	184	240	314	520	917	1,293	1,437	909	668	300	157	7,080
Still gas	13,297	10,486	11,488	11,529	12,735	13,132	13,993	13,629	12,851	12,490	11,696	12,470	149,796
Miscellaneous products	1,571	1,574	1,681	1,943	1,698	1,450	1,536	1,454	1,101	1,323	1,190	1,321	17,842
Total domestic demand	475,074	426,717	414,715	378,502	380,486	373,854	392,018	395,736	377,962	410,732	409,944	466,049	4,901,789
Stocks, all oils:													
Crude oil and lease condensate	244,946	245,271	256,864	262,087	262,021	264,896	265,755	266,368	262,771	266,330	271,587	272,193	272,193
Unfinished oils	87,946	87,806	89,009	93,775	100,065	97,698	97,365	95,819	92,938	95,975	94,609	93,399	93,399
Natural gasoline and plant condensate [8]	5,652	6,467	7,238	6,920	6,727	6,535	6,840	6,884	5,512	5,548	5,290	5,466	5,466
Refined products	552,004	524,116	528,622	535,830	561,412	590,806	621,035	641,476	671,240	673,693	664,223	628,514	628,514
Total	890,548	863,660	881,733	898,612	930,225	959,935	990,995	1,010,547	1,032,461	1,041,546	1,035,709	999,572	999,572
1969 [p]													
New Supply:													
Domestic production:													
Crude petroleum	260,575	236,405	265,690	263,542	276,460	274,644	274,677	267,778	265,774	271,804	266,085	280,562	3,203,996
Lease condensate	14,946	13,574	15,025	13,612	13,562	14,298	13,483	13,296	13,078	13,788	14,282	14,811	167,755
Natural gas plant liquids	48,468	45,169	49,184	47,203	49,017	46,839	48,247	48,578	47,061	49,723	49,112	51,640	580,241
Imports: [1]													
Crude petroleum	35,442	36,537	45,654	43,568	44,137	40,960	43,209	44,887	42,364	45,042	43,775	48,274	513,849
Unfinished oils	2,184	3,583	2,723	2,556	2,459	2,844	2,761	3,520	4,056	2,806	3,724	4,792	38,008
Refined products	66,334	54,002	57,997	48,240	43,958	38,032	42,751	45,899	48,009	46,767	45,045	65,637	602,671
Other hydrocarbons and hydrogen refinery input	275	291	399	363	321	331	473	379	374	337	349	321	4,213
Total new supply	428,224	389,561	436,672	419,084	429,914	417,948	425,601	424,337	420,716	430,267	422,372	466,037	5,110,733
Crude petroleum unaccounted for [2]	+930	−360	−830	+1,237	+1,033	−1,214	+1,512	+73	−1,179	−2,166	−1,063	+224	−1,803
Processing gain	9,665	8,709	9,730	8,814	9,463	9,747	10,315	9,643	11,305	13,344	11,872	10,383	122,990

Total supply	438,819	397,910	445,572	429,135	440,410	426,481	437,428	434,053	430,842	441,445	433,181	476,644	5,231,920
Change in stocks, all oils [3]	−61,248	−31,575	−2,033	+17,408	+28,926	+25,848	+18,156	+10,184	+9,271	+5,511	−4,736	−33,161	−17,449
Total disposition of primary supply	500,067	429,485	447,605	411,727	411,484	400,633	419,272	423,869	421,571	435,934	437,917	509,805	5,249,369
Exports: [4]													
Crude petroleum	-------	220	176	93	216	1	-------	144	83	162	240	101	1,436
Refined products	5,833	6,120	6,914	6,673	7,580	7,493	6,487	8,522	7,556	6,966	6,799	6,973	83,916
Crude losses	334	329	356	342	356	355	369	365	354	356	352	373	4,241
Domestic demand for products:													
Gasoline:													
Motor gasoline	156,446	143,671	157,200	166,124	175,220	170,687	185,857	182,740	169,081	175,228	161,737	172,988	2,016,979
Aviation gasoline	1,999	1,510	2,602	2,500	2,380	2,436	2,502	2,243	1,916	2,012	1,873	1,517	25,490
Total	158,445	145,181	159,802	168,624	177,600	173,123	188,359	184,983	170,997	177,240	163,610	174,505	2,042,469
Jet fuel:													
Naphtha-type	8,400	8,269	11,206	9,030	10,096	9,792	10,478	9,923	8,370	7,293	7,387	8,076	108,320
Kerosine-type	20,568	18,129	19,549	19,774	19,823	21,805	21,383	21,419	22,704	20,833	22,157	25,069	253,213
Total	28,968	26,398	30,755	28,804	29,919	31,597	31,861	31,342	31,074	28,126	29,544	33,145	361,533
Ethane, including ethylene	5,954	5,423	6,008	5,603	6,021	5,580	5,756	6,343	5,877	6,147	6,504	7,000	72,216
Liquefied gases:													
LRG [5] for fuel use	6,116	5,923	5,794	5,180	5,598	6,456	6,480	6,118	6,441	6,138	6,767	7,436	74,447
LRG [5] for chemical use	2,591	2,607	3,232	3,377	3,192	3,185	3,391	3,591	2,681	2,754	2,517	2,443	35,561
LPG [6] for fuel and chemical use	37,435	25,100	23,192	17,393	14,321	14,134	14,765	16,298	18,292	24,021	27,239	31,214	263,404
Total	46,142	33,630	32,218	25,950	23,111	23,775	24,636	26,007	27,414	32,913	36,523	41,093	373,412
Kerosine	15,478	11,858	10,208	5,805	5,528	4,505	5,639	5,161	7,270	7,088	9,257	12,571	100,368
Distillate fuel oil	119,246	96,292	91,079	66,921	58,749	51,635	49,935	50,782	58,191	62,387	82,912	111,975	900,104
Residual fuel oil	82,361	68,121	68,093	58,635	51,762	47,478	48,403	51,307	54,494	58,631	55,534	77,103	721,922
Petrochemical feedstocks: [7]													
Still gas	747	711	909	791	789	877	864	995	794	895	794	819	9,985
Naphtha −400°	4,421	4,272	5,408	4,552	4,650	4,705	4,340	5,392	4,660	5,302	4,767	5,100	57,569
Other	1,846	2,225	1,846	2,201	2,102	2,410	2,481	2,242	2,047	2,518	2,450	2,725	27,093
Total	7,014	7,208	8,163	7,544	7,541	7,992	7,685	8,629	7,501	8,715	8,011	8,644	94,647
Special naphthas	2,594	1,633	2,845	2,639	2,292	2,868	2,515	2,632	2,675	2,511	2,118	2,277	29,599
Lubricants	3,679	3,650	4,030	4,168	4,442	4,118	4,318	4,096	4,077	4,611	3,656	3,896	48,741
Wax	435	441	445	371	468	425	373	342	434	434	338	397	4,903
Coke	6,141	6,142	7,222	6,070	6,475	6,401	7,411	6,518	6,857	6,932	6,878	7,788	80,835
Asphalt	3,891	4,059	5,651	9,283	13,504	16,964	18,412	19,125	19,157	16,708	9,805	6,732	143,291
Road oil	124	47	131	265	663	1,092	1,391	1,690	1,478	1,114	502	259	8,756
Still gas	11,906	11,425	12,293	12,640	13,633	13,929	14,355	14,504	14,469	13,422	14,000	13,787	160,363
Miscellaneous products	1,522	1,308	1,216	1,297	1,624	1,302	1,367	1,377	1,613	1,471	1,334	1,186	16,617
Total domestic demand	493,900	422,816	440,159	404,619	403,332	392,784	412,416	414,838	413,578	428,450	430,526	502,358	5,159,776

See footnotes at end of table.

Table 2.—Supply and demand of all oils in the United States, by months—Continued

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Stocks all oils:													
Crude oil and lease condensate	279,483	265,298	264,178	273,204	281,271	284,544	277,482	267,721	262,528	264,285	264,756	265,227	265,227
Unfinished oils	90,528	93,335	94,411	100,759	105,318	104,081	101,914	97,454	97,818	97,976	95,609	97,819	97,819
Natural gasoline and plant condensate [8]	5,492	6,029	6,235	5,889	6,137	6,236	6,745	7,118	6,453	6,291	5,779	5,704	5,704
Refined products	562,821	542,087	539,892	542,272	558,324	582,037	608,913	632,945	647,710	651,468	649,140	613,373	613,373
Total	938,324	906,749	904,716	922,124	951,050	976,898	995,054	1,005,238	1,014,509	1,020,020	1,015,284	982,123	982,123

p Preliminary.
[1] Bureau of Mines data for crude oil and unfinished oils; U.S. Department of Commerce data for all other imports.
[2] Represents the difference between supply and indicated demand for crude petroleum.
[3] Minus represents withdrawal from stock, which is added to total disposition; plus represents stock increase, which is subtracted from total disposition.
[4] U.S. Department of Commerce data.
[5] Liquefied refinery gas.
[6] Liquefied petroleum gas.
[7] Produced at petroleum refineries. Data for LRG for petrochemical feedstocks are included with those for "Liquefied gases."
[8] Includes isopentane.

Table 3.—Estimates of proved crude oil reserves in the United States on December 31, by States [1]

(Million barrels)

State	1965	1966	1967	1968	1969
Eastern States:					
Illinois	371	362	336	314	272
Indiana	57	48	47	40	41
Kentucky	108	101	94	80	73
Michigan	53	71	63	55	52
New York	12	10	15	13	12
Ohio	101	101	114	132	127
Pennsylvania	77	73	63	59	55
West Virginia	55	57	56	54	53
Total	834	823	788	747	685
Central and Southern States:					
Alabama	66	85	79	73	67
Arkansas	201	181	176	159	127
Kansas	752	726	625	601	566
Louisiana [2]	5,246	5,408	5,456	5,608	5,689
Mississippi	360	374	357	326	360
Nebraska	71	57	63	55	47
New Mexico	895	1,025	926	865	840
North Dakota	395	321	290	287	235
Oklahoma	1,517	1,518	1,459	1,395	1,390
Texas [2]	14,303	14,077	14,494	13,810	13,063
Total	23,806	23,772	23,925	23,179	22,384
Mountain States:					
Colorado	327	344	340	420	401
Montana	274	282	308	345	276
Utah	197	213	201	180	195
Wyoming	1,169	1,073	1,044	1,101	997
Total	1,967	1,912	1,893	2,046	1,869
Pacific Coast States:					
Alaska	160	322	381	[3] 373	432
California [2]	4,567	4,608	4,369	4,341	4,243
Total	4,727	4,930	4,750	4,714	4,675
Other States [4]	18	15	21	21	19
Total United States	31,352	31,452	31,377	30,707	29,632

[1] From reports of Committee of Petroleum Reserves, American Petroleum Institute. Includes crude oil that may be extracted by present methods from fields completely developed or sufficiently explored to permit reasonably accurate calculations. The change in reserves during any year represents total new discoveries, extensions, and revisions, minus production.

[2] Includes offshore reserves. The December 31, 1969, total for Louisiana and Texas was 2,768.

[3] Does not give credit to reserves associated with 1968 discoveries on the North Slope of Alaska. As of December 31, 1969, the API Committee did not have sufficient information to make a meaningful determination of proved reserves associated with these discoveries.

[4] Includes Arizona, Florida, Missouri, Nevada, South Dakota, Tennessee, and Virginia.

Table 4.—Supply and disposition of crude petroleum (including lease condensate) in the United States

(Thousand barrels)

Supply and disposition	1965	1966	1967	1968	1969 p
Supply:					
Production	2,848,514	3,027,763	3,215,742	3,329,042	3,371,751
Imports [1]	452,040	447,120	411,649	472,323	513,849
Total new supply	3,300,554	3,474,883	3,627,391	3,801,365	3,885,600
Stock changes: [2]					
Domestic crude	−8,404	+17,863	+7,799	+17,653	−4,668
Foreign crude	−1,364	+239	+2,780	+5,570	−2,298
Unaccounted for [3]	---	---	---	+7,138	−1,803
Disposition by use:					
Runs of domestic crude	2,847,821	3,000,789	3,174,004	3,308,044	3,364,360
Runs of foreign crude	453,021	446,404	408,590	466,316	515,738
Exports [4]	1,097	1,477	26,541	1,802	1,436
Transfers:					
Distillate	773	752	730	712	654
Residual	3,950	3,551	3,671	4,272	4,334
Losses	3,660	3,808	3,276	4,134	4,241
Total disposition by use	3,310,322	3,456,781	3,616,812	3,785,280	3,890,763

p Preliminary except for crude petroleum production.
[1] Bureau of Mines data.
[2] Minus represents withdrawal from stock; plus represents stock increase.
[3] Represents the difference between supply and indicated demand for crude petroleum beginning with 1968.
[4] U.S. Department of Commerce data.

Table 5.—Supply and disposition of crude petroleum (including lease condensate) in the United States, by months

(Thousand barrels)

Supply and disposition	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1968													
New supply:													
Production	279,855	270,417	288,891	273,687	285,356	274,319	283,846	283,150	267,972	276,402	269,076	276,071	3,329,042
Imports [1]	30,537	28,152	35,506	32,459	37,462	40,212	45,717	43,243	42,474	45,912	40,779	49,870	472,323
Total new supply	310,392	298,569	324,397	306,146	322,818	314,531	329,563	326,393	310,446	322,314	309,855	325,941	3,801,365
Change in stocks, end of period: [2]													
Domestic crude	−1,277	+1,101	+9,324	+4,306	−844	+2,825	−782	+762	−1,780	+5	+7,863	−3,850	+17,653
Foreign crude [3]	−2,747	−776	+2,269	+917	+778	+50	+1,641	−149	−1,817	+3,554	−2,606	+4,456	+5,570
Unaccounted for [3]	−553	−218	+760	−403	+2,032	−520	+216	+3,506	−834	+1,609	+1,296	+247	+7,138
Disposition by use:													
Runs of domestic crude	279,642	268,151	279,536	268,027	287,427	270,038	284,115	285,153	268,029	277,183	261,387	279,356	3,308,044
Runs of foreign crude	33,230	28,879	33,235	31,482	36,653	40,131	44,011	43,307	44,342	42,304	43,374	45,368	466,316
Exports [4]	250	283	41	144	87	226	2	86	76	111	402	94	1,802
Transfers:													
Distillate	58	57	65	61	54	58	61	62	60	62	55	59	712
Residual	340	329	344	476	341	343	373	320	360	355	341	350	4,272
Losses	343	327	343	330	354	340	358	358	342	349	335	355	4,134
Total disposition by use	313,863	298,026	313,564	300,520	324,916	311,136	328,920	329,286	313,209	320,364	305,894	325,582	3,785,280
1969 p													
New supply:													
Production	275,521	249,979	280,715	277,154	290,022	288,942	288,160	281,074	278,852	285,592	280,367	295,373	3,371,751
Imports [1]	35,442	36,537	45,654	43,568	44,137	40,960	43,209	44,887	42,364	45,042	43,775	48,274	513,849
Total new supply	310,963	286,516	326,369	320,722	334,159	329,902	331,369	325,961	321,216	330,634	324,142	343,647	3,885,600
Change in stocks, end of period: [2]													
Domestic crude	+13,671	−13,127	−4,316	+8,070	+5,586	+4,027	−6,002	−8,417	−2,972	+547	+80	−1,815	−4,668
Foreign crude	−6,381	−1,058	+3,196	+956	+2,481	−754	−1,060	−1,344	−2,221	+1,210	+391	+2,286	−2,298
Unaccounted for [3]	+930	−360	−830	+1,237	+1,033	−1,214	+1,512	+73	−1,179	−2,166	−1,063	+224	−1,803
Disposition by use:													
Runs of domestic crude	262,052	261,730	283,299	269,496	284,561	282,944	294,965	288,632	279,789	282,070	278,253	296,569	3,364,360
Runs of foreign crude	41,791	37,584	42,419	42,583	41,597	41,718	44,202	46,237	44,574	43,705	43,373	45,955	515,738
Exports [4]	-------	220	176	93	216	1	-------	144	83	162	240	101	1,436
Transfers:													
Distillate	55	53	60	54	50	52	54	54	53	57	56	56	654
Residual	371	425	349	365	345	345	353	363	377	361	334	346	4,334
Losses	334	329	356	342	356	355	369	365	354	356	352	373	4,241
Total disposition by use	304,603	300,341	326,659	312,933	327,125	325,415	339,943	335,795	325,230	326,711	322,608	343,400	3,890,763

p Preliminary except for crude petroleum production.
[1] Bureau of Mines data.
[2] Minus represents withdrawal from stocks; plus represents stock increase.
[3] Represents the difference between supply and indicated demand for crude petroleum.
[4] U.S. Department of Commerce.

Table 6.—Production of crude petroleum (including lease condensate) in the United States, by States and months

(Thousand barrels)

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1968													
Alabama	636	590	628	636	635	616	627	632	638	670	654	673	7,635
Alaska	4,612	4,459	5,351	5,254	5,775	5,910	6,051	6,008	5,434	5,650	5,736	5,964	66,204
Arizona	368	340	326	304	293	252	257	258	254	253	236	229	3,370
Arkansas	1,765	1,603	1,715	1,654	1,700	1,615	1,600	1,593	1,530	1,602	1,522	1,565	19,464
California:													
South	13,659	12,868	13,948	13,313	14,154	13,675	14,044	14,069	13,638	14,173	13,839	14,395	165,775
Central Coastal	5,444	5,149	5,472	5,184	5,352	5,208	5,401	5,498	5,329	5,555	5,297	5,357	64,246
East Central	12,348	11,724	12,462	11,963	12,319	11,880	12,226	12,238	11,693	12,101	11,706	11,966	144,626
North	64	62	65	68	71	71	65	68	70	91	80	74	849
Total California	31,515	29,803	31,947	30,528	31,896	30,834	31,736	31,873	30,730	31,920	30,922	31,792	375,496
Colorado	2,747	2,677	2,840	2,747	2,688	2,628	2,710	2,659	2,532	2,585	2,471	2,653	31,937
Florida	117	109	120	119	122	121	125	124	124	136	130	127	1,474
Illinois	4,778	4,464	4,757	4,809	4,872	4,618	4,976	4,857	4,497	4,786	4,437	4,540	56,391
Indiana	725	671	764	750	750	711	739	734	708	728	702	710	8,692
Kansas	8,163	7,737	8,120	8,099	8,027	7,751	8,041	7,837	7,797	7,914	7,507	7,512	94,505
Kentucky	1,194	1,153	1,181	1,225	1,216	1,126	1,194	1,156	1,137	1,203	1,116	1,135	14,036
Louisiana:													
Gulf Coast	63,320	63,258	66,069	60,092	66,026	63,400	65,197	66,240	62,054	63,112	62,511	65,276	766,555
Rest of State	4,382	4,208	4,455	4,187	4,344	4,126	4,278	4,314	4,029	4,232	4,122	4,194	50,871
Total Louisiana	67,702	67,466	70,524	64,279	70,370	67,526	69,475	70,554	66,083	67,344	66,633	69,470	817,426
Michigan	1,132	1,040	1,104	1,110	1,111	1,048	1,117	1,085	1,044	1,126	1,037	1,020	12,974
Mississippi	4,861	4,609	4,964	4,757	4,961	4,786	4,939	4,979	4,860	5,041	4,886	5,065	58,708
Missouri	7	6	7	5	5	5	5	5	5	5	5	5	65
Montana	3,457	3,200	3,949	3,897	4,273	4,348	4,480	4,429	4,096	4,149	4,099	4,083	48,460
Nebraska	1,134	1,079	1,166	1,105	1,131	1,088	1,114	1,093	1,062	1,087	1,077	1,047	13,183
Nevada	29	25	24	22	18	19	18	16	28	24	24	24	271
New Mexico:													
Southeastern	9,834	9,263	10,034	9,678	9,988	9,528	9,942	10,005	9,764	10,237	9,862	10,034	118,169
Northwestern	969	889	930	878	880	839	823	821	788	821	850	893	10,381
Total New Mexico	10,803	10,152	10,964	10,556	10,868	10,367	10,765	10,826	10,552	11,058	10,712	10,927	128,550
New York	136	124	130	125	132	125	132	165	120	122	109	112	1,532
North Dakota	2,120	2,101	2,235	2,031	2,193	2,067	2,114	2,088	2,039	2,106	1,965	1,981	25,040
Ohio	831	858	896	959	923	904	953	1,009	964	1,036	957	914	11,204
Oklahoma	18,571	17,806	19,200	18,689	18,832	18,393	18,876	19,207	18,251	18,725	18,208	18,865	223,623
Pennsylvania	404	368	367	318	326	310	334	344	334	356	344	355	4,160
South Dakota	16	16	16	16	17	17	16	15	15	16	14	13	187
Tennessee	-------	1	-------	1	-------	1	-------	1	-------	1	-------	1	6
Texas:													
District 01	1,581	1,513	1,647	1,558	1,609	1,560	1,598	1,609	1,545	1,597	1,560	1,567	18,944
District 02	6,020	5,962	6,332	5,864	5,940	5,640	5,922	5,774	5,381	5,497	5,399	5,638	69,369
District 03	13,243	12,981	13,961	13,020	13,278	12,727	13,322	12,854	11,879	12,291	11,830	12,193	153,579
District 04	8,907	8,605	9,166	8,640	8,621	8,145	8,456	8,296	7,737	7,950	7,770	7,886	100,179

District 05	1,432	1,390	1,466	1,353	1,403	1,357	1,432	1,403	1,289	1,345	1,351	1,396	16,617
District 06, except East Texas	4,663	4,598	5,028	4,841	4,970	4,726	4,984	4,853	4,421	4,649	4,472	4,523	56,728
East Texas	4,621	4,628	4,923	4,530	4,555	4,398	4,584	4,423	4,028	4,138	4,004	4,236	53,068
District 07B	3,233	3,078	3,273	3,123	3,224	3,084	3,238	3,191	3,031	3,158	3,017	3,123	37,773
District 07C	4,632	4,422	4,748	4,403	4,827	4,254	4,333	4,242	4,009	4,127	3,981	4,021	51,999
District 08	25,013	24,004	25,506	24,321	24,755	23,707	24,549	24,276	23,186	23,973	23,217	23,281	289,788
District 08A	16,083	15,736	16,786	15,947	16,291	15,610	16,358	16,136	15,036	15,563	15,057	15,176	189,779
District 09	5,443	5,131	5,448	5,250	5,334	5,064	5,234	5,183	4,991	5,130	4,994	5,040	62,242
District 10	2,899	2,748	2,911	2,824	2,869	2,708	2,805	2,770	2,662	2,755	2,681	2,683	33,315
Total Texas	97,770	94,796	101,195	95,674	97,676	92,980	96,815	95,010	89,195	92,173	89,333	90,763	1,133,380
Utah	1,925	1,720	2,006	1,919	1,998	1,888	1,954	1,974	1,945	2,073	2,056	2,046	23,504
Virginia	-------	-------	-------	1	-------	-------	-------	1	-------	-------	-------	1	3
West Virginia	310	277	292	294	259	253	299	300	263	294	241	230	3,312
Wyoming	12,027	11,167	12,103	11,804	12,289	12,012	12,384	12,318	11,735	12,219	11,943	12,249	144,250
Total:													
1968	279,855	270,417	288,891	273,687	285,356	274,319	283,846	283,150	267,972	276,402	269,076	276,071	3,329,042
1967	265,577	241,366	264,854	254,252	259,923	256,174	283,776	292,495	272,845	278,997	269,348	276,135	3,215,742
Daily average, 1968	9,028	9,325	9,319	9,123	9,205	9,144	9,156	9,134	8,932	8,916	8,969	8,906	9,096
Pennsylvania grade (included in United States total)	1,010	934	961	922	895	863	949	1,004	903	972	878	873	11,164
1969													
Alabama	676	576	683	669	674	643	638	602	620	648	631	641	7,701
Alaska	5,479	5,165	5,883	6,032	6,526	6,073	5,985	6,279	6,526	6,764	6,556	6,685	73,953
Arizona	231	206	223	209	209	193	196	201	194	189	193	189	2,433
Arkansas	1,546	1,393	1,536	1,526	1,540	1,478	1,479	1,503	1,472	1,541	1,479	1,556	18,049
California:													
South	14,054	12,983	14,152	13,745	14,622	14,126	14,652	14,587	14,064	14,397	13,977	14,320	169,679
Central Coastal	5,051	4,182	4,893	4,981	5,534	5,422	5,833	5,993	5,817	6,110	6,007	6,074	65,897
East Central	11,814	10,722	11,970	11,601	11,918	11,485	11,801	11,706	11,161	11,662	11,370	11,662	138,872
North	76	73	77	78	88	71	69	66	67	60	61	57	843
Total California	30,995	27,960	31,092	30,405	32,162	31,104	32,355	32,352	31,109	32,229	31,415	32,113	375,291
Colorado	2,458	2,284	2,396	2,435	2,425	2,344	2,422	2,374	2,363	2,289	2,231	2,273	28,294
Florida	130	117	138	140	144	146	151	144	140	144	172	165	1,731
Illinois	4,405	4,038	4,452	4,342	4,438	4,184	4,282	4,217	4,166	4,214	3,897	4,089	50,724
Indiana	645	627	694	676	643	612	673	656	663	656	627	669	7,841
Kansas	7,453	6,908	7,513	7,441	7,631	7,359	7,518	7,451	7,364	7,393	7,185	7,500	88,716
Kentucky	1,104	1,004	1,123	1,107	1,104	1,059	1,120	1,052	1,077	1,107	1,005	1,062	12,924
Louisiana:													
Gulf Coast	63,903	58,150	67,425	66,249	69,436	68,557	68,301	62,661	66,360	65,805	68,175	71,051	796,073
Rest of State	4,236	3,764	4,126	4,146	4,158	3,977	4,035	4,042	3,954	4,080	3,965	4,047	48,530
Total Louisiana	68,139	61,914	71,551	70,395	73,594	72,534	72,336	66,703	70,314	69,885	72,140	75,098	844,603
Michigan	1,037	978	1,027	1,041	1,008	985	1,056	1,012	1,020	1,048	976	1,025	12,213
Mississippi	4,988	4,619	5,326	5,211	5,420	5,374	5,627	5,536	5,400	5,680	5,451	5,651	64,283
Missouri	6	5	6	5	6	5	6	6	5	6	5	6	67
Montana	3,922	3,488	3,742	3,575	3,796	3,710	3,810	3,735	3,593	3,620	3,455	3,508	43,954
Nebraska	1,061	967	1,064	1,035	1,045	994	1,011	1,016	983	979	960	991	12,106
Nevada	20	20	21	21	22	20	19	20	17	13	10	20	223

See footnotes at end of table.

Table 6.—Production of crude petroleum (including lease condensate) in the United States, by States and months—Continued

(Thousand barrels)

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
New Mexico:													
Southeastern	10,165	9,199	10,000	9,846	10,187	9,922	10,129	10,013	9,842	10,441	10,081	10,353	120,178
Northwestern	836	774	838	770	728	717	695	681	703	766	762	779	9,049
Total New Mexico	11,001	9,973	10,838	10,616	10,915	10,639	10,824	10,694	10,545	11,207	10,843	11,132	129,227
New York	109	98	103	102	103	102	102	99	110	105	101	122	1,256
North Dakota	1,878	1,752	1,971	1,863	1,557	1,952	1,991	1,983	1,933	1,991	1,885	1,947	22,703
Ohio	995	880	1,005	970	935	911	944	913	903	856	822	838	10,972
Oklahoma	19,295	17,529	18,972	18,658	19,022	18,666	18,826	18,947	18,499	19,000	18,690	18,625	224,729
Pennsylvania	339	340	335	368	371	384	402	373	399	403	388	346	4,448
South Dakota	11	11	11	13	17	14	13	15	13	14	13	13	158
Tennessee	-------	1	-------	1	-------	1	-------	1	7	7	7	7	32
Texas:													
District 01	1,568	1,412	1,548	1,507	1,538	1,484	1,529	1,527	1,486	1,528	1,451	1,523	18,101
District 02	5,732	5,157	5,939	6,061	6,578	6,892	6,600	6,429	6,200	6,442	6,169	6,893	75,092
District 03	12,245	10,952	12,520	12,663	13,583	14,231	13,473	13,200	12,607	13,126	12,504	13,959	155,063
District 04	7,976	7,289	8,128	7,927	8,245	8,110	7,999	7,856	7,512	7,783	7,545	7,935	94,305
District 05	1,412	1,270	1,439	1,441	1,492	1,603	1,494	1,480	1,401	1,481	1,412	1,625	17,550
District 06, except East Texas	4,666	4,190	4,773	4,955	5,311	5,685	5,293	5,125	4,939	5,210	5,061	6,307	61,515
East Texas	4,312	3,820	4,442	4,584	5,075	5,590	5,065	4,959	4,711	4,973	4,741	5,641	57,913
District 07B	3,180	2,831	3,211	3,138	3,242	3,280	3,313	3,253	3,140	3,261	3,137	3,174	38,160
District 07C	4,159	3,739	4,171	3,936	4,029	3,911	3,893	3,888	3,772	3,820	3,734	3,890	46,942
District 08	23,983	21,651	24,514	24,029	25,070	24,852	24,711	24,730	23,903	24,911	24,030	25,472	291,856
District 08A	16,201	14,401	15,805	16,125	17,601	18,471	18,013	17,626	17,548	18,245	17,742	19,789	207,567
District 09	5,052	4,524	4,976	4,856	4,987	4,871	4,863	4,813	4,596	4,724	4,554	4,678	57,494
District 10	2,626	2,379	2,574	2,553	2,605	2,522	2,547	2,545	2,464	2,482	2,416	2,504	30,217
Total Texas	93,112	83,615	94,040	93,775	99,356	101,502	98,793	97,431	94,279	97,986	94,496	103,390	1,151,775
Utah	2,022	1,820	1,966	1,966	2,036	1,945	1,974	2,157	1,875	1,964	1,621	1,949	23,295
Virginia	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	1	1
West Virginia	207	244	257	272	270	257	269	253	271	296	235	273	3,104
Wyoming	12,257	11,447	12,747	12,285	13,053	13,752	13,338	13,349	12,992	13,358	12,878	13,489	154,945
Total:													
1969	275,521	249,979	280,715	277,154	290,022	288,942	288,160	281,074	278,852	285,592	280,367	295,373	3,371,751
1968	279,855	270,417	288,891	273,687	285,356	274,319	283,846	283,150	267,972	276,402	269,076	276,071	3,329,042
Daily average, 1969	8,888	8,928	9,055	9,238	9,356	9,631	9,295	9,067	9,295	9,213	9,346	9,528	9,238
Pennsylvania grade (included in United States total)	906	922	953	1,011	1,002	997	1,042	973	1,031	1,085	964	988	11,874

Sources of 1969 data:

Alabama —State Oil and Gas Board of Alabama.
Alaska —Division of Mines and Geology, Alaska Department of Natural Resources.
Arizona —Arizona Oil and Gas Conservation Commission.
Arkansas —Arkansas Oil and Gas Commission.
California —Division of Oil and Gas, Department of Conservation, State of California.
Colorado —Colorado Oil and Gas Conservation Commission.
Florida —Division of Geology, Florida Board of Conservation.
Illinois —Oil and Gas Section, Illinois Geological Survey.
Indiana —Petroleum Section, Indiana Geological Survey.
Kansas —Kansas Corporation Commission.
Kentucky —Kentucky Geological Survey.
Louisiana —Louisiana Department of Conservation.
Michigan —Natural Resources Commission, Department of Natural Resources, State of Michigan.
Mississippi —Mississippi State Oil and Gas Board.
Missouri —Missouri Division of Geological Survey and Water Resources.
Montana —Oil and Gas Conservation Commission of the State of Montana.
Nebraska —Nebraska Oil and Gas Conservation Commission.
Nevada —Nevada Oil and Gas Conservation Commission.
New Mexico —New Mexico Oil Conservation Commission.
New York —Geological Survey, New York State Museum and Science Service.
North Dakota—State Geological Survey of North Dakota.
Ohio —Ohio Oil and Gas Association.
Oklahoma —Oklahoma Tax Commission.
Pennsylvania —Bureau of Topographic and Geologic Survey, State Planning Board Commonwealth of Pennsylvania.
South Dakota—South Dakota Geological Survey.
Tennessee —Division of Geology, Tennessee Department of Conservation.
Texas —Oil and Gas Division, Railroad Commission of Texas.
Utah —Utah Oil and Gas Conservation Commission.
Virginia —Division of Mines and Quarries, Department of Labor and Industry, Commonwealth of Virginia.
West Virginia —Geological and Economic Survey, State of West Virginia.
Wyoming —Wyoming State Board of Equalization, Ad Valorem Tax Division, and the State Oil and Gas Commission.

Table 7.—Percentage of total U.S. crude petroleum produced, by States

State	1965	1966	1967	1968	1969
Texas	35.1	34.9	34.8	34.1	34.2
Louisiana	20.9	22.3	24.1	24.6	25.0
California	11.1	11.4	11.2	11.2	11.1
Oklahoma	7.1	7.4	7.2	6.7	6.7
Wyoming	4.9	4.4	4.2	4.3	4.6
New Mexico	4.1	4.1	3.9	3.8	3.8
Kansas	3.7	3.4	3.1	2.9	2.6
Alaska	.4	.5	.9	2.0	2.2
Mississippi	1.9	1.8	1.8	1.7	1.9
Illinois	2.3	2.0	1.8	1.7	1.5
Montana	1.2	1.2	1.1	1.5	1.3
Colorado	1.2	1.1	1.1	1.0	.8
Utah	.9	.8	.7	.7	.7
North Dakota	.9	.9	.8	.7	.7
Arkansas	.9	.8	.7	.6	.5
Kentucky	.7	.6	.5	.4	.4
Michigan	.5	.5	.4	.4	.4
Nebraska	.6	.5	.4	.4	.4
Other States	1.6	1.4	1.3	1.3	1.2
Total	100.0	100.0	100.0	100.0	100.0

Table 8.—Production and reserves of crude petroleum in leading fields in the United States

(Thousand barrels)

Field [1]	State	Production			Estimated reserves
		1968	1969	Total since discovery [2]	
Wilmington	California	78,253	89,053	324,553	1,276,297
East Texas	Texas	48,460	56,244	3,870,993	2,129,013
Timbalier Bay	Louisiana	35,815	34,458	262,493	97,507
Kelly-Snyder	Texas	27,636	33,723	470,783	717,517
Sho-Vel-Tum	Oklahoma	32,611	33,483	841,161	59,962
Caillou-Island	Louisiana	34,028	32,955	389,839	110,161
Midway-Sunset	California	33,201	32,916	1,056,985	270,000
Wasson	Texas	30,064	32,079	487,048	115,729
Seeligson (all fields)	do	28,938	31,995	378,197	110,381
McArthur River	Alaska	21,308	31,440	53,499	250,000
Bay Marchand, Block 2	Louisiana	29,797	28,763	273,002	327,534
Kern River	California	25,280	25,550	501,777	204,900
West Delta, Block 30	Louisiana	23,473	23,949	192,812	207,188
Grand Isle, Block 16	do	15,592	21,112	117,172	57,828
South Pass, Block 24	do	21,647	20,904	324,144	427,856
South Pass, Block 27	do	21,889	20,548	176,737	134,263
Goldsmith	Texas	18,568	20,293	450,978	41,139
Grand Isle, Block 43	Louisiana	13,756	19,207	57,808	62,192
West Delta, Block 73	do	12,910	18,651	63,390	66,610
Slaughter	Texas	20,256	18,117	399,809	129,191
Panhandle	do	19,296	17,622	1,215,946	430,415
Huntington Beach	California	19,342	17,598	829,715	140,515
Elk Basin	Montana, Wyoming	20,050	17,533	365,724	34,276
Tom O'Connor	Texas	11,620	17,396	350,080	100,593
South Timbalier, Block 135	Louisiana	14,941	17,342	71,341	58,659
Sooner-Trend	Oklahoma	17,062	17,244	102,198	130,000
Sprayberry Trend	Texas	21,170	15,996	289,627	157,684
Main Pass, Block 41	Louisiana	18,272	15,961	61,470	38,530
Hawkins	Texas	14,964	15,941	360,296	154,701
West Ranch	do	13,692	15,441	194,763	47,938
Vacuum	New Mexico	15,306	15,147	190,895	94,105
Garden Island Bay	Louisiana	15,336	15,125	108,118	60,111
West Delta, Block 27	do	15,972	14,805	53,257	60,001
Oregon Basin	Wyoming	12,031	14,795	177,384	41,001
Ward-Estes North	Texas	12,724	14,466	266,302	40,698
Bell Creek	Montana	15,670	13,939	30,581	83,558
Salt Creek	Wyoming	13,343	13,559	483,176	26,824
Swanson River	Alaska	13,620	13,132	101,703	105,056
Hastings, East and West	Texas	12,432	13,051	405,619	224,517
Ship Shoal, Block 208	Louisiana	6,626	12,610	33,217	65,159
Beverly Hills	California	12,780	12,361	45,556	122,591
Golden Trend	Oklahoma	11,961	11,661	346,874	148,126
Lake Washington	Louisiana	13,105	11,623	163,915	137,848
Webster	Texas	9,204	11,428	322,072	127,928
Carpenteria Offshore	California	5,492	11,329	21,213	95,000
Rangely	Colorado	15,344	11,303	436,156	163,844
La Fitte	Louisiana	11,814	11,282	166,961	53,038

See footnotes at end of table.

Table 8.—Production and reserves of crude petroleum in leading fields in the United States—Continued

(Thousand barrels)

Field [1]	State	Production 1968	Production 1969	Production Total since discovery [2]	Estimated reserves
Headlee and North	Texas	10,425	11,115	57,113	101,273
Cote Blanche Bay West	Louisiana	9,720	10,954	84,249	45,061
Cowden, South (Foster, Johnson)	Texas	8,375	10,895	256,749	63,251
Main Pass, Block 69	Louisiana	11,672	10,866	138,332	161,668
Weeks Island	do	9,638	10,535	172,914	64,059
San Ardo	California	14,226	10,521	217,743	99,515
Middle Ground Shoal	Alaska	14,214	10,373	34,672	150,000
West Bay	Louisiana	12,084	10,315	134,534	75,466
Pegasus	Texas	11,219	10,252	117,740	49,260
Cogdell Area	do	7,948	10,070	131,581	65,718
Fairway	do	8,316	10,050	46,198	148,964
Thompson (all fields)	do	8,364	10,030	302,853	42,147
Trading Bay	Alaska	3,082	9,938	13,749	50,000
Conroe	Texas	8,784	9,436	458,920	145,644
Borregas (all fields)	do	10,212	9,409	89,052	55,022
Cowden, North	do	7,987	9,396	225,576	34,424
Yates	do	7,650	9,313	519,526	775,161
Lake Barre	Louisiana	12,696	9,276	141,958	108,042
Sand Hills	Texas	9,231	9,253	163,618	33,382
Granite Point	Alaska	13,119	9,208	29,380	145,672
Sheridan	Texas	5,838	9,199	72,946	37,054
Belridge South	California	8,889	9,045	150,675	72,300
Keystone	Texas	7,945	8,947	242,472	60,528
Van and Van Shallow	do	7,836	8,810	349,697	56,303
Bayou Sale	Louisiana	9,070	8,798	140,302	59,708
Kelsey (all fields)	Texas	7,068	8,708	91,179	35,063
Greater Aneth	Utah	8,891	8,638	220,786	231,214
Diamond M	Texas	8,281	8,633	164,209	330,791
Coalinga	California	9,387	8,575	595,693	68,600
Ventura	do	8,405	8,575	740,673	70,946
Bay St. Elaine	Louisiana	8,912	8,525	112,982	40,018
Dune	Texas	5,694	8,341	77,957	73,508
McElroy	do	7,846	8,334	267,058	82,942
Empire Abo	New Mexico	7,903	8,177	60,489	39,511
Old Ocean	Texas	3,354	8,101	134,895	65,105
Anahuac	do	5,892	7,963	201,434	64,566
Levelland	do	8,491	7,932	182,611	68,085
Means and North	do	6,996	7,894	113,326	16,674
Old Illinois	Illinois	7,538	7,880	658,370	16,630
Vada	New Mexico	1,945	7,758	13,163	40,060
Quarantine Bay	Louisiana	9,017	7,533	123,380	47,620
Dollarhide	Texas	5,705	7,319	88,252	55,127
Clay City	Illinois	6,827	7,220	274,334	25,666
Midland Farms (all fields)	Texas	7,066	7,208	151,147	60,672
Fullerton (all fields)	do	6,884	7,093	210,697	64,303
Postle	Oklahoma	6,210	7,056	26,160	23,834

[1] Fields under 7 million barrels not shown for current year.
[2] Includes revisions, if any.

Table 9.—Well completions in the United States, by quarters [1]

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total Number	Total Percent
1968:						
Oil	2,793	3,567	3,785	4,197	14,342	46.8
Gas [2]	760	790	846	1,059	3,455	11.3
Dry [r]	2,539	2,915	3,427	3,958	12,839	41.9
Total [r]	6,092	7,272	8,058	9,214	30,636	100.0
1969:						
Oil	3,240	3,315	3,501	4,312	14,368	44.6
Gas [2]	852	865	1,049	1,317	4,083	12.7
Dry	2,890	2.910	3.255	4.667	13.722	42.7
Total	6,982	7,090	7,805	10,296	32,173	100.0

[r] Revised. Data by quarters adjusted to agree with annual totals.
[1] Excludes service wells.
[2] Includes condensate wells.

Source: American Association of Petroleum Geologists and American Petroleum Institute, except for 1968, which includes some Bureau of Mines data for California, and 1969 which includes Nevada data.

Table 10.—Well completions in the United States, by States and districts [1]

State and district	1968				1969			
	Oil	Gas [2]	Dry	Total	Oil	Gas [2]	Dry	Total
Alabama	9	1	22	32	10	1	37	48
Alaska	77	7	20	104	38	11	14	63
Arizona	4	------	6	10	9	2	27	38
Arkansas	103	46	173	322	151	40	228	419
California	2,202	76	463	2,741	1,543	59	398	2,000
Colorado	108	50	336	494	158	47	609	814
Florida	3	------	10	13	6	------	7	13
Georgia	------	------	------	------	------	------	2	2
Illinois	544	1	497	1,042	417	5	458	880
Indiana	122	14	201	337	129	7	231	367
Kansas	1,210	90	1,735	3,035	1,271	184	1,522	2,977
Kentucky	383	205	693	1,281	296	142	514	952
Louisiana:								
North	310	143	489	942	309	123	416	848
South	560	210	681	1,451	471	230	763	1,464
Offshore	476	184	388	1,048	372	190	263	825
Total Louisiana	1,346	537	1,558	3,441	1,152	543	1,442	3,137
Michigan	73	28	269	370	73	15	244	332
Mississippi	161	12	506	679	195	16	504	715
Missouri	12	------	4	16	17	------	12	29
Montana	319	40	506	865	186	31	578	795
Nebraska	64	------	221	285	57	1	325	383
Nevada	------	------	r 15	r 15	------	------	2	2
New Mexico:								
West	30	127	45	202	58	237	89	384
East	482	23	190	695	503	26	261	790
Total New Mexico	512	150	235	897	561	263	350	1,174
New York	83	10	13	106	112	12	10	134
North Dakota	49	------	134	183	49	------	203	252
Ohio	726	230	207	1,163	645	395	198	1,238
Oklahoma	1,323	370	1,047	2,740	1,604	397	1,112	3,113
Pennsylvania	472	253	70	795	547	277	72	896
South Dakota	------	------	4	4	------	------	56	56
Tennessee	------	6	20	26	4	7	15	26
Texas:								
Gulf Coast	499	198	722	1,419	517	206	630	1,353
West	1,434	160	610	2,204	1,512	136	605	2,253
East	227	67	289	583	292	56	208	556
Panhandle	187	74	79	340	205	85	93	383
Rest of State	1,432	264	1,372	3,068	1,730	420	1,961	4,111
Total Texas	3,779	763	3,072	7,614	4,256	903	3,497	8,656
Utah	38	5	56	99	47	16	111	174
Vermont	------	------	------	------	------	------	1	1
Virginia	------	------	------	------	1	------	9	10
Washington	------	------	2	2	------	------	------	------
West Virginia	119	522	92	733	135	652	115	902
Wyoming	501	39	652	1,192	699	57	819	1,575
Total United States	14,342	3,455	r 12,839	r 30,636	14,368	4,083	13,722	32,173

r Revised.
[1] Excludes service wells.
[2] Includes condensate wells.

Source: American Association of Petroleum Geologists and American Petroleum Institute, except California for 1968 and Nevada in 1969, which includes some Bureau of Mines data.

Table 11.—Producing oil wells in the United States and average production per well per day, by States

State	Producing oil wells			
	1968		1969	
	Approximate number of oil wells producing Dec. 31	Average production per well per day (barrels) [1]	Approximate number of oil wells producing Dec. 31	Average production per well per day (barrels) [1]
Alabama	[2] 546	38.7	[2] 550	38.5
Alaska	163	1,407.7	183	1,171.2
Arizona	22	438.5	29	261.4
Arkansas	6,445	8.2	6,118	7.9
California:				
South	11,402	39.2	11,178	41.2
Central Coastal	5,616	30.7	5,494	32.5
East Central	24,286	16.4	24,265	15.7
North	56	40.7	60	39.8
Total California	41,360	24.7	40,997	25.0
Colorado	1,825	49.1	1,811	42.6
Illinois	27,236	5.6	26,733	5.1
Indiana	[2] 4,330	5.2	[2] 4,094	5.1
Kansas	45,145	5.6	44,665	5.4
Kentucky	[2] 12,311	3.0	[2] 11,843	2.9
Louisiana:				
Gulf Coast	16,486	125.6	15,745	135.3
Northern	13,780	10.1	13,648	9.7
Total Louisiana	30,266	73.3	29,393	77.6
Michigan	4,273	8.6	3,878	8.2
Mississippi	2,599	62.2	2,548	68.4
Montana	3,385	39.1	3,331	35.9
Nebraska	1,403	25.4	1,305	24.5
New Mexico:				
Southeastern	15,323	21.1	15,522	21.3
Northwestern	1,580	18.2	1,566	15.8
Total New Mexico	16,903	20.9	17,088	20.8
New York	4,201	.9	5,263	.7
North Dakota	2,075	33.1	1,987	30.6
Ohio	15,480	2.0	15,737	1.9
Oklahoma	81,052	7.5	80,952	7.6
Pennsylvania	42,500	.3	37,625	.3
South Dakota	27	18.6	26	16.3
Texas:				
District 01	10,620	4.9	10,584	4.7
District 02	5,863	31.8	5,695	35.6
District 03	12,504	33.1	12,159	34.5
District 04	9,778	27.3	9,269	27.1
District 05	3,159	13.6	3,092	15.4
District 06, except East Texas	6,165	13.9	5,945	27.8
East Texas	15,902	12.9	15,486	10.1
District 07B	13,714	7.4	13,079	7.8
District 07C	8,273	17.2	8,093	15.7
District 08	39,006	20.1	38,047	20.8
District 08A	18,035	28.7	17,693	31.8
District 09	31,276	5.4	30,424	5.1
District 10	13,627	6.6	13,575	6.1
Total Texas	187,922	16.3	183,141	17.0
Utah	875	73.6	843	74.3
West Virginia	13,049	.7	[2] 12,849	.7
Wyoming	8,305	46.8	8,978	49.1
Other States:				
Florida	44	94.8	45	106.6
Missouri	128	1.3	164	1.3
Nevada	13	57.0	11	50.9
Tennessee	[2] 32	.5	[2] 35	2.6
Virginia	5	1.8	5	.5
Total	222	21.7	260	23.4
Total United States	553,920	16.2	542,227	16.9

[1] Based on the average number of wells during the year.
[2] Estimated by Bureau of Mines; all other numbers of producing oil wells furnished by State agencies.

Table 12.—Daily average demand for crude petroleum (including lease condensate) in the United States, by States of origin and months

(Thousand barrels)

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1968													
Alabama	22.7	16.0	20.7	23.4	15.9	20.5	18.3	20.0	31.9	20.1	22.1	18.7	20.8
Alaska	178.6	139.7	154.4	149.5	189.8	238.2	164.4	196.3	180.3	165.8	215.8	186.4	180.0
Arizona	10.7	11.9	11.0	10.4	9.1	8.8	8.5	8.2	8.8	8.3	7.9	7.8	9.3
Arkansas	56.4	55.0	50.4	55.8	55.7	55.5	49.9	51.4	51.4	51.8	54.2	52.5	53.3
California	949.5	929.2	1,038.0	1,079.2	1,076.9	1,035.5	1,046.1	1,029.9	1,080.7	1,033.0	966.5	998.9	1,022.3
Colorado	92.7	84.3	93.7	92.4	79.3	85.9	87.8	95.4	82.2	80.6	80.0	84.4	86.6
Florida	5.5	1.1	6.4	3.0	5.4	2.4	6.5	.7	4.0	3.8	6.3	4.0	4.1
Illinois	180.7	150.7	158.4	124.8	144.9	155.0	156.2	166.8	172.7	159.2	147.9	160.7	156.6
Indiana	24.2	24.3	22.0	22.5	22.7	23.9	24.0	26.4	21.6	22.4	24.1	19.8	23.2
Kansas	276.2	282.9	239.8	257.5	249.1	267.1	242.5	270.6	259.7	255.0	254.7	265.3	259.9
Kentucky	42.8	43.6	32.9	38.9	33.6	30.6	42.5	38.8	37.8	29.2	45.0	39.9	37.9
Louisiana	2,129.4	2,362.3	2,191.9	2,227.7	2,285.7	2,196.3	2,301.5	2,069.5	2,120.9	2,182.8	2,099.2	2,313.2	2,206.4
Michigan	37.1	38.4	34.1	35.3	34.3	34.2	37.3	34.6	30.9	37.1	38.0	37.2	35.7
Mississippi	158.0	147.6	149.3	167.6	153.6	163.7	122.4	153.5	163.3	129.1	189.6	134.7	152.5
Missouri	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
Montana	116.0	120.0	100.8	116.9	135.2	124.6	172.1	145.9	145.0	133.8	133.9	133.3	131.5
Nebraska	39.2	41.2	43.8	20.3	43.4	31.1	45.4	33.4	44.3	31.8	30.8	39.3	37.0
Nevada	.9	.9	.8	.8	.6	.6	.6	.5	.9	.8	.8	.8	.7
New Mexico	360.9	359.6	356.4	320.6	346.4	343.1	340.6	377.1	328.0	367.2	386.2	349.6	353.0
New York	4.4	4.3	4.2	4.2	4.3	4.2	4.3	5.3	4.0	3.9	3.6	3.6	4.2
North Dakota	64.7	70.9	71.4	69.5	64.4	71.1	67.0	69.0	65.7	70.8	71.2	69.9	68.8
Ohio	29.5	27.8	27.1	29.1	31.4	31.2	27.0	32.5	31.4	35.5	35.7	31.1	30.8
Oklahoma	633.4	644.4	602.2	608.4	544.6	604.4	599.7	628.2	597.9	591.8	599.9	603.7	604.7
Pennsylvania	17.8	10.4	12.5	12.3	7.4	10.7	9.4	8.7	12.1	14.0	10.0	17.4	11.9
South Dakota	.5	.6	.5	.6	.5	.6	.5	.5	.5	.5	.5	.4	.5
Tennessee	------	.0	------	.0	------	.0	------	.0	------	.0	------	.0	.0
Texas	3,204.8	3,275.6	3,163.2	3,047.6	3,204.7	3,066.4	3,087.3	3,112.9	2,994.6	3,021.3	2,856.0	3,006.6	3,086.8
Utah	51.3	59.8	61.5	55.5	77.1	57.6	65.5	60.1	65.7	64.3	65.0	72.3	63.0
Virginia	------	------	------	.0	------	------	------	.0	------	------	------	.0	.0
West Virginia	9.8	10.7	7.9	9.7	9.2	8.6	10.0	9.2	9.1	9.0	9.0	9.6	9.3
Wyoming	370.9	373.4	362.8	395.7	406.9	377.8	444.1	463.7	446.1	392.9	353.0	368.4	396.5
Total domestic crude	9,068.8	9,286.8	9,018.3	8,979.4	9,232.3	9,049.8	9,181.6	9,109.3	8,991.7	8,916.0	8,707.1	9,029.7	9,047.5
Foreign crude	1,073.7	997.5	1,072.2	1,051.4	1,183.3	1,338.7	1,421.8	1,399.7	1,476.4	1,366.4	1,446.2	1,465.0	1,275.3
Grand total 1968	10,142.5	10,284.3	10,090.5	10,030.8	10,388.5	10,603.4	10,509.0	10,468.1	10,282.4	10,282.4	10,153.3	10,494.7	10,322.8
Pennsylvania grade (included in total domestic crude above)	38.1	28.7	30.5	32.0	26.4	28.9	30.9	29.4	32.5	32.9	28.2	38.1	31.4
1969													
Alabama	17.5	26.2	18.0	24.9	19.5	21.5	23.1	20.4	18.2	19.4	18.2	27.7	21.2
Alaska	138.5	203.8	191.8	245.8	158.0	186.6	202.0	202.9	177.1	198.5	240.2	183.3	193.8
Arizona	7.5	6.5	6.7	7.1	7.5	5.6	7.2	6.3	6.5	6.6	4.9	8.4	6.7
Arkansas	42.1	62.7	52.3	50.3	39.2	51.3	51.7	48.5	51.4	49.6	49.5	50.4	49.8
California	890.5	1,086.2	1,010.6	1,001.1	1,133.0	1,006.0	1,083.7	1,008.9	1,077.9	1,045.7	1,012.4	1,058.7	1,034.2
Colorado	74.1	76.5	88.4	65.5	91.2	82.6	69.5	101.8	80.7	74.2	61.2	66.6	77.8
Florida	2.5	8.4	3.5	1.4	11.5	------	6.4	5.6	1.8	3.9	6.6	4.3	4.7
Illinois	146.5	132.6	143.7	128.8	126.1	142.7	141.3	130.0	142.2	136.0	138.0	150.5	138.3

Indiana	23.2	24.6	21.9	20.9	19.9	21.7	23.2	21.9	14.0	20.1	23.9	26.4	21.8
Kansas	178.9	284.8	254.4	252.0	220.4	249.7	255.1	245.1	228.3	241.5	248.9	238.0	241.0
Kentucky	32.2	39.7	32.2	38.4	36.4	43.1	39.2	33.9	39.5	32.3	49.2	39.2	37.9
Louisiana	2,131.3	2,337.5	2,244.5	2,326.8	2,325.1	2,377.1	2,369.2	2,214.1	2,339.0	2,249.9	2,453.1	2,449.4	2,317.3
Michigan	33.9	31.9	35.5	33.6	34.9	27.9	35.8	35.5	31.0	33.2	31.7	37.5	33.6
Mississippi	163.3	169.7	167.4	163.7	149.4	217.7	171.2	166.4	193.6	195.4	177.2	176.9	175.9
Missouri	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
Montana	122.3	126.0	112.5	116.9	120.8	134.0	114.1	134.2	133.2	115.7	112.3	114.2	121.3
Nebraska	37.3	32.5	33.1	36.2	27.1	21.5	41.4	35.4	30.3	24.5	42.8	30.8	32.7
Nevada	.6	.7	.6	.6	.8	.6	.6	.6	.7	.5	.3	.6	.6
New Mexico	327.7	390.4	348.7	343.5	383.6	354.8	364.3	340.5	331.3	365.2	336.9	402.5	357.3
New York	3.5	3.5	3.3	3.4	3.3	3.4	3.3	3.2	3.7	3.4	3.4	3.9	3.4
North Dakota	59.2	61.8	64.7	54.2	29.9	68.8	67.5	66.1	66.6	68.4	62.8	66.9	61.4
Ohio	25.7	34.8	33.1	32.9	32.1	25.7	32.1	28.0	33.1	24.0	28.8	28.2	29.8
Oklahoma	626.9	657.5	638.9	593.9	602.4	626.1	602.5	625.2	609.9	608.0	629.7	580.1	616.4
Pennsylvania	12.2	12.0	13.5	12.5	11.6	11.3	11.9	8.9	15.7	15.2	14.5	16.3	13.0
South Dakota	.4	.4	.4	.4	.6	.5	.4	.5	.4	.5	.4	.4	.4
Tennessee	-------	.0	-------	.0	-------	.0	-------	.0	.2	.2	.2	.2	.1
Texas	2,942.8	3,118.5	3,194.3	2,929.0	3,116.3	3,241.1	3,218.1	3,324.6	3,196.6	3,152.0	3,160.0	3,326.5	3,160.7
Utah	57.1	67.2	60.4	64.8	65.0	60.7	77.0	69.8	64.8	56.8	53.5	60.3	63.1
Virginia	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	.0	.0
West Virginia	8.1	7.8	8.3	8.9	8.2	7.9	10.1	9.8	7.0	7.7	9.5	10.2	8.7
Wyoming	340.8	392.6	411.6	411.8	401.4	507.1	467.0	450.1	499.2	446.4	371.9	428.1	427.4
Total domestic crude	8,446.8	9,396.6	9,194.5	8,969.5	9,175.4	9,497.2	9,489.1	9,338.4	9,394.1	9,195.0	9,342.9	9,586.7	9,250.5
Foreign crude	1,349.1	1,342.7	1,369.6	1,420.4	1,343.7	1,390.4	1,428.0	1,491.3	1,486.2	1,413.9	1,446.1	1,483.5	1,414.1
Grand total 1969	9,795.9	10,739.3	10,564.1	10,389.9	10,519.1	10,887.6	10,917.1	10,829.7	10,880.3	10,608.9	10,789.0	11,070.2	10,664.6
Pennsylvania grade (included in total domestic crude above)	33.7	32.3	33.4	32.0	30.5	32.3	32.3	30.5	37.3	33.6	48.3	25.9	33.5

Table 13.—Indicated demand for crude petroleum (including lease condensate) in the United States, by States of origin and months

(Thousand barrels)

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1968													
Alabama	702	465	643	701	493	615	566	621	957	624	662	578	7,627
Alaska	5,537	4,050	4,787	4,485	5,883	7,147	5,097	6,086	5,409	5,141	6,475	5,778	65,875
Arizona	330	344	341	312	282	264	262	254	265	257	238	241	3,390
Arkansas	1,748	1,594	1,561	1,675	1,726	1,666	1,548	1,595	1,541	1,607	1,627	1,628	19,516
California	29,435	26,948	32,177	32,376	33,384	31,066	32,429	31,927	32,421	32,022	28,996	30,967	374,148
Colorado	2,873	2,444	2,904	2,772	2,459	2,576	2,722	2,957	2,467	2,498	2,400	2,617	31,689
Florida	171	33	197	91	167	72	203	23	121	116	188	124	1,506
Illinois	5,601	4,370	4,910	3,745	4,492	4,649	4,841	5,170	5,181	4,936	4,436	4,983	57,314
Indiana	751	705	683	674	704	718	743	817	647	694	723	612	8,471
Kansas	8,561	8,203	7,433	7,725	7,723	8,012	7,516	8,388	7,792	7,905	7,640	8,225	95,123
Kentucky	1,327	1,265	1,019	1,166	1,041	919	1,319	1,202	1,133	905	1,350	1,237	13,883
Louisiana	66,010	68,506	67,950	66,832	70,858	65,889	71,346	64,153	63,628	67,668	62,976	71,708	807,524
Michigan	1,149	1,115	1,057	1,058	1,063	1,026	1,157	1,073	927	1,149	1,140	1,153	13,067
Mississippi	4,899	4,279	4,629	5,028	4,761	4,912	3,794	4,757	4,898	4,008	5,687	4,175	55,822
Missouri	7	7	6	5	5	6	5	5	5	5	5	5	66
Montana	3,597	3,480	3,124	3,508	4,191	3,737	5,336	4,522	4,349	4,147	4,017	4,132	48,140
Nebraska	1,216	1,194	1,359	609	1,344	933	1,408	1,036	1,330	987	925	1,217	13,558
Nevada	29	25	24	22	18	19	18	16	28	24	24	24	271
New Mexico	11,189	10,429	11,047	9,618	10,739	10,292	10,560	11,689	9,841	11,383	11,586	10,836	129,209
New York	136	124	130	125	132	125	132	165	120	122	109	112	1,532
North Dakota	2,006	2,056	2,213	2,086	1,998	2,132	2,077	2,140	1,970	2,195	2,136	2,168	25,177
Ohio	915	807	840	873	973	987	836	1,006	942	1,101	1,070	964	11,264
Oklahoma	19,636	18,689	18,669	18,252	16,883	18,131	18,591	19,473	17,937	18,347	17,998	18,716	221,322
Pennsylvania	550	301	389	370	228	322	291	271	363	433	301	540	4,359
South Dakota	16	16	16	16	17	17	16	15	15	16	14	13	187
Tennessee	-------	1	-------	1	-------	1	-------	1	-------	1	-------	1	6
Texas	99,350	94,992	98,058	91,428	99,347	91,992	95,707	96,500	89,838	93,659	85,681	93,205	1,129,757
Utah	1,591	1,735	1,907	1,665	2,389	1,728	2,031	1,863	1,970	1,993	1,949	2,242	23,063
Virginia	-------	-------	-------	1	-------	-------	-------	1	-------	-------	-------	1	3
West Virginia	303	309	246	292	285	257	311	286	273	279	269	298	3,408
Wyoming	11,497	10,830	11,248	11,870	12,615	11,334	13,766	14,376	13,384	12,180	10,591	11,421	145,112
Total domestic crude	281,132	269,316	279,567	269,381	286,200	271,494	284,628	282,388	269,752	276,397	261,213	279,921	3,311,389
Foreign crude	33,284	28,928	33,237	31,542	36,684	40,162	44,076	43,392	44,291	42,358	43,385	45,414	466,753
Grand total 1968	314,416	298,244	312,804	300,923	322,884	311,656	328,704	325,780	314,043	318,755	304,598	325,335	3,778,142
Daily average:													
Domestic crude	9,069	9,287	9,018	8,979	9,232	9,050	9,182	9,109	8,992	8,916	8,707	9,030	9,048
Domestic and foreign crude	10,142	10,284	10,090	10,131	10,416	10,389	10,603	10,509	10,468	10,282	10,153	10,495	10,323
Pennsylvania grade (included in total domestic above)	1,182	833	947	959	818	868	957	912	974	1,021	846	1,180	11,497
1969													
Alabama	541	733	557	747	605	644	716	633	547	600	547	859	7,729
Alaska	4,295	5,705	5,946	7,374	4,898	5,599	6,262	6,289	5,312	6,155	7,207	5,681	70,723
Arizona	233	183	207	213	232	167	224	196	194	205	147	261	2,462
Arkansas	1,305	1,756	1,621	1,508	1,214	1,538	1,602	1,502	1,541	1,537	1,485	1,561	18,170
California	27,605	30,414	31,329	30,033	35,122	30,179	33,595	31,275	32,338	32,417	30,373	32,818	377,498

Colorado	2,297	2,142	2,741	1,966	2,828	2,477	2,154	3,156	2,422	2,301	1,836	2,064	28,384
Florida	77	234	108	42	358	-------	199	174	53	122	196	134	1,697
Illinois	4,542	3,713	4,454	3,865	3,910	4,282	4,381	4,030	4,266	4,215	4,140	4,666	50,464
Indiana	720	690	680	626	616	650	719	678	420	622	715	819	7,955
Kansas	5,546	7,973	7,886	7,559	6,832	7,491	7,909	7,597	6,849	7,486	7,468	7,378	87,974
Kentucky	997	1,112	999	1,151	1,127	1,292	1,216	1,051	1,186	1,000	1,475	1,215	13,821
Louisiana	66,071	65,451	69,581	69,805	72,079	71,313	73,446	68,687	70,171	69,748	73,594	75,932	845,828
Michigan	1,051	893	1,101	1,007	1,083	836	1,108	1,101	931	1,030	952	1,164	12,257
Mississippi	5,064	4,751	5,189	4,912	4,631	6,532	5,307	5,159	5,807	6,057	5,316	5,485	64,210
Missouri	6	5	6	5	6	5	6	6	5	6	5	6	67
Montana	3,790	3,528	3,486	3,508	3,744	4,022	3,537	4,161	3,996	3,586	3,369	3,541	44,268
Nebraska	1,156	911	1,027	1,086	839	646	1,283	1,096	908	759	1,284	955	11,950
Nevada	20	20	19	18	24	17	20	19	21	14	10	18	220
New Mexico	10,159	10,931	10,809	10,304	11,892	10,643	11,293	10,554	9,941	11,322	10,108	12,476	130,432
New York	109	98	103	102	103	102	102	99	110	105	101	122	1,256
North Dakota	1,884	1,731	2,006	1,625	927	2,065	2,092	2,050	1,998	2,120	1,883	2,075	22,406
Ohio	796	975	1,027	986	994	770	995	869	994	745	863	873	10,887
Oklahoma	19,433	18,411	19,805	17,817	18,675	18,784	18,677	19,381	18,293	18,849	18,890	17,982	224,997
Pennsylvania	379	337	420	376	360	339	368	276	471	472	435	504	4,737
South Dakota	11	11	11	13	17	14	13	15	13	14	13	13	158
Tennessee	-------	1	-------	1	-------	1	-------	1	7	7	7	7	32
Texas	91,228	87,317	99,024	87,869	96,605	97,233	99,762	103,063	95,898	97,711	94,822	103,123	1,153,655
Utah	1,770	1,881	1,873	1,945	2,016	1,822	2,387	2,165	1,944	1,762	1,604	1,869	23,038
Virginia	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	1	1
West Virginia	251	217	257	267	255	239	313	305	211	240	286	316	3,157
Wyoming	10,564	10,982	12,759	12,354	12,444	15,213	14,476	13,953	14,977	13,838	11,156	13,270	155,986
Total domestic crude	261,850	268,106	285,031	269,084	284,436	284,915	294,162	289,491	281,824	285,045	280,287	297,188	3,376,419
Foreign crude	41,823	37,595	42,458	42,612	41,656	41,714	44,269	46,231	44,585	43,832	43,384	45,988	516,147
Grand total 1969	303,673	300,701	327,489	311,696	326,092	326,629	338,431	335,722	326,409	328,877	323,671	343,176	3,892,566
Daily average:													
Domestic crude	8,447	9,396	9,194	8,970	9,175	9,497	9,489	9,339	9,394	9,195	9,343	9,587	9,251
Domestic and foreign crude	9,796	10,739	10,564	10,390	10,519	10,888	10,917	10,830	10,880	10,609	10,789	11,070	10,665
Pennsylvania grade (included in total domestic above)	1,044	903	1,035	960	944	968	1,001	946	1,118	1,043	1,448	804	12,214

Table 14.—Refinery receipts of domestic

(Thousand

Receiving district and State	Total domestic receipts	Intrastate receipts	Interstate receipts from— Ala. and Miss.	Ark.	Calif., Nev., Alaska	Colo.	N.Y. and Fla.	Ill.
District I:								
Delaware, Maryland	6,384	---	---	---	---	---	1,840	---
Florida, Georgia Virginia	1,638	---	1,405	---	---	---	---	---
New Jersey	78,849	---	13,316	---	---	---	---	---
New York	2,480	---	---	---	---	---	---	160
Pennsylvania:								
East	95,975	---	1,324	---	---	---	---	---
West	17,715	5,489	---	---	---	42	936	469
West Virginia	2,864	1,575	---	---	---	---	---	---
Total	205,905	7,064	16,045	---	---	42	2,776	629
District II:								
Illinois	243,734	21,025	1,718	---	---	887	---	---
Indiana	184,183	6,812	---	---	---	1,156	---	2,150
Kansas	136,717	77,849	---	---	---	1,113	---	---
Kentucky, Tennessee	57,330	8,464	1,312	---	---	---	[1] 12	11,903
Michigan	39,473	11,640	---	---	---	---	---	3,580
Minnesota, Wisconsin	6,556	---	---	---	---	---	---	---
Missouri, Nebraska	28,641	---	---	---	---	---	---	---
North Dakota	16,938	16,048	---	---	---	---	---	---
Ohio:								
East	22,728	5,983 (East and West)	1,323	---	---	2,528	---	2,832
West	118,212		3,621	---	---	3,794	---	15,155
Oklahoma	157,985	114,233	---	---	---	1,488	---	---
Total	1,012,497	262,054	7,974	---	---	10,966	12	35,620
District III:								
Alabama	8,083	1,150	3,335	---	---	---	---	---
Arkansas	30,312	16,516	---	---	---	---	---	---
Louisiana	423,942	361,014	23,459	200	---	---	---	---
Mississippi	59,593	12,537	---	---	---	---	---	---
New Mexico	14,305	14,184	---	---	121	---	---	---
Texas	1,018,207	766,763	1,078	---	---	---	---	---
Total	1,554,442	1,172,164	27,872	200	121	---	---	---
District IV:								
Colorado	13,265	1,680	---	---	---	---	---	---
Montana	29,328	12,831	---	---	---	---	---	---
Utah	39,375	10,172	---	---	150	16,841	---	---
Wyoming	46,386	45,279	---	---	---	671	---	---
Total	128,354	69,962	---	---	150	17,512	---	---
District V:								
California	450,390	375,767	---	---	[4] 59,811	72	---	---
Other States[3]	13,841	7,905	---	---	5,936	---	---	---
Total	464,231	383,672	---	---	65,747	72	---	---
Total United States	3,365,429	1,894,916	51,891	200	66,018	28,592	2,788	36,249
Daily average	9,220	5,192	142	1	181	78	8	99

[1] Oil from Virginia.
[2] Includes 12,000 barrels from Tennessee.

crude oil, by state and district in 1969

barrels)

Interstate receipts from—												
Ind. and Mich.	Kans.	Ohio and Ky.	La.	Mont.	Nebr., N. Dak., S. Dak.	N. Mex.	Okla.	Texas	Utah	W. Va.	Wyo.	Total interstate receipts
------	------	------	266	------	------	------	------	4,278	------	------	------	6,384
------	------	------	------	------	------	------	------	233	------	------	------	1,638
------	------	------	50,009	------	------	------	------	15,524	------	------	------	78,849
------	------	3	650	295	------	------	1,372	------	------	------	------	2,480
------	------	------	43,936	------	------	232	------	50,483	------	------	------	95,975
------	16	3,296	------	4,470	59	------	1,327	------	------	1,611	------	12,226
------	------	1,289	------	------	------	------	------	------	------	------	------	1,289
------	16	4,588	94,861	4,765	59	232	2,699	70,518	------	1,611	------	198,841
436	2,966	------	40,966	1,625	1,593	21,036	31,276	109,462	------	------	10,744	222,709
195	13,328	4	10,789	10,478	3,954	20,584	30,607	50,568	------	------	33,558	177,371
------	------	------	------	1,621	1,579	6,706	16,568	17,423	------	------	13,858	58,868
------	------	[2] 80	35,389	------	------	------	------	------	------	------	170	48,866
------	------	------	------	------	------	------	------	14,418	------	------	9,835	27,833
------	------	------	------	------	6,556	------	------	------	------	------	------	6,556
------	1,659	------	------	------	766	7,828	3,588	7,808	------	------	6,992	28,641
------	------	------	------	890	------	------	------	------	------	------	------	890
------	1,018	------	5,050	------	------	------	1,736	------	------	------	2,279	16,766
------	353	------	44,664	42	725	1,575	4,101	38,416	------	------	5,745	118,191
------	3,624	------	------	------	------	3,672	------	33,496	1,472	------	------	43,752
631	22,948	84	136,858	14,656	15,173	61,401	87,876	271,591	1,472	------	83,181	750,443
------	------	------	3,598	------	------	------	------	------	------	------	------	6,933
------	------	------	3,723	------	------	------	------	10,073	------	------	------	13,796
------	------	------	------	------	------	37	35	39,197	------	------	------	62,928
------	------	------	47,056	------	------	------	------	------	------	------	------	47,056
------	------	------	------	------	------	------	------	------	------	------	------	121
------	1	------	196,134	------	------	49,770	1,676	------	2,785	------	------	251,444
------	1	------	250,511	------	------	49,807	1,711	49,270	2,785	------	------	382,278
------	------	------	------	2,754	------	1	------	------	18	------	8,812	11,585
------	------	------	------	------	------	------	------	------	------	------	16,497	16,497
------	------	------	------	------	------	56	------	------	------	------	12,156	29,203
------	------	------	------	429	7	------	------	------	------	------	------	1,107
------	------	------	------	3,183	7	57	------	------	18	------	37,465	58,392
------	------	------	------	------	------	3,601	------	339	10,800	------	------	74,623
------	------	------	------	------	------	------	------	------	------	------	------	5,936
------	------	------	------	------	------	3,601	------	339	10,800	------	------	80,559
631	22,965	4,672	482,230	22,604	15,239	115,098	92,286	391,718	15,075	1,611	120,646	1,470,513
2	63	13	1,321	62	42	315	253	1,073	41	4	331	4,029

[3] Alaska, Hawaii, Oregon, and Washington.
[4] Includes 2,216,000 barrels from Arizona.

Table 15.—Crude runs to stills and refinery receipts of crude oil by origin of the crude and method of transportation in 1969

(Thousand barrels)

District and State	Crude runs to stills	Refinery fuel use and losses	Refinery receipts of domestic crude— By State of origin of domestic crude	Change in refinery stocks	By receiving State and method of transportation: Intrastate: Pipelines	Intrastate: Tank cars and trucks	Intrastate: Tankers and barges	Interstate: Pipelines	Interstate: Tank cars and trucks	Interstate: Tankers and barges	Refinery receipts of foreign crude: Pipelines	Refinery receipts of foreign crude: Tankers and barges
District I:												
Delaware, Maryland	38,218	1	------	−115	------	------	------	------	------	6,384	------	31,720
Florida, Georgia, Virginia	18,022	3	1,852	−617	------	------	------	------	439	1,199	------	15,770
New Jersey	175,079	90	------	−1,754	------	------	------	------	------	78,849	------	94,566
New York	28,395	------	936	+50	------	------	------	2,480	------	------	25,965	------
Pennsylvania:												
East	197,888	130	------	−1,447	------	------	------	------	------	95,975	------	100,596
West	18,129	50	5,489	−74	5,310	179	------	9,561	1,385	1,280	390	------
West Virginia	2,884	------	3,186	−20	1,453	122	------	746	543	------	------	------
Total	[1] 478,615	274	11,463	−3,977	6,763	301	------	12,787	2,367	183,687	26,355	242,652
District II:												
Illinois	243,680	58	57,274	+206	20,941	84	------	222,709	------	------	210	------
Indiana	184,217	27	7,248	−61	6,295	517	------	177,172	199	------	------	------
Kansas	136,283	54	100,814	+380	75,253	2,596	------	58,845	23	------	------	------
Kentucky, Tennessee	57,512	32	8,476	−214	4,192	243	4,029	32,471	24	16,371	------	------
Michigan	51,877	−3	11,835	+146	10,225	1,415	------	27,833	------	------	12,547	------
Minnesota, Wisconsin	55,542	2	------	+488	------	------	------	6,556	------	------	49,476	------
Missouri, Nebraska	28,587	------	8,676	+54	------	------	------	28,641	------	------	------	------
North Dakota	16,887	−3	[2] 22,611	+54	16,048	------	------	890	------	------	------	------
Ohio:												
East	22,811	4	} 10,643	{ +22	2,852	3,110	------	16,766	------	------	109	------
West	[3] 144,452	46		−536	------	21	------	118,191	------	------	25,750	------
Oklahoma	157,825	56	206,519	+252	110,516	3,717	------	43,752	------	------	148	------
Total	1,099,673	273	434,096	+791	246,322	11,703	4,029	733,826	246	16,371	88,240	------
District III:												
Alabama	8,152	25	7,131	−94	------	9	1,141	------	342	6,591	------	------
Arkansas	30,317	3	16,716	−8	15,602	914	------	13,323	473	------	------	------
Louisiana	423,836	177	843,244	−71	287,289	3,309	70,416	49,007	1,134	12,787	------	------
Mississippi	59,532	−20	58,447	+81	10,922	1,615	------	47,056	------	------	------	------
New Mexico	14,209	55	129,282	+41	11,918	2,266	------	121	------	------	------	------
Texas	1,020,142	257	1,158,481	−2,192	733,840	9,371	23,552	124,864	102	126,478	------	------
Total	1,556,188	497	2,213,301	−2,243	1,059,571	17,484	95,109	234,371	2,051	145,856	------	------
District IV:												
Colorado	13,718	61	30,272	+197	------	1,680	------	11,495	90	------	711	------
Montana	40,199	27	35,435	−62	11,946	885	------	16,497	------	------	10,836	------
Utah	39,253	4	25,247	+118	7,881	2,291	------	28,206	997	------	------	------

Wyoming	47,474	4	165,925	+7	44,542	737	--------	936	171	--------	1,099	--------
Total	140,644	96	256,879	+260	64,369	5,593	--------	57,134	1,258	--------	12,646	--------
District V:												
California	504,993	276	380,330	+2,440	330,196	6,757	38,814	16,813	73	57,737	--------	57,319
Other States [4]	99,985	132	69,360	+99	7,905	--------	--------	--------	--------	5,936	71,980	14,395
Total	604,978	408	449,690	+2,539	338,101	6,757	38,814	16,813	73	63,673	71,980	71,714
Total United States	3,880,098	1,548	3,365,429	−2,630	1,715,126	41,838	137,952	1,054,931	5,995	409,587	[5] 199,221	314,366
Daily Average	10,630	4	9,220	−7	4,699	115	378	2,890	16	1,122	546	861

[1] Includes 291,608,000 barrels in Delaware River Valley.
[2] Includes 7,000 barrels from South Dakota.
[3] Includes some Athabasca hydrocarbons.
[4] Alaska, Arizona, Hawaii, Nevada, and Washington.
[5] Excludes crude oil imported for direct fuel use by pipeline.

Table 16.—Transportation of petroleum products by pipelines in the United States, 1969, by months

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	1968 total
Turned into lines:														
Gasoline:														
Motor	103,343	97,840	110,571	109,699	115,874	117,367	121,013	120,943	112,421	116,423	114,102	115,228	1,354,824	1,280,946
Aviation	413	360	488	457	550	547	364	612	474	592	361	440	5,658	7,355
Total gasoline	103,756	98,200	111,059	110,156	116,424	117,914	121,377	121,555	112,895	117,015	114,463	115,668	1,360,482	1,288,301
Jet fuel:														
Naphtha-type	1,838	2,344	2,459	2,403	2,558	2,237	2,318	2,465	2,421	2,379	2,237	2,268	27,927	26,258
Kerosine-type	12,243	11,635	12,591	12,171	11,999	12,720	13,182	13,271	13,888	12,564	14,575	13,482	154,321	128,271
Total jet fuel	14,081	13,979	15,050	14,574	14,557	14,957	15,500	15,736	16,309	14,943	16,812	15,750	182,248	154,529
Kerosine	8,516	7,712	6,469	4,553	3,942	3,796	4,812	4,827	4,993	5,545	6,675	8,270	70,110	62,609
Distillate fuel oil	60,940	48,530	46,414	38,454	40,646	39,071	41,176	40,431	41,186	42,605	41,219	57,093	537,765	537,600
Natural gas liquids	27,725	22,551	22,820	20,008	23,294	22,351	24,082	22,965	22,285	25,215	27,248	36,365	296,909	252,683
Delivered from lines:														
Gasoline:														
Motor	101,479	97,374	107,656	110,723	116,184	117,814	122,353	120,223	113,898	117,108	113,122	115,107	1,353,041	1,281,812
Aviation	380	296	535	497	458	619	385	547	474	601	347	399	5,538	7,320
Total gasoline	101,859	97,670	108,191	111,220	116,642	118,433	122,738	120,770	114,372	117,709	113,469	115,506	1,358,579	1,289,132
Jet fuel														
Naphtha-type	1,940	2,365	2,596	2,276	2,608	2,201	2,339	2,444	2,263	2,402	2,268	2,342	28,044	26,268
Kerosine-type	12,177	11,221	11,809	12,219	11,852	12,505	13,014	13,179	13,501	12,701	14,098	13,600	151,876	126,795
Total jet fuel	14,117	13,586	14,405	14,495	14,460	14,706	15,353	15,623	15,764	15,103	16,366	15,942	179,920	153,063
Kerosine	8,759	7,804	6,514	4,618	4,148	3,263	4,853	3,940	4,921	5,001	6,472	7,892	68,185	62,219
Distillate fuel oil	63,726	51,644	49,421	39,461	39,491	38,234	38,793	37,368	39,915	41,928	41,101	59,400	540,482	538,452
Natural gas liquids	27,757	22,903	22,750	20,029	21,524	21,968	23,318	22,361	21,856	25,019	27,451	35,827	292,763	251,364

Table 16.—Transportation of petroleum products by pipelines in the United States, 1969, by months—Continued

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	1968 total
Shortage or overage:														
Gasoline:														
Motor	−74	−95	−293	−81	−46	−37	−15	−51	−109	−75	−95	−224	−1,195	−1,238
Aviation	27	4	19	16	17	13	10	15	11	15	14	15	176	109
Total gasoline	−47	−91	−274	−65	−29	−24	−5	−36	−98	−60	−81	−209	−1,019	−1,129
Jet fuel:														
Naphtha-type	55	−43	−1	8	−6	7	2	7	−9	2	16	1	39	20
Kerosine-type	110	83	150	83	122	140	120	182	123	105	112	162	1,492	1,222
Total jet fuel	165	40	149	91	116	147	122	189	114	107	128	163	1,531	1,242
Kerosine	106	117	135	93	61	70	71	92	77	108	97	163	1,190	1,211
Distillate fuel oil	−40	35	−47	−127	−34	−92	−54	−32	−39	−150	34	−168	−714	−314
Natural gas liquids	136	158	66	82	88	13	40	51	118	132	75	162	1,121	749
Stocks in lines and working tanks at end of month:														
Gasoline:														
Motor	36,983	37,544	40,752	39,809	39,545	39,135	37,810	38,581	37,213	36,603	37,678	38,023	38,023	35,045
Aviation	286	346	280	224	299	214	183	233	222	198	198	224	224	280
Total gasoline	37,269	37,890	41,032	40,033	39,844	39,349	37,993	38,814	37,435	36,801	37,876	38,247	38,247	35,325
Jet fuel:														
Naphtha-type	628	650	514	633	589	618	595	609	776	751	704	629	629	785
Kerosine-type	2,498	2,829	3,461	3,330	3,355	3,430	3,478	3,388	3,652	3,410	3,775	3,495	3,495	2,542
Total jet fuel	3,126	3,479	3,975	3,963	3,944	4,048	4,073	3,997	4,428	4,161	4,479	4,124	4,124	3,327
Kerosine	2,199	1,990	1,810	1,652	1,385	1,848	1,736	2,531	2,526	2,962	3,068	3,283	3,283	2,548
Distillate fuel oil	22,343	19,194	16,234	15,354	16,543	17,472	19,909	23,004	24,314	25,141	25,225	23,086	23,086	25,089
Natural gas liquids	7,624	7,114	7,118	7,015	8,697	9,067	9,791	10,344	10,655	10,719	10,441	10,817	10,817	7,792

Table 17.—Transportation of petroleum products by pipeline between PAD districts in the United States, 1969, by months

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	1968 total
From District I to District II:														
Gasoline:														
Motor	2,609	2,097	2,341	2,806	2,905	2,832	3,039	3,059	3,077	2,963	2,551	2,725	33,004	30,094
Aviation	12	-------	22	8	9	7	19	24	7	18	-------	21	147	103
Total gasoline	2,621	2,097	2,363	2,814	2,914	2,839	3,058	3,083	3,084	2,981	2,551	2,746	33,151	30,197
Jet fuel:														
Naphtha-type	-------	-------	-------	-------	-------	-------	28	-------	24	6	36	64	158	-------
Kerosine-type	73	117	86	40	37	55	54	65	64	106	77	147	921	755
Total jet fuel	73	117	86	40	37	55	82	65	88	112	113	211	1,079	755
Kerosine	124	118	93	29	38	33	32	55	76	111	111	153	973	787
Distillate fuel oil	739	631	616	440	630	729	392	494	580	594	619	637	7,101	6,827
From District II to District I:														
Gasoline (motor)	736	663	776	664	421	780	1,060	854	446	755	881	973	9,009	10,745
Jet fuel (kerosine-type)	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	30	29	59	-------
Distillate fuel oil	14	19	20	7	-------	10	31	50	18	21	20	38	248	199
Natural gas liquids	726	370	954	745	933	890	854	903	589	636	821	846	9,267	7,437
From District II to District III:														
Gasoline:														
Motor	1,680	1,340	1,441	1,505	1,641	1,656	1,770	1,565	1,250	1,520	1,888	1,377	18,633	17,460
Aviation	------	8	-------	-------	43	-------	-------	-------	-------	-------	-------	-------	51	101
Total gasoline	1,680	1,348	1,441	1,505	1,684	1,656	1,770	1,565	1,250	1,520	1,888	1,377	18,684	17,561
Jet fuel:														
Naphtha-type	82	80	79	110	60	92	30	82	40	113	46	40	854	1,024
Kerosine-type	-------	-------	-------	-------	-------	-------	-------	12	26	-------	40	1	79	2
Total jet fuel	82	80	79	110	60	92	30	94	66	113	86	41	933	1,026
Distillate fuel oil	230	287	374	469	505	367	359	376	269	319	342	607	4,504	5,176
Natural gas liquids	174	158	181	161	154	165	173	190	166	168	167	171	2,028	64
From District III to District I:														
Gasoline:														
Motor	20,476	19,614	22,482	24,144	24,837	24,508	26,561	25,407	24,794	25,441	23,317	22,894	284,475	268,214
Aviation	59	22	63	42	63	9	62	52	27	85	23	76	583	907
Total gasoline	20,535	19,636	22,545	24,186	24,900	24,517	26,623	25,459	24,821	25,526	23,340	22,970	285,058	269,121

Table 17.—Transportation of petroleum products by pipeline between PAD districts in the United States, 1969, by months—Continued

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	total 1968
From District III to District I—Continued														
Jet fuel:														
Naphtha-type	95	160	168	100	185	138	142	159	118	158	126	150	1,699	1,598
Kerosine-type	2,886	2,743	3,194	3,117	3,071	3,326	3,355	3,160	3,250	3,343	3,681	3,925	39,051	29,278
Total jet fuel	2,981	2,903	3,362	3,217	3,256	3,464	3,497	3,319	3,368	3,501	3,807	4,075	40,750	30,876
Kerosine	2,506	2,339	1,728	1,062	869	514	728	842	1,012	1,155	1,715	2,112	16,582	17,165
Distillate fuel oil	18,088	15,528	15,057	12,288	11,398	12,601	12,654	10,741	11,648	11,924	11,914	16,362	160,203	160,316
Natural gas liquids	1,816	1,173	1,301	407	393	643	1,066	800	686	808	1,113	1,854	12,060	11,070
From District III to District II:														
Gasoline:														
Motor	3,434	2,916	4,520	3,757	4,228	4,134	3,951	3,885	3,511	4,490	4,086	3,788	46,700	44,875
Aviation	166	106	165	152	128	170	117	220	134	160	129	120	1,767	1,738
Total gasoline	3,600	3,022	4,685	3,909	4,356	4,304	4,068	4,105	3,645	4,650	4,215	3,908	48,467	46,613
Jet fuel:														
Naphtha-type	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	1	1	-------
Kerosine-type	100	-------	122	108	209	198	124	188	143	157	139	114	1,602	1,247
Total jet fuel	100	-------	122	108	209	198	124	188	143	157	139	115	1,603	1,247
Kerosine	160	154	89	92	123	143	45	135	84	131	115	156	1,427	1,253
Distillate fuel oil	1,337	1,329	559	768	836	504	694	1,515	828	671	791	1,382	11,214	11,713
Natural gas liquids	6,429	4,346	4,539	4,150	3,767	3,713	3,555	2,777	3,891	4,625	4,954	5,761	52,507	50,011
From District III to District IV:														
Gasoline:														
Motor	261	226	254	289	341	307	387	392	318	320	283	312	3,690	3,735
Aviation	23	24	21	23	22	22	23	26	25	19	24	21	273	294
Total gasoline	284	250	275	312	363	329	410	418	343	339	307	333	3,963	4,029
Jet fuel (kerosine-type)	285	271	299	275	258	308	328	313	319	270	317	346	3,589	3,500
Kerosine	6	5	6	3	2	2	2	2	5	5	5	8	51	115
Distillate fuel oil	38	33	39	48	51	44	48	43	42	44	37	51	518	543
Natural gas liquids	130	120	128	72	43	41	47	62	71	92	112	134	1,052	958
From District III to District V:														
Gasoline (motor)	965	985	978	1,055	985	974	992	1,010	834	621	810	924	11,133	10,183

Jet fuel:														
Naphtha-type	279	288	252	281	302	292	245	316	300	293	273	353	3,474	3,933
Kerosine-type	207	211	224	178	234	211	237	233	227	196	192	214	2,564	2,522
Total jet fuel	486	499	476	459	536	503	482	549	527	489	465	567	6,038	6,455
Kerosine	8	12	6	-------	-------	-------	-------	-------	-------	-------	-------	-------	26	42
Distillate fuel oil	276	123	311	248	288	254	253	242	240	310	274	268	3,087	2,940
From District IV to District II:														
Gasoline (motor)	241	215	247	319	366	360	483	408	415	369	295	292	4,010	3,686
Kerosine	10	8	16	7	5	9	7	9	5	7	4	4	91	68
Distillate fuel oil	159	120	161	119	177	125	178	235	265	295	281	237	2,352	1,804
From District IV to District V:														
Gasoline:														
Motor	893	938	929	1,043	1,086	950	840	894	1,181	986	950	1,051	11,741	10,211
Aviation	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	5
Total gasoline	893	938	929	1,043	1,086	950	840	894	1,181	986	950	1,051	11,741	10,216
Jet fuel:														
Naphtha-type	75	93	35	12	32	13	54	44	101	98	64	66	687	841
Kerosine-type	38	41	120	131	129	185	220	216	118	112	111	39	1,460	709
Total jet fuel	113	134	155	143	161	198	274	260	219	210	175	105	2,147	1,550
Distillate fuel oil	482	458	592	394	268	200	274	571	465	442	657	673	5,476	5,255

Table 18.—Pipeline tariff rates for crude petroleum and petroleum products, January 1

(Dollars per barrel)

Origin	Destination	1968	1969	1970
Crude oil:				
West Texas	Houston, Tex	$0.145–$0.16	$0.14–$0.16	$0.14–$0.16
Do	East Chicago, Ind	.29 – .31	.28	.28
Do	Wood River, Ill	.27 – .28	.27– .28	.26
Oklahoma	Chicago, Ill	.22	.22	.22
Do	Wood River, Ill	.19	.19	.19
Eastern Wyoming	Chicago, Ill	.32 – .33	.33	.30
Do	Wood River, Ill	.29 – .30	.30	.30
Refined products:				
Houston, Tex	Atlanta, Ga	.219– .277	.2770	.2770
Do	New York, N.Y	.305	.3055	.2870
Tulsa, Okla	Minneapolis, Minn	.52	.52	.65
Salt Lake City, Utah	Spokane, Wash	.48	.48	.50
Philadelphia, Pa	Rochester, N.Y	.24	.24	.24

Source: Interstate Commerce Commission.

Table 19.—Receipts of domestic and foreign crude petroleum at refineries in the United States by mode of transport

(Million barrels)

Transport	1965	1966	1967	1968	1969 p
By water:					
Intrastate	147.3	152.0	129.1	136.8	138.0
Interstate	296.6	347.7	428.4	428.8	409.6
Foreign	344.4	320.7	265.3	303.0	314.3
Total	788.3	820.4	822.8	868.6	861.9
By pipeline:					
Intrastate	1,407.0	1,465.8	1,581.1	1,673.0	1,715.1
Interstate	955.8	996.2	995.9	1,023.7	1,055.0
Foreign	107.4	126.0	146.6	169.2	199.2
Total	2,470.2	2,588.0	2,723.6	2,865.9	2,969.3
By tank cars and trucks:					
Intrastate	34.8	38.1	40.0	40.8	41.8
Interstate	3.5	4.5	5.7	6.8	6.0
Foreign	-------	-------	-------	-------	-------
Total	38.3	42.6	45.7	47.6	47.8
Grand total	3,296.8	3,451.0	3,592.1	3,782.1	3,879.0

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Table 20.—Petroleum oils, crude and refined, shipped from gulf and west coasts to east coast ports and from the gulf coast to west coast ports, 1969, by months

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	1968 total
Gulf coast to east coast:														
Crude oil	17,378	12,557	15,345	15,696	16,062	13,451	14,068	15,101	15,657	13,636	15,598	16,272	180,821	188,280
Unfinished oils	2,237	2,955	1,978	3,348	3,532	3,852	4,613	3,721	3,029	2,115	1,512	2,469	35,361	15,092
Gasoline:														
Motor	10,022	10,555	13,391	12,259	13,614	8,784	9,127	11,812	12,132	10,960	13,636	14,927	141,219	153,367
Aviation	376	254	336	628	419	532	395	426	350	376	385	260	4,737	5,433
Total	10,398	10,809	13,727	12,887	14,033	9,316	9,522	12,238	12,482	11,336	14,021	15,187	145,956	158,800
Special naphthas	246	440	535	391	405	230	672	527	481	454	514	396	5,291	4,757
Kerosine	2,125	2,074	1,704	1,399	916	945	840	931	886	1,343	1,198	2,321	16,682	19,599
Distillate fuel oil	11,977	11,621	12,604	11,770	8,194	8,567	8,029	6,583	7,793	8,301	10,605	13,551	119,595	122,521
Residual fuel oil	1,071	1,775	3,484	2,745	3,043	2,414	2,939	1,985	2,287	1,602	1,627	2,354	27,326	34,985
Jet fuel:														
Naphtha-type	1,093	1,303	1,906	1,545	1,354	1,839	1,987	1,793	1,705	1,583	1,803	1,633	19,544	15,890
Kerosine-type	2,223	2,240	2,059	2,860	2,206	2,741	2,373	2,006	2,475	2,254	2,292	3,047	28,776	27,614
Total	3,316	3,543	3,965	4,405	3,560	4,580	4,360	3,799	4,180	3,837	4,095	4,680	48,320	43,504
Lubricating oil	461	545	887	951	1,460	849	511	954	502	954	1,014	864	9,952	9,551
Wax	------	14	4	26	27	10	31	31	24	53	30	32	282	88
Asphalt and road oil	100	236	487	514	496	519	518	490	383	497	427	683	5,350	5,946
Liquefied gases	200	196	214	136	143	166	167	216	189	424	347	474	2,872	2,094
Petrochemical feedstocks	232	490	523	259	323	342	449	295	216	251	364	412	4,156	3,053
Other products	70	108	216	159	197	75	135	178	182	168	210	126	1,824	1,418
Total	49,811	47,363	55,673	54,686	52,391	45,316	46,854	47,049	48,291	44,971	51,562	59,821	603,788	609,688
West coast to east coast:														
Crude oil	------	------	------	------	------	------	------	------	------	------	------	------	-------	268
Gasoline (motor)	------	------	------	------	------	------	------	------	------	------	------	------	-------	180
Distillate fuel oil	------	------	------	------	------	------	------	------	------	------	------	------	-------	183
Residual fuel oil	------	------	------	------	------	------	------	87	------	------	------	------	87	98
Jet fuel (kerosine type)	------	------	------	------	------	------	------	------	------	------	------	------	-------	15
Lubricating oil	21	33	99	42	99	18	79	114	41	75	70	64	755	815
Wax	------	------	3	------	------	------	------	------	------	------	------	------	3	------
Other products	------	------	------	------	------	------	------	------	------	------	------	------	-------	4
Total	21	33	102	42	99	18	79	201	41	75	70	64	845	1,563

Table 20.—Petroleum oils, crude and refined, shipped from gulf and west coasts to east coast ports and from the gulf coast to west coast ports, 1969, by months—Continued

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	1968 total
Gulf coast to west coast:														
Crude oil	------	------	------	------	------	215	------	------	------	------	------	------	215	197
Gasoline:														
Motor	951	20	377	205	359	105	408	------	205	------	------	------	2,630	6,860
Aviation	------	------	186	9	80	118	------	------	------	------	------	49	442	679
Total	951	20	563	214	439	223	408	------	205	------	------	49	3,072	7,539
Special naphthas	------	------	16	26	------	16	------	------	33	------	------	------	91	143
Kerosine	------	------	------	------	------	------	1	------	1	------	------	------	2	66
Distillate fuel oil	157	271	157	234	177	------	208	------	------	129	128	------	1,461	1,363
Residual fuel oil	3	------	------	------	------	------	------	------	------	------	------	------	3	62
Jet fuel:														
Naphtha-type	338	------	523	------	356	237	412	358	191	472	308	546	3,741	5,876
Kerosine-type	326	26	278	------	493	73	484	661	82	------	290	97	2,810	3,603
Total	664	26	801	------	849	310	896	1,019	273	472	598	643	6,551	9,479
Lubricating oil	42	101	90	187	112	87	155	108	203	22	124	144	1,375	1,386
Petrochemical feedstocks	------	------	3	106	------	33	3	------	------	------	16	34	195	266
Other products	------	------	------	------	------	------	------	------	------	------	------	------	-------	23
Total	1,817	418	1,630	767	1,577	884	1,671	1,127	715	623	866	870	12,965	20,524

Table 21.—Barge movements via the Mississippi River of crude oil and products from PAD district III to PAD districts I and II, 1969, by months

(Thousand barrels)

Movements from District III to—	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	1968 total
DISTRICT I														
Gasoline:														
Motor gasoline	1,205	801	1,117	1,116	1,067	1,065	1,232	1,047	1,227	1,015	1,161	1,534	13,587	11,829
Aviation gasoline	17	5	31	15	9	20	15	12	7	21	23	15	190	273
Total	1,222	806	1,148	1,131	1,076	1,085	1,247	1,059	1,234	1,036	1,184	1,549	13,777	12,102
Special naphthas	21	20	5	28	16	23	18	18	28	20	29	18	244	152
Kerosine	146	70	128	70	47	71	173	111	89	161	245	147	1,458	522
Distillate fuel oil	229	199	240	124	135	144	186	126	140	171	255	369	2,318	1,452
Residual fuel oil	-----	-----	-----	-----	14	14	-----	-----	-----	-----	-----	-----	28	332
Jet fuel (kerosine-type)	16	53	68	67	84	96	66	64	51	83	58	68	774	591
Lubricating oil	155	110	133	182	186	140	177	153	99	147	170	257	1,909	1,899
Wax	-----	-----	-----	-----	-----	-----	-----	2	-----	-----	-----	-----	2	16
Petrochemical feedstocks	-----	221	18	99	26	20	3	35	76	58	43	60	659	275
Other products	12	13	17	16	27	21	14	25	28	9	-----	19	201	130
Total	1,801	1,492	1,757	1,717	1,611	1,614	1,884	1,593	1,745	1,685	1,984	2,487	21,370	17,471
DISTRICT II														
Crude oil	1,431	1,334	1,487	1,246	1,366	1,380	1,532	1,482	1,296	979	1,284	1,554	16,371	27,898
Unfinished oils	2	4	7	4	4	4	8	-----	8	4	-----	5	50	316
Gasoline:														
Motor gasoline	3,367	2,899	3,981	3,251	3,294	2,937	4,173	3,146	3,012	3,771	2,930	3,484	40,245	33,733
Aviation gasoline	70	35	56	54	89	48	59	65	79	43	38	35	671	720
Total	3,437	2,934	4,037	3,305	3,383	2,985	4,232	3,211	3,091	3,814	2,968	3,519	40,916	34,453
Special naphthas	123	208	161	201	146	155	189	247	189	253	223	164	2,259	2,389
Kerosine	353	297	495	334	293	254	366	253	311	560	315	430	4,261	3,630
Distillate fuel oil	765	973	700	1,188	997	375	671	430	442	527	566	957	8,591	8,542
Residual fuel oil	744	664	505	292	259	157	507	635	568	401	358	634	5,724	6,926
Jet fuel:														
Naphtha-type	-----	-----	10	-----	-----	-----	62	-----	11	-----	-----	-----	83	61
Kerosine-type	951	529	486	566	703	951	276	353	717	765	675	530	7,502	5,955
Total	951	529	496	566	703	951	338	353	728	765	675	530	7,585	6,016
Lubricating oil	147	179	427	140	203	225	691	291	125	255	159	140	2,982	2,375
Wax	-----	-----	3	-----	-----	-----	-----	-----	-----	-----	-----	-----	3	-----
Asphalt and road oil	130	166	213	326	190	334	340	-----	248	142	278	35	2,402	3,716
Liquefied gases	121	115	114	112	113	112	112	170	56	120	64	64	1,273	943
Petrochemical feedstocks	122	134	108	136	100	155	107	156	146	152	158	106	1,580	1,755
Other products	47	38	27	45	63	34	92	38	32	27	70	34	547	694
Total	8,373	7,575	8,780	7,895	7,820	7,121	9,185	7,266	7,240	7,999	7,118	8,172	94,544	99,653

Table 22.—Stocks of crude petroleum, natural gas liquids, and refined products in the United States at yearend

(Thousand barrels)

	1965	1966	1967	1968	1969
Crude petroleum:					
At refineries	59,386	62,720	72,093	78,718	76,088
Pipeline and tank farm	144,740	153,930	158,797	177,133	172,252
Producers	16,163	21,741	18,080	16,342	16,887
Total crude petroleum	220,289	238,391	248,970	272,193	265,227
Unfinished oils	88,609	89,213	90,201	93,399	97,819
Natural gasoline, plant condensate, and isopentane	5,237	4,563	5,782	5,466	5,704
Refined products	522,209	548,938	599,158	628,514	613,373
Grand total	836,344	881,105	944,111	999,572	982,123

Table 23.—Stocks of crude petroleum in the United States, by State of origin and date, 1969

(Thousand barrels)

State of origin	Jan. 1	Jan. 31	Feb. 28	Mar. 31	Apr. 30	May 31	June 30	July 31	Aug. 31	Sept. 30	Oct. 31	Nov. 30	Dec. 31
Alabama	306	441	284	410	332	401	400	322	291	364	412	496	278
Alaska	2,551	3,735	3,195	3,132	1,790	3,418	3,892	3,615	3,605	4,819	5,428	4,777	5,781
Arizona	135	133	156	172	168	145	171	143	148	148	132	178	106
Arkansas	877	1,118	755	670	688	1,014	954	831	832	763	767	761	756
California	31,866	35,256	32,802	32,565	32,937	29,977	30,902	29,662	30,739	29,510	29,322	30,364	29,659
Colorado	3,258	3,419	3,561	3,216	3,685	3,282	3,149	3,417	2,635	2,576	2,564	2,959	3,168
Florida	224	277	160	190	288	74	220	172	142	229	251	227	258
Illinois	5,572	5,435	5,760	5,758	6,235	6,763	6,665	6,566	6,753	6,653	6,652	6,409	5,832
Indiana	545	470	407	421	471	498	460	414	392	635	669	581	431
Kansas	5,845	7,752	6,687	6,314	6,196	6,995	6,863	6,472	6,326	6,841	6,748	6,465	6,587
Kentucky	1,459	1,566	1,458	1,582	1,538	1,515	1,282	1,186	1,187	1,078	1,185	715	562
Louisiana	36,456	38,524	34,987	36,957	37,547	39,062	40,283	39,173	37,239	37,382	37,519	36,065	35,231
Michigan	679	665	750	676	710	635	784	732	643	732	750	774	635
Mississippi	5,205	5,129	4,997	5,134	5,433	6,222	5,064	5,384	5,761	5,354	4,977	5,112	5,278
Montana	4,369	4,501	4,461	4,717	4,784	4,836	4,524	4,797	4,371	3,968	4,002	4,088	4,055
Nebraska	892	797	853	890	839	1,045	1,393	1,121	1,041	1,116	1,336	1,012	1,048
Nevada	-------	-------	-------	2	5	3	6	5	6	2	1	1	3
New Mexico	8,997	9,839	8,881	8,910	9,222	8,245	8,241	7,772	7,912	8,516	8,401	9,136	7,792
New York	30	30	30	30	30	30	30	30	30	30	30	30	30
North Dakota	1,329	1,373	1,394	1,359	1,597	2,227	2,114	2,013	1,946	1,881	1,752	1,754	1,626
Ohio	728	927	832	810	794	735	876	825	869	778	889	848	813
Oklahoma	18,572	18,434	17,552	16,719	17,560	17,907	17,789	17,938	17,504	17,710	17,861	17,661	18,304
Pennsylvania	1,480	1,440	1,443	1,358	1,350	1,361	1,406	1,440	1,537	1,465	1,396	1,349	1,191
Texas	100,383	102,267	98,565	93,581	99,487	102,238	106,507	105,538	99,906	98,287	98,562	98,236	98,503
Utah	2,507	2,759	2,698	2,791	2,812	2,832	2,955	2,542	2,534	2,465	2,667	2,684	2,764
West Virginia	1,020	976	1,003	1,003	1,008	1,023	1,041	997	945	1,005	1,061	1,010	967
Wyoming	16,334	18,027	18,492	18,480	18,411	19,020	17,559	16,421	15,817	13,832	13,352	15,074	15,293
Total domestic crude	251,619	265,290	252,163	247,847	255,917	261,503	265,530	259,528	251,111	248,139	248,686	248,766	246,951
Foreign crude located in districts—													
I–IV	15,169	9,937	9,994	11,677	13,077	12,832	12,759	11,980	10,259	9,189	9,544	9,797	11,696
V	5,405	4,256	3,141	4,654	4,210	6,936	6,255	5,974	6,351	5,200	6,055	6,193	6,580
Total foreign crude	20,574	14,193	13,135	16,331	17,287	19,768	19,014	17,954	16,610	14,389	15,599	15,990	18,276
Total crude stocks	272,193	279,483	265,298	264,178	273,204	281,271	284,544	277,482	267,721	262,528	264,285	264,756	265,227
Pennsylvania grade (included above)	2,913	2,775	2,794	2,712	2,763	2,821	2,850	2,891	2,918	2,831	2,873	2,389	2,573

Table 24.—Stocks of crude petroleum in the United States, by location and date, 1969

(Thousand barrels)

Location	Jan. 1	Jan. 31	Feb. 28	Mar. 31	Apr. 30	May 31	June 30	July 31	Aug. 31	Sept. 30	Oct. 31	Nov. 30	Dec. 31
Alabama	1,057	1,038	927	956	951	937	902	1,128	1,155	957	665	1,160	1,069
Alaska	433	407	817	343	419	599	466	783	718	842	713	683	904
Arizona	468	462	494	528	523	451	497	496	479	480	480	496	448
Arkansas	1,398	1,577	1,286	1,201	1,124	1,502	1,478	1,356	1,341	1,285	1,323	1,291	1,289
California, Nevada, Oregon, Washington	39,185	43,402	38,675	40,276	38,805	39,391	40,699	38,758	40,061	39,029	39,617	40,320	40,602
Colorado	1,675	2,035	2,071	1,683	1,909	1,778	1,772	1,757	1,769	1,639	1,799	1,836	1,945
Florida, Georgia, South Carolina, Virginia	1,498	1,109	803	675	1,329	1,196	976	776	1,138	520	890	1,089	831
Hawaii	876	163	341	549	549	1,228	1,026	689	834	545	1,357	1,088	1,408
Illinois	17,732	19,041	18,295	17,461	19,136	20,147	19,346	19,096	17,907	18,051	17,678	16,789	15,950
Indiana	4,122	4,361	4,446	5,167	5,479	4,846	4,610	5,122	4,592	4,811	4,668	4,663	4,268
Iowa, Missouri	6,980	6,489	6,528	6,311	6,625	6,672	6,296	6,421	6,302	5,918	6,130	6,405	6,761
Kansas	9,627	11,611	10,606	9,614	9,511	10,528	10,122	9,741	9,181	9,564	9,379	9,979	10,082
Kentucky, Tennessee	4,720	5,105	4,857	5,200	5,105	5,203	5,013	5,094	5,141	4,923	5,161	4,930	4,456
Louisiana	18,027	19,013	17,457	20,020	19,207	19,800	20,288	18,327	18,364	17,649	17,818	17,344	17,928
Maryland	291	224	202	410	283	176	308	212	307	286	313	87	145
Massachusetts, Delaware, Rhode Island	850	850	558	667	1,372	1,265	686	739	792	421	746	916	881
Michigan	1,610	1,456	1,619	1,753	1,409	1,479	1,753	1,690	1,479	1,576	1,664	1,605	1,531
Minnesota, Wisconsin	1,753	1,950	2,101	2,255	2,476	2,401	2,408	2,353	2,418	2,393	2,007	2,401	2,264
Mississippi	5,248	5,328	5,609	5,857	5,729	5,805	5,946	5,388	5,335	5,691	5,931	5,530	5,891
Montana	2,770	2,928	2,746	2,962	3,189	3,325	3,132	3,233	2,658	2,156	2,319	2,430	2,476
Nebraska	1,491	1,756	1,748	1,780	1,757	1,716	1,720	1,600	1,563	1,563	1,422	1,418	1,423
New Jersey	8,228	6,357	5,406	5,622	6,539	7,291	6,239	6,035	6,953	6,004	5,360	5,349	6,474
New Mexico	3,984	4,188	4,174	4,094	4,300	4,244	4,288	4,164	4,014	3,904	4,213	4,353	4,246
New York	315	577	517	524	551	366	388	497	400	370	391	367	343
North Dakota	1,185	1,218	1,231	1,125	1,271	1,883	1,689	1,541	1,430	1,351	1,329	1,267	1,268
Ohio	6,478	6,217	6,438	6,693	7,090	6,702	6,859	7,014	6,836	6,571	6,367	6,669	5,779
Oklahoma	17,991	18,611	17,294	17,014	17,918	18,362	19,375	19,494	18,810	19,050	20,348	19,526	19,367
Pennsylvania	11,273	10,327	9,484	10,289	10,384	10,182	11,055	11,296	9,202	10,219	8,904	9,503	9,545
Texas	90,687	90,421	86,843	81,862	87,345	89,861	94,194	92,420	86,753	86,095	86,244	85,534	85,833
Utah	732	762	944	958	989	1,000	968	1,005	1,007	914	900	901	974
West Virginia	615	529	533	516	584	629	619	618	597	653	678	682	673
Wyoming	8,894	9,971	10,248	9,813	9,346	10,306	9,426	8,639	8,185	7,098	7,471	8,145	8,173
Total	272,193	279,483	265,298	264,178	273,204	281,271	284,544	277,482	267,721	262,528	264,285	264,756	265,227

Table 25.—Stocks of crude petroleum in the United States, by classification, location, and date, 1969

(Thousand barrels)

Classification and location	Jan. 1	Jan. 31	Feb. 28	Mar. 31	Apr. 30	May 31	June 30	July 31	Aug. 31	Sept. 30	Oct. 31	Nov. 30	Dec. 31
At refineries:													
Alabama	225	237	201	183	192	182	147	131	158	169	174	212	131
Alaska	54	67	72	49	64	64	67	77	36	67	76	69	92
Arkansas	171	206	189	217	243	242	215	206	205	206	248	190	163
California, Oregon, Washington	17,756	20,173	16,883	19,940	20,151	20,611	20,894	20,277	22,115	20,793	20,792	19,934	19,725
Colorado	315	537	521	342	518	415	291	304	260	245	453	458	512
Florida, Georgia, South Carolina, Virginia	1,275	951	644	501	1,205	1,126	757	605	1,002	433	639	890	658
Hawaii	876	163	341	549	549	1,228	1,026	689	834	545	1,357	1,088	1,408
Illinois	3,376	3,706	3,649	3,647	4,000	3,947	3,613	3,958	3,470	3,411	3,198	3,904	3,582
Indiana	1,323	1,307	1,287	1,340	1,582	1,368	1,272	1,482	1,420	1,372	1,380	1,386	1,262
Kansas	1,564	1,928	1,784	1,679	1,613	1,949	1,817	1,854	1,905	1,999	1,833	1,801	1,944
Kentucky, Tennessee	1,230	1,409	1,190	1,292	1,205	1,202	1,341	1,398	1,437	1,158	1,339	1,323	1,016
Louisiana	5,311	5,713	5,747	5,756	5,874	6,430	6,537	5,845	5,600	4,747	5,043	4,579	5,240
Maryland	291	224	202	410	283	176	308	212	307	286	313	87	145
Massachusetts, Delaware, Rhode Island	850	850	558	667	1,372	1,265	686	739	792	421	746	916	881
Michigan	683	700	852	1,051	730	689	873	960	734	755	848	832	829
Minnesota, Wisconsin	1,058	1,220	1,272	1,553	1,625	1,553	1,550	1,559	1,652	1,607	1,202	1,496	1,546
Mississippi	564	675	616	811	682	738	844	801	729	717	816	569	645
Missouri	256	283	238	270	314	294	249	284	303	300	227	292	314
Montana	734	759	615	753	740	782	760	730	630	472	554	638	672
Nebraska	29	35	36	32	20	22	28	30	21	20	24	30	25
New Jersey	8,228	6,357	5,406	5,622	6,539	7,291	6,239	6,035	6,953	6,004	5,360	5,349	6,474
New Mexico	180	262	311	287	294	243	208	220	179	145	172	162	221
New York	210	430	387	377	405	251	269	355	272	236	257	271	260
North Dakota	229	206	208	154	255	646	640	471	386	317	263	269	283
Ohio	2,534	2,105	2,371	2,732	2,871	2,669	2,726	2,861	2,615	2,545	2,424	2,473	2,020
Oklahoma	1,602	1,624	1,579	1,603	2,004	2,163	2,056	1,972	2,005	1,932	1,957	2,014	1,854
Pennsylvania	9,385	8,409	7,483	8,352	8,504	8,327	9,164	9,375	7,187	8,334	7,015	7,599	7,864
Texas	17,341	15,880	15,671	15,607	16,553	16,220	16,792	16,463	16,041	15,869	15,819	14,993	15,149
Utah	340	368	441	439	494	553	500	554	535	449	390	353	458
West Virginia	118	84	86	60	87	62	47	74	89	90	87	86	98
Wyoming	610	755	710	638	636	767	701	616	519	621	729	683	617
Total at refineries	78,718	77,623	71,550	76,913	81,604	83,475	82,617	81,137	80,391	76,265	75,735	74,946	76,088
Pipeline and tank-farm stocks:													
Alabama	766	702	630	676	663	659	658	903	902	694	397	856	839
Alaska	376	336	741	290	352	531	395	702	676	771	633	610	808
Arkansas	1,132	1,267	993	863	760	1,139	1,142	1,029	1,021	964	960	981	1,022
California, Arizona	19,825	21,150	20,008	18,566	16,392	16,811	17,830	16,689	16,105	16,065	16,832	17,979	18,207
Colorado	1,235	1,373	1,425	1,216	1,266	1,238	1,356	1,328	1,384	1,269	1,221	1,237	1,310
Florida	215	149	151	164	116	60	209	156	128	78	242	186	163
Illinois	14,024	15,010	14,329	13,488	14,816	15,882	15,412	14,831	14,116	14,331	14,181	12,580	12,062
Indiana	2,765	3,020	3,125	3,793	3,863	3,444	3,304	3,606	3,138	3,405	3,254	3,243	2,972
Iowa, Missouri	6,724	6,206	6,290	6,041	6,311	6,378	6,047	6,137	5,999	5,618	5,903	6,113	6,447
Kansas	7,704	9,316	8,462	7,579	7,540	8,221	7,887	7,548	6,925	7,221	7,205	7,832	7,805
Kentucky, Tennessee	3,427	3,633	3,604	3,845	3,837	3,938	3,609	3,633	3,641	3,708	3,765	3,550	3,383

Table 25.—Stocks of crude petroleum in the United States, by classification, location, and date, 1969—Continued

(Thousand barrels)

Classification and location	Jan. 1	Jan. 31	Feb. 28	Mar. 31	Apr. 30	May 31	June 30	July 31	Aug. 31	Sept. 30	Oct. 31	Nov. 30	Dec. 31
Pipeline and tank-farm stocks—Continued													
Louisiana	10,525	11,038	9,410	11,817	10,997	10,931	11,451	10,212	10,448	10,493	10,335	10,331	10,223
Michigan	844	673	684	619	596	707	797	647	662	738	733	692	621
Minnesota, Wisconsin	695	730	829	702	851	848	858	794	766	786	805	905	718
Mississippi	4,348	4,298	4,671	4,715	4,726	4,736	4,771	4,256	4,275	4,661	4,784	4,617	4,942
Montana	1,587	1,719	1,723	1,797	2,030	2,156	1,966	2,114	1,648	1,321	1,368	1,430	1,453
Nebraska	1,359	1,618	1,609	1,645	1,634	1,591	1,589	1,467	1,439	1,445	1,300	1,290	1,300
New Mexico	2,292	2,385	2,353	2,274	2,464	2,497	2,597	2,513	2,392	2,349	2,602	2,738	2,586
New York	75	117	100	117	116	85	89	112	98	104	104	66	53
North Dakota	794	842	846	817	839	941	890	913	887	894	932	860	845
Ohio	3,869	4,037	3,992	3,886	4,144	3,958	4,058	4,078	4,146	3,951	3,868	4,121	3,684
Oklahoma	15,328	15,907	14,621	14,297	14,864	15,159	16,182	16,476	15,691	16,073	17,368	16,442	16,460
Pennsylvania	1,753	1,803	1,886	1,822	1,758	1,733	1,769	1,799	1,893	1,763	1,767	1,782	1,559
Texas	67,091	68,679	65,310	60,296	65,120	67,759	71,268	70,376	64,596	64,194	65,077	64,730	64,896
Utah	315	316	442	451	431	398	415	404	421	408	455	497	466
West Virginia	332	280	282	291	332	402	407	379	343	398	426	431	410
Wyoming	7,733	8,676	8,998	8,618	8,173	9,007	8,176	7,504	7,108	5,945	6,210	6,924	7,018
Total	177,133	185,280	177,514	170,685	174,991	181,209	185,132	180,606	170,848	169,647	172,727	173,023	172,252
Lease stocks	16,342	16,580	16,234	16,580	16,609	16,587	16,795	15,739	16,482	16,616	15,823	16,787	16,887
Total stocks:													
1969	272,193	279,483	265,298	264,178	273,204	281,271	284,544	277,482	267,721	262,528	264,285	264,756	265,227
1968	248,970	244,946	245,271	256,864	262,087	262,021	264,896	265,755	266,368	262,771	266,330	271,587	272,193

Table 26.—Value of crude petroleum at wells in the United States, by States

State	1968		1969	
	Total value at wells (thousand dollars)	Average value per barrel	Total value at wells (thousand dollars)	Average value per barrel
Alabama	20,385	$2.67	20,793	$2.70
Alaska	186,695	2.82	214,464	2.90
Arizona	9,606	2.85	7,056	2.90
Arkansas	53,137	2.73	51,079	2.83
California	883,644	2.35	920,060	2.45
Colorado	94,215	2.95	88,277	3.12
Illinois	173,120	3.07	161,302	3.18
Indiana	26,511	3.05	25,013	3.19
Kansas	285,405	3.02	283,891	3.20
Kentucky	41,125	2.93	40,194	3.11
Louisiana:				
Gulf Coast	2,414,466	3.15	2,635,002	3.31
Northern	156,175	3.07	156,267	3.22
Total Louisiana	2,570,641	3.14	2,791,269	3.30
Michigan	38,287	2.95	37,494	3.07
Mississippi	164,396	2.80	187,514	2.92
Montana	124,488	2.57	118,359	2.69
Nebraska	36,781	2.79	36,075	2.98
New Mexico:				
Southeastern	350,430	2.97	378,561	3.15
Northwestern	28,278	2.72	25,880	2.86
Total New Mexico	378,708	2.95	404,441	3.13
New York	7,093	4.63	5,683	4.52
North Dakota	66,106	2.64	63,568	2.80
Ohio	35,722	3.19	36,098	3.29
Oklahoma	668,202	2.99	701,155	3.12
Pennsylvania	18,698	4.49	20,086	4.52
South Dakota	401	2.15	362	2.29
Texas:				
Gulf Coast	737,066	3.31	787,130	3.42
East Texas Field	165,041	3.11	187,638	3.24
West Texas	1,565,993	2.95	1,715,586	3.14
Panhandle	100,478	3.02	95,788	3.17
Rest of State	882,129	3.02	910,186	3.17
Total Texas	3,450,707	3.04	3,696,328	3.21
Utah	62,826	2.67	65,320	2.80
West Virginia	13,149	3.97	11,888	3.83
Wyoming	380,589	2.64	433,846	2.80
Other States [1]	4,189	2.30	5,065	2.47
Total United States	9,794,826	2.94	10,426,680	3.09

[1] Florida, Missouri, Nevada, Tennessee, and Virginia.

Table 27.—Posted price per barrel of petroleum at wells in the United States in 1969 by grade, with date of price change

(Dollars)

Date of change	Pennsylvania grade: Bradford and Allegheny districts	Pennsylvania grade: In southwest Pennsylvania	Corning grade	Western Kentucky	Indiana-Illinois	Coldwater Mich.	Oklahoma-Kansas: 34°–34.9° API	Oklahoma-Kansas: 36°–36.9° API
Jan. 1	4.63	4.08	3.12	3.20	3.20	3.00	3.02	3.10
Mar. 1	----	----	3.17	3.25	3.25	3.05	----	----
Mar. 15	----	----	3.22	3.30	3.30	----	3.17	3.25
Apr. 1	----	----	----	3.35	3.35	3.10	----	----
Dec. 16	----	----	3.17	----	----	----	----	----

Date of change	Panhandle, Tex. (Carson, Gray, Hutchinson, and Wheeler Counties) 35°–35.9° API	West Texas 30°–30.9° API (sweet)	Lea County, N. Mex. 30°–30.9° API (sour)	South Texas Mirando 24°–24.9° API	East Texas	Conroe, Texas	Texas: 30°–30.9° API	Texas: 20°–20.9° API
Jan. 1	3.06	2.96	2.80	3.25	3.20	3.35	3.10	3.00
Feb. 25	3.22	----	----	----	3.40	----	----	----
Mar. 1	----	3.16	3.00	3.30	3.30	----	----	----
Mar. 15	3.17	----	2.94	----	----	----	----	----
Mar. 22	----	----	----	3.35	----	3.45	3.20	3.10
Apr. 19	----	----	----	3.45	3.40	----	----	----
May 9	----	----	----	----	3.35	----	----	----
May 15	----	----	----	3.40	----	----	----	----
June 1	----	3.11	----	----	----	----	----	----

Date of change	Louisiana 30°–30.9° API	Caddo-Pine Island, La. 36°–39.9° API	Magnolia Smackover Limestone, Ark. 31°–31.9° API	Elk Basin, Wyo. (including Montana) 30°–30.9° API	Coalinga 32°–32.9° API	California: Kettleman Hills 37°–37.9° API	California: Midway Sunset 19°–19.9° API	California: Wilmington 24°–24.9° API
Jan. 1	3.10	3.04	2.72	2.71	2.96	3.21	2.23	2.58
Feb. 24	----	----	----	2.76	----	----	----	----
Mar. 1	3.15	----	----	2.81	3.06	3.31	2.33	2.68
Mar. 10	----	----	2.82	----	----	----	----	----
Mar. 22	3.20	3.19	----	----	----	----	----	----
Apr. 1	----	----	----	----	3.16	3.41	2.43	2.78
Apr. 19	3.30	----	----	2.91	----	----	----	----

Source: Platt's Oil Price Handbook.

Table 28.—Wholesale price index, crude petroleum

(1957–59 = 100)

Month	1965	1966	1967	1968	1969
January	96.7	96.9	98.2	99.0	99.7
February	96.7	97.0	98.2	99.0	99.9
March	96.7	97.0	98.3	99.0	103.7
April	96.7	97.0	98.3	99.0	104.8
May	96.7	97.2	98.3	99.0	104.7
June	96.7	97.4	98.3	99.3	104.5
July	96.7	97.5	98.4	99.4	104.5
August	96.7	97.7	99.0	99.7	104.5
September	96.7	97.7	99.0	99.7	104.5
October	96.7	98.1	99.0	99.7	104.5
November	96.7	98.1	99.0	99.7	104.5
December	96.9	98.1	99.0	99.7	104.5
Average	96.8	97.5	98.6	99.4	103.7

Source: Bureau of Labor Statistics, U.S. Department of Labor.

Table 29.—Average monthly price of petroleum products in the United States, 1968–69

Product and grade	Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
Gasoline, 92-octane (cents per gallon):														
At refineries in Oklahoma	1968	11.33	11.59	11.90	11.99	11.62	11.88	11.88	11.88	11.88	11.69	12.63	11.54	11.73
	1969	11.77	11.75	12.48	12.44	12.29	12.22	12.09	12.28	12.18	12.17	12.25	12.29	12.18
Tank-wagon prices to dealers at 55 cities on first of month	1968	16.54	16.17	16.13	16.40	16.53	16.72	16.63	16.65	16.82	16.84	16.42	16.24	16.51
	1969	16.86	16.72	17.43	17.49	17.31	17.57	17.37	16.83	17.20	16.67	16.73	17.17	17.11
At service stations (including all taxes)	1968	33.65	33.18	33.18	33.48	33.70	33.99	33.94	33.87	34.17	34.22	33.66	33.40	33.71
	1969	34.31	34.14	35.09	35.25	35.02	35.40	35.30	34.61	35.10	34.36	34.45	35.03	34.84
Kerosine (cents per gallon):														
No. 1 range at Chicago district	1968	10.75	10.75	10.75	10.66	10.52	10.50	10.50	10.50	10.50	10.50	10.68	10.75	10.61
	1969	10.93	11.00	10.94	10.75	10.75	10.75	10.68	10.68	10.71	10.89	11.09	11.25	10.87
No. 1 fuel oil at Oklahoma	1968	10.37	10.38	10.38	10.21	10.13	10.13	10.13	10.00	10.00	10.00	10.00	10.03	10.14
	1969	10.34	10.61	10.60	10.50	10.26	10.25	10.16	10.25	10.33	10.36	10.25	10.58	10.37
Kerosine (or No. 1 fuel oil) at New York Harbor	1968	11.80	11.80	11.80	11.95	12.20	12.20	12.20	12.08	12.20	12.20	12.00	12.00	12.00
	1969	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
Kerosine (or No. 1 fuel oil) at Tampa	1968	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50
	1969	11.50	11.50	11.59	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.51
Distillate and diesel fuel oil (cents per gallon):														
No. 2 fuel oil at refineries, Oklahoma	1968	9.62	9.63	9.63	9.46	9.38	9.38	9.38	9.25	9.25	9.25	9.25	9.28	9.39
	1969	9.59	9.86	9.85	9.75	9.52	9.50	9.41	9.50	9.58	9.61	9.61	9.83	9.63
No. 2 fuel oil at New York Harbor	1968	10.80	10.80	10.80	10.95	11.20	11.20	11.20	11.08	11.00	11.00	11.00	11.00	11.00
	1969	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00
Diesel oil, shore plants, New York	1968	11.10	11.10	11.10	11.25	11.50	11.50	11.50	11.38	11.30	11.30	11.30	11.30	11.30
	1969	11.30	11.30	11.30	11.30	11.30	11.30	11.30	11.30	11.30	11.30	11.30	11.30	11.30
Diesel oil for ships (dollars per barrel):														
New York	1968	4.56	4.56	4.56	4.61	4.73	4.73	4.73	4.68	4.65	4.58	4.56	4.56	4.63
	1969	4.63	4.63	4.63	4.63	4.63	4.63	4.63	4.63	4.63	4.63	4.63	4.63	4.63
New Orleans	1968	4.39	4.29	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.27
	1969	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.26
San Pedro	1968	4.59	4.59	4.64	4.72	4.72	4.72	4.72	4.72	4.72	4.72	4.72	4.72	4.69
	1969	4.72	4.72	4.78	4.97	4.97	4.97	4.97	4.97	4.97	4.97	4.97	4.97	4.91
Residual fuel oil (dollars per barrel):														
No. 6 fuel at refineries, Oklahoma	1968	1.70	1.70	1.70	1.70	1.70	1.68	1.65	1.65	1.65	1.65	1.65	1.65	1.67
	1969	1.74	1.78	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.71
No. 5 fuel oil at New York Harbor [1]	1968	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83
Bunker "C" for ships:														
New York [1]	1968	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28
New Orleans [1]	1968	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22
San Pedro	1968	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.89	1.88	1.88	1.88	1.91
	1969	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.90	1.90	1.88
Lubricating oil (cents per gallon):														
Oklahoma:														
200 viscosity, No. 3 color, neutral [1]	1968	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50
150–160 viscosity, 210° API, bright stock, 10–25 pour test [1]	1968	24.50	24.50	24.50	24.50	24.50	24.50	24.50	24.50	24.50	24.50	24.50	24.50	24.50
Pennsylvania:														
200 viscosity, No. 3 color, neutral, 420–425 flash, 25 pour test [1]	1968	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
600 steam-refined cylinder stock, filterable [1]	1968	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50
South Texas: 500 viscosity, No. 2½–3½ color, neutral [1]	1968	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00

Table 29.—Average monthly price of petroleum products in the United States, 1968–69—Continued

Product and grade	Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
Liquid petroleum gas (propane) (cents per gallon):														
New York Harbor/Philadelphia	1968	8.75	8.75	8.48	8.00	7.33	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.67
	1969	7.25	7.25	7.25	6.96	6.75	6.75	6.75	6.75	6.78	7.50	7.54	7.50	7.09
Oklahoma	1968	5.69	5.49	4.68	4.13	3.77	3.75	3.75	3.75	3.75	3.75	3.75	4.05	4.19
	1969	4.25	4.25	4.25	3.63	3.25	3.25	3.25	3.25	4.07	4.25	4.53	4.75	3.92
Baton Rouge	1968	6.25	6.11	5.39	4.75	4.34	4.25	[illegible]	4.25	4.25	4.25	4.25	4.55	4.74
	1969	4.75	4.75	4.75	4.13	3.75	3.75	3.75	3.75	4.57	4.75	4.97	5.25	4.41
Wax (cents per pound): Pennsylvania 124°–126° API, white crude scale [1]	1968	6.13	6.13	6.13	6.13	6.13	6.13	6.13	6.13	6.13	6.13	6.13	6.13	6.13

[1] No change in price during 1969.

Source: Platt's Oil Price Handbook.

Table 30.—Salient statistics of the major refined petroleum products in the United States

(Thousand barrels)

Product	1967	1968	1969 p
Isopentane:			
Production	3,021	2,660	3,457
Stocks at plants	24	44	10
Used at refineries	3,005	2,640	3,491
Natural gasoline:			
Production	136,273	145,214	154,472
Stocks end of year:			
At plants	2,645	2,584	3,358
At refineries	2,077	1,860	1,557
Total stocks	4,722	4,444	4,915
Used at refineries	135,516	145,492	154,001
Plant condensate:			
Production	37,970	38,494	34,133
Stocks end of year:			
At plants	895	841	547
At refineries	141	137	232
Total stocks	1,036	978	779
Used at refineries	37,524	38,552	34,332
Finished gasoline:			
Production:			
At refineries	1,838,522	1,933,827	2,022,407
At gas processing plants	7,261	6,211	5,745
Total gasoline production	1,845,783	1,940,038	2,028,152
Stocks end of year:			
At refineries	207,715	211,256	217,084
At plants	265	270	308
Total stocks	207,980	211,526	217,392
Imports	15,215	21,591	22,709
Exports	4,877	2,083	2,526
Domestic demand	1,842,686	1,956,000	2,042,469
Motor gasoline:			
Production:			
At refineries	1,801,448	1,902,264	1,995,947
At gas processing plants	7,261	6,211	5,745
Total motor gasoline production	1,808,709	1,908,475	2,001,692
Stocks end of year:			
At refineries	199,790	204,226	210,891
At plants	265	270	308
Total motor gasoline stocks	200,055	204,496	211,199
Imports	15,215	21,591	22,709
Exports	848	249	719
Domestic demand	1,809,782	1,925,376	2,016,979
Aviation gasoline:			
Production	37,074	31,563	26,460
Stocks end of year	7,925	7,030	6,193
Exports	4,029	1,834	1,807
Domestic demand	32,904	30,624	25,490
Jet fuel:			
Production	273,229	314,928	321,718
Stocks end of year	22,211	24,277	28,073
Imports	32,391	38,507	45,539
Exports	2,021	2,092	1,928
Domestic demand	300,770	349,378	361,533
Naphtha-type:			
Production:			
At refineries	109,650	121,165	104,748
At gas processing plants	44	277	18
Total production	109,694	121,442	104,766
Stocks end of year:			
At refineries	9,023	8,880	8,537
At plants	14	24	19
Total stocks	9,037	8,904	8,556

See footnotes at end of table.

Table 30.—Salient statistics of the major refined petroleum products in the United States—Continued

(Thousand barrels)

Product	1967	1968	1969 p
Jet fuel—Continued			
Naphtha-type—Continued			
Imports	5,450	7,117	5,134
Exports	1,804	2,091	1,928
Domestic demand	111,546	126,601	108,320
Kerosine-type:			
Production	163,535	193,486	216,952
Stocks end of year	13,174	15,373	19,517
Imports	26,941	31,390	40,405
Exports	217	1	---------
Domestic demand	189,224	222,777	253,213
Ethane (including ethylene):			
Production:			
At gas processing plants	36,733	45,803	63,027
At refineries	7,028	9,446	9,159
Total production	43,761	55,249	72,186
Stocks end of year:			
At plants	2,115	2,212	2,182
At refineries	---------	---------	---------
Total stocks	2,115	2,212	2,182
Domestic demand:			
Plant ethane	36,089	45,706	63,057
Refinery ethane and/or ethylene	7,028	9,446	9,159
Total domestic demand	43,117	55,152	72,216
Liquefied gases:			
Production:			
At gas processing plants (LPG)	289,885	305,459	315,430
At refineries (LRG):			
For fuel use	67,589	71,102	75,659
For chemical use	36,900	37,539	38,703
Total production at refineries	104,489	108,641	114,362
Total production	394,374	414,100	429,792
Stocks end of year:			
LPG stocks:			
At plants	56,570	68,928	51,799
At refineries	555	647	571
Total LPG stocks	57,125	69,575	52,370
LRG stocks:			
For fuel use	4,741	4,225	4,782
For chemical use	184	148	268
Total LRG stocks	4,925	4,373	5,050
Total stocks	62,050	73,948	57,420
Imports	9,885	11,647	12,651
Exports	9,262	10,608	12,795
LPG used at refineries	68,675	72,652	72,764
Domestic demand:			
LPG for fuel and chemical use	198,434	221,869	263,404
LRG for fuel use	65,978	71,628	74,447
LRG for chemical use	36,922	37,092	35,561
Total domestic demand	301,334	330,589	373,412
Propane (including propylene):			
Production:			
At gas processing plants	169,767	184,409	195,346
At refineries:			
For fuel use	53,689	56,847	57,022
For chemical use	18,444	17,489	19,721
Total production at refineries	72,133	74,336	76,743
Total production	241,900	258,745	272,089

See footnotes at end of table.

Table 30.—Salient statistics of the major refined petroleum products in the United States—Continued

(Thousand barrels)

Product	1967	1968	1969 p
Propane (including propylene)—Continued			
Stocks end of year:			
Plant propane stocks:			
At plants	37,064	44,523	31,375
At refineries	5	5	4
Total plant propane stocks	37,069	44,528	31,379
Refinery propane and/or propylene stocks:			
For fuel use	3,445	2,947	3,083
For chemical use	63	73	215
Total refinery propane and/or propylene stocks	3,508	3,020	3,298
Total stocks	40,577	47,548	34,677
Imports	4,190	5,627	5,251
Exports	1,782	2,542	2,412
Plant propane used at refineries	2,040	1,587	1,632
Domestic demand:			
Plant propane	154,644	178,448	209,702
Refinery propane and/or propylene:			
For fuel use	52,586	57,345	56,886
For chemical use	18,452	17,479	19,579
Total refinery propane and/or propylene domestic demand	71,038	74,824	76,465
Total domestic demand	225,682	253,272	286,167
Butane (including butylene):			
Production:			
At gas processing plants	75,492	78,903	86,471
At refineries:			
For fuel use	10,147	9,584	13,535
For chemical use	10,089	12,441	10,987
Total production at refineries	20,236	22,025	24,522
Total production	95,728	100,928	110,993
Stocks end of year:			
Plant butane stocks:			
At plants	14,057	16,141	13,330
At refineries	292	357	270
Total plant butane stocks	14,349	16,498	13,600
Refinery butane and/or butylene stocks:			
For fuel use	1,137	936	1,448
For chemical use	79	42	36
Total refinery butane and/or butylene stocks	1,216	978	1,484
Total stocks	15,565	17,476	15,084
Imports	5,695	6,020	7,400
Exports	914	1,184	3,084
Plant butane used at refineries	35,586	41,526	40,268
Domestic demand:			
Plant butane	37,321	40,064	53,417
Refinery butane and/or butylene:			
For fuel use	9,737	9,785	13,023
For chemical use	10,101	12,478	10,993
Total refinery butane and/or butylene	19,838	22,263	24,016
Total domestic demand	57,159	62,327	77,433
Butane-propane mixture:			
Production:			
At gas processing plants	15,433	12,367	6,711

See footnotes at end of table.

Table 30.—Salient statistics of the major refined petroleum products in the United States—Continued

(Thousand barrels)

Product	1967	1968	1969 p
Butane-propane mixture—Continued			
Production—Continued			
At refineries:			
For fuel use	3,753	4,671	5,102
For chemical use	7,022	6,494	6,289
Total production at refineries	10,775	11,165	11,391
Total production	26,208	23,532	18,102
Stocks end of year:			
Plant butane-propane mixture:			
At plants	413	528	240
At refineries	53	12	91
Total plant butane-propane mixture stocks	466	540	331
Refinery butane-propane mixture:			
For fuel use	159	342	251
For chemical use	---------	1	---------
Total refinery butane-propane mixture stocks	159	343	251
Total stocks	625	883	582
Exports	6,566	6,882	7,299
Plant butane-propane mixture used at refineries	2,483	2,527	3,013
Domestic demand:			
Plant butane-propane mixture	6,469	3,357	285
Refinery butane-propane mixture:			
For fuel use	3,655	4,488	4,538
For chemical use	7,022	6,020	3,268
Total refinery butane-propane mixture	10,677	10,508	7,806
Total domestic demand	17,146	13,865	8,091
Isobutane:			
Production:			
At gas processing plants	29,193	29,780	26,902
At refineries	1,345	1,115	1,706
Total production	30,538	30,895	28,608
Stocks end of year:			
Plant isobutane:			
At plants	5,036	7,736	6,854
At refineries	205	273	206
Total plant isobutane stocks	5,241	8,009	7,060
Refinery isobutane	42	32	17
Total stocks	5,283	8,041	7,077
Plant isobutane used at refineries	28,566	27,012	27,851
Domestic demand: Refinery isobutane for chemical use	1,347	1,125	1,721
Kerosine (including range oil):			
Production:			
At refineries	99,061	100,545	101,738
At gas processing plants	1,293	1,027	1,121
Total production	100,354	101,572	102,859
Stocks end of year:			
At refineries	25,008	23,190	26,531
At plants	358	290	249
Total stocks	25,366	23,480	26,780
Imports	33	190	965
Exports	156	613	156
Domestic demand	100,078	102,934	100,368
Distillate fuel oil:			
Production:			
At refineries	804,429	839,373	846,863
At gas processing plants	359	1,308	1,541
Total production	804,788	840,681	848,404
Crude used directly as distillate	730	712	654

See footnotes at end of table.

Table 30.—Salient statistics of the major refined petroleum products in the United States—Continued

(Thousand barrels)

Product	1967	1968	1969 p
Distillate fuel oil—Continued			
Stocks end of year:			
At refineries	159,674	173,093	171,664
At plants	29	65	50
Total stocks	159,703	173,158	171,714
Imports	18,492	48,148	50,883
Exports	4,269	1,547	1,281
Domestic demand	818,150	874,539	900,104
Residual fuel oil:			
Production	275,956	275,814	265,906
Crude used directly as residual	3,671	4,272	4,334
Stocks end of year	65,597	67,359	60,395
Imports	395,939	409,928	461,611
Exports	21,940	20,013	16,893
Domestic demand	651,885	668,239	721,922
Petrochemical feedstocks (excluding LRG): [1]			
Production	87,428	95,422	98,356
Stocks end of year	3,254	2,945	2,845
Imports: Naphtha − 400 ° API	280	---------	40
Exports: Other	2,995	2,795	3,849
Domestic demand:			
Still gas	9,532	9,844	9,985
Naphtha − 400 ° API	50,349	55,618	57,569
Other	24,054	27,474	27,093
Total domestic demand	83,935	92,936	94,647
Special naphthas:			
Production:			
At refineries	26,912	27,643	28,397
At gas processing plants	51	473	492
Total production	26,963	28,116	28,889
Stocks end of year:			
At refineries	5,742	5,816	6,281
At plants	6	13	11
Total stocks	5,748	5,829	6,292
Imports	375	1,399	3,191
Exports	1,976	2,427	2,018
Domestic demand	25,203	27,007	29,599
Lubricants:			
Production	64,870	65,684	65,080
Stocks end of year	14,774	14,023	14,088
Imports	40	33	163
Exports:			
Grease	357	298	271
Oil	18,338	17,703	16,166
Total exports	18,695	18,001	16,437
Domestic demand	44,123	48,467	48,741
Wax (1 bbl = 280 lb.):			
Production	5,719	5,887	6,362
Stocks end of year	1,045	1,001	997
Imports	20	17	158
Exports	1,687	1,588	1,621
Domestic demand	3,868	4,360	4,903
Coke (5 bbl = 1 short ton):			
Production:			
Marketable coke	42,944	45,823	52,006
Catalyst coke	47,989	49,367	50,862
Total production	90,933	95,190	102,868
Stocks end of year	6,821	6,195	5,198
Exports	16,279	19,497	23,030
Domestic demand	75,130	76,319	80,835
Asphalt (5.5 bbl. = 1 short ton):			
Production	127,767	135,460	135,691
Stocks end of year	19,939	20,055	16,753
Imports	6,447	6,236	4,761
Exports	459	429	463
Domestic demand	131,125	141,151	143,291

See footnotes at end of table.

Table 30.—Salient statistics of the major refined petroleum products in the United States—Continued

(Thousand barrels)

Product	1967	1968	1969 p
Road oil:			
Production	6,978	6,826	9,086
Stocks end of year	804	550	880
Domestic demand	7,093	7,080	8,756
Still gas for fuel: Production	140,034	149,796	160,363
Miscellaneous products:			
Production:			
At refineries	14,919	15,711	17,139
At gas processing plants	1,566	3,385	805
Total production	16,485	19,096	17,944
Stocks end of year:			
At refineries	1,703	1,931	2,345
At plants	48	25	19
Total stocks	1,751	1,956	2,364
Exports	903	1,049	919
Domestic demand	15,995	17,842	16,617
Unfinished oils (net):			
Input (+) or output (−)	+34,237	+26,152	+33,588
Stocks end of year	90,201	93,399	97,819
Imports	35,225	29,350	38,008

p Preliminary.
[1] Produced at petroleum refineries. Data for LRG for petrochemical feedstocks are included with those for "Liquefied gases."
Note: "Stocks at refineries" include stocks at refineries and bulk terminals operated by refining and refined products pipeline companies, including pipeline fill. "Stocks at plants" include stocks at plants and terminals operated by natural gas processing companies and natural gas liquids stocks at terminals of pipeline companies, including pipeline fill.

Table 31.—Stocks of refined petroleum products in the United States at end of month

(Thousand barrels)

Product	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1968												
Gasoline:												
Motor	212,772	216,430	215,814	202,756	196,435	194,548	186,762	179,783	188,730	186,549	191,845	204,496
Aviation	7,641	7,755	7,585	6,732	6,617	6,402	6,380	6,339	6,345	6,660	7,024	7,030
Total	220,413	224,185	223,399	209,488	203,052	200,950	193,142	186,122	195,075	193,209	198,869	211,526
Jet fuel:												
Naphtha-type	9,263	9,154	8,486	8,493	8,670	8,443	9,270	8,593	9,408	8,765	9,228	8,904
Kerosine-type	13,653	13,854	14,275	14,610	16,505	15,196	15,578	15,840	15,704	16,071	15,537	15,373
Total	22,916	23,008	22,761	23,103	25,175	23,639	24,848	24,433	25,112	24,836	24,765	24,277
Ethane	2,130	2,056	2,203	2,382	2,341	2,242	2,300	2,355	2,369	2,295	2,231	2,212
Liquefied gases [1]	51,685	46,915	49,165	57,335	66,091	73,207	78,834	84,205	89,500	88,491	83,313	73,948
Kerosine	19,250	16,712	16,360	18,583	20,912	23,040	25,689	27,188	28,036	28,936	27,094	23,480
Distillate fuel oil	119,802	96,869	93,499	101,174	115,777	139,517	168,116	191,391	205,976	211,847	204,047	173,158
Residual fuel oil	58,585	55,074	60,472	62,830	66,910	67,566	72,448	74,312	75,803	76,940	74,041	67,359
Petrochemical feedstocks	3,328	3,330	2,932	2,914	2,891	2,990	3,172	2,808	2,827	2,949	3,126	2,945
Special naphthas	5,812	5,506	5,299	5,537	5,812	5,672	5,517	5,696	5,453	5,732	5,823	5,829
Lubricants	15,092	15,064	14,983	14,673	14,359	14,362	13,634	13,767	13,512	13,664	13,796	14,023
Wax	1,036	1,052	1,047	1,079	1,015	1,052	1,052	1,047	989	958	927	1,001
Coke	6,709	6,487	6,518	6,088	6,095	6,297	6,299	6,407	6,597	6,163	6,200	6,195
Asphalt	22,675	25,001	26,902	27,578	27,757	26,918	22,993	19,093	17,233	15,035	17,389	20,055
Road oil	885	955	1,167	1,240	1,401	1,363	1,185	866	753	603	521	550
Miscellaneous	1,736	1,902	1,915	1,826	1,824	1,991	1,811	1,786	2,005	2,035	2,081	1,956
Unfinished oils	87,946	87,806	89,009	93,775	100,065	97,698	97,365	95,819	92,938	95,975	94,609	93,399
Total 1968	639,950	611,922	617,631	629,605	661,477	688,504	718,400	737,295	764,178	769,668	758,832	721,913
1969												
Gasoline:												
Motor	207,972	216,015	222,595	210,668	202,134	196,461	187,772	183,908	188,804	189,473	202,538	211,199
Aviation	6,492	6,535	6,602	5,969	5,543	5,347	5,303	5,466	5,448	5,562	5,824	6,193
Total	214,464	222,550	229,197	216,637	207,677	201,808	193,075	189,374	194,252	195,035	208,362	217,392
Jet fuel:												
Naphtha-type	8,738	8,840	8,445	8,520	8,654	8,896	9,320	8,880	8,863	9,152	9,058	8,556
Kerosine-type	14,176	16,094	17,123	18,268	19,663	19,515	20,536	21,347	20,003	20,141	20,473	19,517
Total	22,914	24,934	25,568	26,788	28,317	28,411	29,856	30,227	28,866	29,293	29,531	28,073
Ethane (including ethylene)	2,121	2,018	1,924	2,123	2,099	2,116	2,188	1,869	1,803	2,061	2,099	2,182
Liquefied gases [1]	56,264	50,476	49,764	55,082	63,549	70,349	76,337	80,574	81,842	77,864	69,414	57,420
Kerosine	19,355	18,586	18,909	20,330	21,989	25,331	27,289	29,735	30,106	30,631	29,429	26,780
Distillate fuel oil	130,609	106,650	96,563	99,826	110,925	132,650	159,081	183,515	197,653	207,986	200,969	171,714
Residual fuel oil	62,957	59,930	57,188	60,213	62,570	62,511	65,144	66,062	65,593	64,225	62,665	60,395

See footnotes at end of table.

Table 31.—Stocks of refined petroleum products in the United States at end of month—Continued

(Thousand barrels)

Product	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1969—Continued												
Petrochemical feedstocks	3,096	2,789	2,776	2,410	2,549	2,603	2,848	2,736	3,075	3,095	3,061	2,845
Special naphthas	5,352	5,955	6,231	5,708	6,180	6,075	5,916	5,794	6,024	5,768	5,957	6,292
Lubricants	13,861	13,824	14,019	13,918	13,453	12,784	12,834	12,799	12,679	12,495	13,617	14,088
Wax	977	931	989	1,041	1,067	1,036	988	1,030	988	946	998	997
Coke	6,490	6,495	6,307	6,545	6,591	6,908	6,570	6,175	5,655	6,124	6,184	5,198
Asphalt	21,926	24,360	27,335	28,444	28,303	26,104	23,357	19,502	16,103	13,177	14,002	16,753
Road oil	686	809	1,180	1,279	1,398	1,411	1,302	1,426	1,157	938	868	880
Miscellaneous	1,749	1,780	1,942	1,928	1,657	1,940	2,128	2,127	1,914	1,830	1,984	2,364
Unfinished oils	90,528	93,335	94,411	100,759	105,318	104,081	101,914	97,454	97,818	97,976	95,609	97,819
Total 1969	653,349	635,422	634,303	643,031	663,642	686,118	710,827	730,399	745,528	749,444	744,749	711,192

[1] Includes LRG used for petrochemical feedstocks.

Table 32.—Input and output of petroleum products at refineries in the United States

(Thousand barrels)

	1965	1966	1967	1968	1969 p
INPUT					
Crude petroleum:					
Domestic	2,847,821	3,000,789	3,174,004	3,308,044	3,364,360
Foreign	453,021	446,404	408,590	[1] 466,316	[1] 515,738
Total crude petroleum	3,300,842	3,447,193	3,582,594	3,774,360	3,880,098
Unfinished oils rerun (net)	32,111	34,632	34,237	26,152	33,588
Total crude and unfinished oils rerun	3,332,953	3,481,825	3,616,831	3,800,512	3,913,686
Natural gas liquids:					
Liquefied petroleum gases	67,419	68,403	68,675	72,652	72,764
Natural gasoline	129,552	133,484	138,521	148,132	157,492
Plant condensate	28,705	33,693	37,524	38,552	34,332
Total natural gas liquids	225,676	235,580	244,720	259,336	264,588
Other hydrocarbons and hydrogen [2]	13	30	87	3,377	4,213
OUTPUT					
Gasoline:					
Motor gasoline [3]	1,645,172	1,742,456	1,801,448	1,902,264	1,995,947
Aviation gasoline	48,569	41,244	37,074	31,563	26,460
Total gasoline [3]	1,693,741	1,783,700	1,838,522	1,933,827	2,022,407
Jet fuel:					
Naphtha-type [3]	82,416	89,473	109,650	121,165	104,748
Kerosine-type	108,639	125,973	163,535	193,486	216,952
Total jet fuel [3]	191,055	215,446	273,185	314,651	321,700
Ethane (including ethylene)	(4)	(4)	7,028	9,446	9,159
Liquefied refinery gas:					
For fuel use	56,125	60,090	67,589	71,102	75,659
For chemical use	50,711	46,128	36,900	37,539	38,703
Total liquefied refinery gas	106,836	106,218	104,489	108,641	114,362
Kerosine [3]	93,149	100,849	99,061	100,545	101,738
Distillate fuel oil [3]	765,071	784,717	804,429	839,373	846,863
Residual fuel oil	268,567	263,961	275,956	275,814	265,906
Petrochemical feedstocks:					
Still gas	8,926	10,068	9,500	9,844	9,985
Naphtha − 400°	24,511	38,446	50,573	55,077	57,389
Other	24,414	25,939	27,355	30,501	30,982
Total petrochemical feedstocks	57,851	74,453	87,428	95,422	98,356
Special naphthas [3]	28,734	29,634	26,912	27,643	28,397
Lubricants	62,925	65,407	64,870	65,684	65,080
Wax [5]	5,456	5,772	5,719	5,887	6,362
Coke [5]	86,040	88,054	90,933	95,190	102,868
Asphalt [5]	123,604	129,579	127,767	135,460	135,691
Road oil	6,565	7,247	6,978	6,826	9,086
Still gas for fuel	135,295	135,459	140,034	149,796	160,363
Miscellaneous [3]	13,994	16,474	14,919	15,711	17,139
Processing gain (−) or loss (+)	−80,241	−89,535	−106,592	−116,691	−122,990

p Preliminary.
[1] Includes some Athabasca hydrocarbons.
[2] Benzol included for 1965–67 only. "Other hydrocarbons and hydrogen" is defined as including all hydrogen, process natural gas, tar sand bitumen, gilsonite, shale oil, and other naturally occurring hydrocarbon mixtures consumed as raw materials in the production of finished products.
[3] Production at natural gasoline plants shown as direct transfers and omitted from input and output at refineries.
[4] Included with liquefied refinery gases.
[5] Conversion factors: 280 pounds of wax to the barrel; 5.0 barrels of coke to the short ton; 5.5 barrels of asphalt to the short ton.

Table 33.—Percentage yields of refined petroleum products from crude oil in the United States [1]

Finished products	1965	1966	1967	1968	1969 p
Gasoline	44.0	44.4	44.0	43.9	44.8
Jet fuel	5.7	6.2	7.5	8.3	8.2
Ethane (including ethylene)	(2)	(2)	(2)	(2)	.2
Liquefied gases	3.2	3.0	3.1	3.1	2.9
Kerosine	2.8	2.9	2.7	2.7	2.6
Distillate fuel oil	22.9	22.5	22.2	22.1	21.7
Residual fuel oil	8.1	7.6	7.7	7.2	6.8
Petrochemical feedstocks	1.7	2.1	2.4	2.5	2.5
Special naphthas	.9	.9	.8	.7	.7
Lubricants	1.9	1.8	1.8	1.7	1.7
Wax	.2	.2	.2	.2	.2
Coke	2.5	2.5	2.5	2.5	2.6
Asphalt	3.7	3.8	3.5	3.6	3.5
Road oil	.2	.2	.2	.1	.2
Still gas	4.1	3.9	3.9	4.0	4.1
Miscellaneous	.5	.5	.4	.4	.4
Shortage	−2.4	−2.5	−2.9	−3.0	−3.1
Total	100.0	100.0	100.0	100.0	100.0

p Preliminary.
[1] Other unfinished oils added to crude in computing yields.
[2] Included with liquefied gases.

Table 34.—Input and output at refineries in the United States, by months

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
INPUT 1968													
Crude petroleum:													
Domestic	279,642	268,151	279,536	268,027	287,427	270,038	284,115	285,153	268,029	277,183	261,387	279,356	3,308,044
Foreign	33,230	28,879	33,235	31,482	36,653	40,131	44,011	43,307	44,342	42,304	43,374	45,368	[1] 466,316
Total crude petroleum	312,872	297,030	312,771	299,509	324,080	310,169	328,126	328,460	312,371	319,487	304,761	324,724	3,774,360
Unfinished oils rerun (net)	4,242	2,481	635	−2,687	−3,823	4,896	3,759	4,010	5,584	−248	3,723	3,580	26,152
Total crude and unfinished oils rerun	317,114	299,511	313,406	296,822	320,257	315,065	331,885	332,470	317,955	319,239	308,484	328,304	3,800,512
Natural gas liquids:													
Liquefied petroleum gases	6,984	5,778	5,241	4,529	4,469	4,433	4,950	5,787	6,065	7,523	8,221	8,672	72,652
Natural gasoline	12,117	10,348	11,422	12,345	13,072	12,640	12,801	13,157	12,597	12,835	12,561	12,237	148,132
Plant condensate	3,390	3,102	3,180	3,116	3,102	3,459	3,170	3,100	3,917	2,876	3,026	3,114	38,552
Total natural gas liquids	22,491	19,228	19,843	19,990	20,643	20,532	20,921	22,044	22,579	23,234	23,808	24,023	259,336
Other hydrocarbons	86	221	286	313	270	269	326	350	380	265	304	307	3,377
OUTPUT 1968													
Gasoline:													
Motor gasoline [2]	156,488	144,882	149,999	144,136	157,403	159,281	166,720	167,078	163,716	163,061	159,438	170,062	1,902,264
Aviation gasoline	2,332	2,165	2,873	2,353	2,785	2,534	3,126	2,736	2,978	2,987	2,405	2,289	31,563
Total gasoline [2]	158,820	147,047	152,872	146,489	160,188	161,815	169,846	169,814	166,694	166,048	161,843	172,351	1,933,827
Jet fuel:													
Naphtha-type [2]	8,760	8,672	9,512	10,866	11,201	9,541	9,837	10,252	11,035	11,981	10,261	9,247	121,165
Kerosine-type	15,269	15,103	15,802	15,600	16,291	15,221	17,069	17,260	16,352	17,318	15,562	16,639	193,486
Total jet fuel [2]	24,029	23,775	25,314	26,466	27,492	24,762	26,906	27,512	27,387	29,299	25,823	25,886	314,651
Ethane (including ethylene)	821	739	737	808	833	788	691	692	925	760	796	856	9,446
Liquefied gases (including ethane):													
LRG for fuel use	5,789	5,582	6,332	5,705	6,778	6,006	6,291	6,337	5,711	5,503	5,283	5,785	71,102
LRG for chemical use	3,036	2,884	3,173	3,215	3,339	3,171	3,080	3,465	3,138	3,019	2,847	3,172	37,539
Total liquefied gases	8,825	8,466	9,505	8,920	10,117	9,177	9,371	9,802	8,849	8,522	8,130	8,957	108,641
Kerosine [2]	10,208	9,602	9,276	7,726	8,125	6,811	6,904	7,530	7,358	8,634	8,616	9,755	100,545
Distillate fuel oil [2]	74,258	74,377	77,212	64,976	68,684	68,990	71,624	70,398	65,958	65,878	65,914	71,104	839,373
Residual fuel oil	27,697	24,538	24,726	22,761	22,658	19,693	21,249	21,401	19,432	20,366	23,652	27,641	275,814
Petrochemical feedstocks:													
Still gas	875	786	878	792	789	774	765	846	875	864	727	873	9,844
Naphtha −400°F	4,797	4,624	3,747	4,592	4,811	4,934	4,397	4,266	4,481	4,943	4,818	4,667	55,077
Other	2,340	2,256	2,527	2,303	2,769	2,535	2,741	2,865	2,437	2,899	2,229	2,600	30,501

See footnotes at end of table.

Table 34.—Input and output at refineries in the United States, by months—Continued

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Petrochemical feedstocks—Continued													
Total petrochemical feedstocks	8,012	7,666	7,152	7,687	8,369	8,243	7,903	7,977	7,793	8,706	7,774	8,140	95,422
Special naphthas [2]	2,140	2,041	2,255	2,287	2,579	2,230	2,358	2,461	2,384	2,478	2,169	2,261	27,643
Lubricants:													
Bright stock	422	502	553	549	398	383	496	498	505	484	512	506	5,808
Neutral	2,369	2,098	2,342	2,417	2,511	2,301	2,594	2,583	2,297	2,436	2,629	2,325	28,902
Other grades	2,313	2,416	2,541	2,561	2,835	2,634	2,372	2,616	2,757	2,920	2,406	2,603	30,974
Total lubricants	5,104	5,016	5,436	5,527	5,744	5,318	5,462	5,697	5,559	5,840	5,547	5,434	65,684
Wax:													
Microcrystalline	94	100	124	93	109	87	110	102	102	109	90	89	1,209
Fully refined	183	231	246	259	231	297	237	228	208	232	255	203	2,810
Other	175	142	127	148	144	145	170	156	153	144	174	190	1,868
Total wax [3]	452	473	497	500	484	529	517	486	463	485	519	482	5,887
Coke [3]	7,676	7,486	7,921	7,419	7,861	7,805	8,178	8,461	8,134	8,112	7,883	8,254	95,190
Asphalt [3]	6,361	6,244	7,299	9,846	12,990	14,155	15,285	15,663	14,835	14,028	10,943	7,811	135,460
Road oil	222	254	452	387	681	879	1,115	1,118	796	518	218	186	6,826
Still gas for fuel	13,297	10,486	11,488	11,529	12,735	13,132	13,993	13,629	12,851	12,490	11,696	12,470	149,796
Miscellaneous products [2]	1,033	1,264	1,227	1,432	1,347	1,377	1,371	1,470	1,374	1,354	1,256	1,206	15,711
Processing gain (−) or loss (+)	−9,264	−10,514	−9,834	−7,635	−9,717	−9,838	−9,641	−9,247	−9,878	−10,780	−10,183	−10,160	−116,691
INPUT 1969 p													
Crude petroleum:													
Domestic	262,052	261,730	283,299	269,496	284,561	282,944	294,965	288,632	279,789	282,070	278,253	296,569	3,364,360
Foreign	41,791	37,584	42,419	42,583	41,597	41,718	44,202	46,237	44,574	43,705	43,373	45,955	[1] 515,738
Total crude petroleum	303,843	299,314	325,718	312,079	326,158	324,662	339,167	334,869	324,363	325,775	321,626	342,524	3,880,098
Unfinished oils rerun (net)	5,055	776	1,647	−3,792	−2,100	4,081	4,928	7,980	3,692	2,648	6,091	2,582	33,588
Total crude and unfinished oils rerun	308,898	300,090	327,365	308,287	324,058	328,743	344,095	342,849	328,055	328,423	327,717	345,106	3,913,686
Natural gas liquids:													
Liquefied petroleum gases	7,102	5,765	5,180	4,328	4,903	4,605	4,733	5,078	5,934	7,698	8,139	9,299	72,764
Natural gasoline	12,556	11,185	12,675	12,938	13,298	13,014	13,841	13,505	13,741	13,673	13,553	13,513	157,492
Plant condensate	3,173	2,834	2,978	2,725	2,775	2,862	2,661	2,947	2,810	2,823	2,874	2,870	34,332
Total natural gas liquids	22,831	19,784	20,833	19,991	20,976	20,481	21,235	21,530	22,485	24,194	24,566	25,682	264,588
Other hydrocarbons	275	291	399	363	321	331	473	379	374	337	349	321	4,213
OUTPUT 1969 p													
Gasoline:													
Motor gasoline [2]	157,198	149,446	160,671	151,830	164,359	163,213	174,681	176,578	171,640	174,301	172,559	179,471	1,995,947
Aviation gasoline	1,494	1,651	2,693	2,002	2,218	2,363	2,641	2,515	2,205	2,346	2,228	2,104	26,460
Total gasoline [2]	158,692	151,097	163,364	153,832	166,577	165,576	177,322	179,093	173,845	176,647	174,787	181,575	2,022,407

Jet fuel:													
Naphtha-type [2]	7,780	8,077	10,079	9,161	9,729	10,009	10,707	9,090	7,947	7,614	7,175	7,380	104,748
Kerosine-type	16,704	17,286	16,748	18,299	18,083	18,187	18,535	18,516	17,149	18,635	18,448	20,362	216,952
Total jet fuel [2]	24,484	25,363	26,827	27,460	27,812	28,196	29,242	27,606	25,096	26,249	25,623	27,742	321,700
Ethane (including ethylene)	782	679	881	683	732	699	723	773	757	805	798	847	9,159
Liquefied gases (including ethane):													
LRG for fuel use	5,343	5,454	6,124	5,924	6,660	6,700	7,240	6,752	6,499	6,284	6,309	6,370	75,659
LRG for chemical use	2,959	2,964	3,519	3,638	3,441	3,318	3,363	3,611	3,001	3,074	2,837	2,978	38,703
Total liquefied gases	8,302	8,418	9,643	9,562	10,101	10,018	10,603	10,363	9,500	9,358	9,146	9,348	114,362
Kerosine [2]	11,148	10,932	10,287	7,162	7,015	7,769	7,442	7,516	7,317	7,493	7,936	9,721	101,738
Distillate fuel oil [2]	69,232	66,279	73,879	66,580	67,165	71,137	73,465	70,838	68,811	70,365	72,379	76,733	846,863
Residual fuel oil	27,873	25,126	25,336	23,595	21,239	19,403	19,493	19,250	19,536	19,543	21,439	24,073	265,906
Petrochemical feedstocks:													
Still gas	747	711	909	791	789	877	864	995	794	895	794	819	9,985
Naphtha −400°	4,768	4,253	5,175	4,279	4,810	4,779	4,416	5,174	4,961	5,164	4,636	4,974	57,389
Other	2,187	2,292	2,403	2,389	2,503	2,649	2,806	2,647	2,394	3,046	2,781	2,885	30,982
Total petrochemical feedstocks	7,702	7,256	8,487	7,459	8,102	8,305	8,086	8,816	8,149	9,105	8,211	8,678	98,356
Special naphthas [2]	1,941	2,291	2,335	2,152	2,600	2,577	2,316	2,436	2,501	2,368	2,410	2,470	28,397
Lubricants:													
Bright stock	361	504	564	503	522	518	630	431	463	451	611	611	6,169
Neutral	2,421	1,849	2,483	2,612	2,779	2,163	2,102	2,279	2,202	2,390	2,726	2,589	28,595
Other grades	1,924	2,078	2,570	2,376	2,376	2,590	2,782	3,062	2,714	2,812	2,486	2,546	30,316
Total lubricants	4,706	4,431	5,617	5,491	5,677	5,271	5,514	5,772	5,379	5,653	5,823	5,746	65,080
Wax:													
Microcrystalline	85	70	123	98	145	96	108	116	100	108	146	82	1,277
Fully refined	263	187	249	239	242	258	188	234	231	242	218	301	2,852
Other	90	209	263	210	249	160	189	184	150	191	171	167	2,233
Total wax [3]	438	466	635	547	636	514	485	534	481	541	535	550	6,362
Coke [3]	7,407	7,411	8,375	8,369	8,445	8,857	9,055	8,759	8,672	8,977	9,135	9,406	102,868
Asphalt [3]	5,527	6,191	8,476	10,235	12,939	14,348	15,154	14,926	15,082	13,464	10,367	8,982	135,691
Road oil	260	170	502	364	782	1,105	1,282	1,814	1,209	895	432	271	9,086
Still gas for fuel	11,906	11,425	12,293	12,640	13,633	13,929	14,355	14,504	14,469	13,422	14,000	13,787	160,363
Miscellaneous products [2]	1,269	1,339	1,390	1,324	1,363	1,598	1,581	1,401	1,415	1,413	1,483	1,563	17,139
Processing gain (−) or loss (+)	−9,665	−8,709	−9,730	−8,814	−9,463	−9,747	−10,315	−9,643	−11,305	−13,344	−11,872	−10,383	−122,990

p Preliminary.
[1] Includes some Athabasca hydrocarbons.
[2] Production at gas processing plants shown as direct transfers and omitted from the input and output at refineries.
[3] Conversion factors: 280 pounds of wax to the barrel; 5.0 barrels of coke to the short ton; 5.5 barrels of asphalt to the short ton.

Table 35.—Input and output at refineries

(Thousand

Item	PAD district I			PAD district II				
	East Coast	Appalachian No. 1	Total	Appalachian No. 2	Ind., Ill. etc.	Minn., Wis., etc.	Okla. Kans., etc.	Total
INPUT 1968								
Crude petroleum:								
Domestic	193,388	24,942	218,330	20,873	634,359	25,242	324,009	1,004,483
Foreign	237,376	21,370	258,746	834	[1] 35,193	42,308	59	[1] 78,394
Total crude petroleum	430,764	46,312	477,076	21,707	669,552	67,550	324,068	1,082,877
Unfinished oils rerun (net)	42,388	1,406	43,794	506	−1,625	79	−806	−1,846
Total crude and unfinished oils rerun	473,152	47,718	520,870	22,213	667,927	67,629	323,262	1,081,031
Natural gas liquids:								
Liquefied petroleum gases	2,031	53	2,084	106	9,342	2,671	8,773	20,892
Natural gasoline	2,385	8	2,393	15	12,305	258	11,113	23,691
Plant condensate	956	21	977	------	183	436	-------	619
Total natural gas liquids	5,372	82	5,454	121	21,830	3,365	19,886	45,202
Other hydrocarbons	-------	------	-------	------	-------	------	140	140
OUTPUT 1968								
Gasoline:								
Motor gasoline [2]	213,140	18,134	231,274	11,732	360,036	37,119	186,046	594,933
Aviation gasoline	1,238	10	1,248	------	2,703	------	830	3,533
Total gasoline [2]	214,378	18,144	232,522	11,732	362,739	37,119	186,876	598,466
Jet fuel:								
Naphtha-type [2]	7,078	838	7,916	6	10,213	978	8,661	19,858
Kerosine-type	11,418	526	11,944	29	27,658	165	11,402	39,254
Total jet fuel [2]	18,496	1,364	19,860	35	37,871	1,143	20,063	59,112
Ethane (including ethylene)	-------	------	-------	------	-------	------	-------	---------
Liquefied gases (including ethane):								
LRG for fuel use	11,307	868	12,175	339	10,342	1,241	9,330	21,252
LRG for chemical use	4,314	38	4,352	------	2,047	------	744	2,791
Total liquefied gases	15,621	906	16,527	339	12,389	1,241	10,074	24,043
Kerosine [2]	11,669	1,327	12,996	809	17,691	2,638	4,976	26,114
Distillate fuel oil [2]	120,821	11,759	132,580	4,528	135,746	16,780	76,681	233,735
Residual fuel oil	36,129	4,700	40,829	1,807	42,563	5,930	5,750	56,050
Petrochemical feedstocks:								
Still gas	1,505	------	1,505	------	1,370	146	21	1,537
Naphtha −400°	3,318	------	3,318	------	4,113	------	1,861	5,974
Other	1,152	464	1,616	------	2,376	------	609	2,985
Total petrochemical feedstocks	5,975	464	6,439	------	7,859	146	2,491	10,496
Special naphthas [2]	1,044	354	1,398	397	3,651	------	1,801	5,849
Lubricants:								
Bright stock	501	1,266	1,767	------	613	------	854	1,467
Neutral	2,233	1,845	4,078	250	4,092	------	3,434	7,776
Other grades	3,715	760	4,475	------	1,218	------	1,364	2,582
Total lubricants	6,449	3,871	10,320	250	5,923	------	5,652	11,825
Wax:								
Microcrystalline	298	233	531	------	37	------	249	286
Fully refined	1,042	41	1,083	30	242	------	263	535
Other	666	231	897	23	134	------	63	220
Total wax [3]	2,006	505	2,511	53	413	------	575	1,041
Coke [3]	12,766	147	12,913	88	18,531	2,901	8,441	29,961
Asphalt [3]	27,478	1,760	29,238	1,823	31,105	2,674	13,697	49,299
Road oil	-------	621	621	------	1,276	212	932	2,420
Still gas for fuel	18,442	1,811	20,253	954	30,161	2,188	12,204	45,507
Miscellaneous products [2]	1,597	109	1,706	8	1,427	122	1,232	2,789
Processing gain (−) or loss (+)	−14,347	−42	−14,389	−489	−19,588	−2,100	−8,157	−30,334

See footnotes at end of table.

in the United States by districts

barrels)

PAD district III						PAD district IV	PAD district V	
Texas Inland	Texas Gulf	La. Gulf	Ark., La., Inland etc.	New Mex.	Total	Other Rocky Mt.	West Coast	United States
135,372	861,995	444,472	51,123	13,411	1,506,373	124,008	454,850	3,308,044
----------	----------	748	----------	----------	748	9,867	118,561	[1] 466,316
135,372	861,995	445,220	51,123	13,411	1,507,121	133,875	573,411	3,774,360
−510	−17,412	−7,407	405	−22	−24,946	−295	9,445	26,152
134,862	844,583	437,813	51,528	13,389	1,482,175	133,580	582,856	3,800,512
8,091	19,202	9,940	1,138	539	38,910	2,944	7,822	72,652
14,381	68,115	19,551	1,076	542	103,665	2,189	16,194	148,132
56	30,831	1,967	3,101	----------	35,955	350	651	38,552
22,528	118,148	31,458	5,315	1,081	178,530	5,483	24,667	259,336
3	221	560	----------	----------	784	166	2,287	3,377
84,035	414,435	212,266	24,016	8,030	742,782	68,612	264,663	1,902,264
2,596	10,296	5,888	----------	----------	18,780	616	7,386	31,563
86,631	424,731	218,154	24,016	8,030	761,562	69,228	272,049	1,933,827
10,233	31,553	14,305	1,683	1,586	59,360	3,537	30,494	121,165
9,201	33,133	46,253	69	----------	88,656	3,578	50,054	193,486
19,434	64,686	60,558	1,752	1,586	148,016	7,115	80,548	314,651
103	6,342	2,213	----------	----------	8,658	----------	788	9,446
3,104	13,619	8,836	1,320	287	27,166	1,971	8,538	71,102
282	19,572	6,801	185	----------	26,840	12	3,544	37,539
3,386	33,191	15,637	1,505	287	54,006	1,983	12,082	108,641
1,504	38,716	17,137	1,637	122	59,116	1,629	690	100,545
22,840	229,489	102,053	12,258	2,351	368,991	32,138	71,929	839,373
4,562	41,336	11,453	2,282	382	60,015	10,765	108,155	275,814
----------	5,986	----------	----------	----------	5,986	134	682	9,844
1,566	37,863	1,740	712	----------	41,881	----------	3,904	55,077
2,628	8,495	12,493	311	188	24,115	355	1,430	30,501
4,194	52,344	14,233	1,023	188	71,982	489	6,016	95,422
980	14,427	568	859	----------	16,834	144	3,418	27,643
----------	1,589	590	----------	----------	2,179	45	350	5,808
----------	9,272	5,634	520	----------	15,426	257	1,365	28,902
156	17,355	1,172	1,472	----------	20,155	55	3,707	30,974
156	28,216	7,396	1,992	----------	37,760	357	5,422	65,684
80	235	66	----------	----------	381	11	----------	1,209
----------	579	306	----------	----------	885	60	247	2,810
----------	424	84	----------	----------	508	18	225	1,868
80	1,238	456	----------	----------	1,774	89	472	5,887
2,289	17,351	10,858	2,147	192	32,837	3,272	16,207	95,190
6,285	7,694	9,782	6,349	684	30,794	7,686	18,443	135,460
52	112	----------	----------	----------	164	2,033	1,588	6,826
4,883	29,914	13,770	2,335	569	51,471	4,699	27,866	149,796
1,140	5,279	1,117	7	----------	7,543	53	3,620	15,711
−1,126	−32,114	−15,554	−1,319	+79	−50,034	−2,451	−19,483	−116,691

Table 35.—Input and output at refineries

(Thousand

Item	PAD district I			PAD district II				
	East Coast	Appalachian No. 1	Total	Appalachian No. 2	Ind., Ill. etc.	Minn., Wis., etc.	Okla. Kans., etc.	Total
INPUT 1969 p								
Crude petroleum:								
Domestic	182,178	23,122	205,300	22,711	643,645	23,309	322,552	1,012,217
Foreign	247,029	26,286	273,315	100	[1] 38,093	49,120	143	[1] 87,456
Total crude petroleum	429,207	49,408	478,615	22,811	681,738	72,429	322,695	1,099,673
Unfinished oils rerun (net)	64,085	1,268	65,353	203	−2,228	−10	1,167	−868
Total crude and unfinished oils rerun	493,292	50,676	543,968	23,014	679,510	72,419	323,862	1,098,805
Natural gas liquids:								
Liquefied petroleum gases	2,449	9	2,458	127	8,773	2,903	9,390	21,193
Natural gasoline	1,867	4	1,871	4	9,873	725	11,569	22,171
Plant condensate	801	23	824	------	291	413	------	704
Total natural gas liquids	5,117	36	5,153	131	18,937	4,041	20,959	44,068
Other hydrocarbons	350	------	350	------	------	------	215	215
OUTPUT 1969 p								
Gasoline:								
Motor gasoline [2]	231,200	20,510	251,710	12,086	370,221	39,572	188,928	610,807
Aviation gasoline	831	------	831	------	2,088	------	655	2,743
Total gasoline [2]	232,031	20,510	252,541	12,086	372,309	39,572	189,583	613,550
Jet fuel:								
Naphtha-type [2]	5,104	722	5,826	------	7,234	1,028	9,272	17,534
Kerosine-type	11,716	573	12,289	22	30,144	1,464	10,555	42,185
Total jet fuel [2]	16,820	1,295	18,115	22	37,378	2,492	19,827	59,719
Ethane (including ethylene)	------	------	------	------	------	------	122	122
Liquefied gases (including ethane):								
LRG for fuel use	12,021	889	12,910	259	10,528	1,427	8,814	21,028
LRG for chemical use	4,720	------	4,720	------	2,552	------	816	3,368
Total liquefied gases	16,741	889	17,630	259	13,080	1,427	9,630	24,396
Kerosine [2]	12,180	1,198	13,378	824	17,078	1,534	4,534	23,970
Distillate fuel oil [2]	124,465	12,342	136,807	5,129	135,896	17,687	78,224	236,936
Residul fuel oil	37,703	4,554	42,257	1,821	43,205	5,890	5,830	56,746
Petrochemical feedstocks:								
Still gas	1,490	------	1,490	------	1,347	------	------	1,347
Naphtha −400°	2,523	------	2,523	------	3,526	------	1,824	5,350
Other	860	557	1,417	------	2,665	------	656	3,321
Total petrochemical feedstocks	4,873	557	5,430	------	7,538	------	2,480	10,018
Special naphthas [2]	734	372	1,106	293	3,821	------	1,385	5,499
Lubricants:								
Bright stock	275	1,202	1,477	------	501	------	802	1,303
Neutral	2,261	1,904	4,165	112	3,787	------	3,497	7,396
Other grades	4,143	764	4,907	------	1,811	------	1,317	3,128
Total lubricants	6,679	3,870	10,549	112	6,099	------	5,616	11,827
Wax:								
Microcrystalline	331	252	583	------	37	------	262	299
Fully refined	1,037	44	1,081	14	228	------	256	498
Other	657	280	937	------	141	------	51	192
Total wax [3]	2,025	576	2,601	14	406	------	569	989
Coke [3]	13,429	147	13,576	96	18,173	3,037	8,641	29,947
Asphalt [3]	27,294	1,676	28,970	1,802	29,921	3,807	13,365	48,895
Road oil	------	585	585	------	3,179	245	1,030	4,454
Still gas for fuel	18,612	2,013	20,625	984	31,016	2,725	13,080	47,805
Miscellaneous products [2]	1,785	155	1,940	14	1,275	122	1,325	2,736
Processing gain (−) or loss (+)	−16,612	−27	−16,639	−311	−21,927	−2,078	−10,205	−34,521

p Preliminary.
[1] Includes some Athabasca hydrocarbons.
[2] Production at gas processing plants shown as direct transfers and omitted from the input and output at refineries.
[3] Conversion factors: 280 pounds of wax to the barrel; 5.0 barrels of coke to the short ton; 5.5 barrels of asphalt to the short ton.

in the United States, by districts—Continued

barrels)

PAD district III						PAD district IV	PAD district V	
Texas Inland	Texas Gulf	La. Gulf	Ark., La., Inland etc.	New Mex.	Total	Other Rocky Mt.	West Coast	United States
141,656	878,486	469,150	52,675	14,209	1,556,176	128,039	462,628	3,364,360
----------	----------	12	----------	----------	12	12,605	142,350	[1] 515,738
141,656	878,486	469,162	52,675	14,209	1,556,188	140,644	604,978	3,880,098
−713	−30,700	−6,856	1,237	−6	−37,038	379	5,762	33,588
140,943	847,786	462,306	53,912	14,203	1,519,150	141,023	610,740	3,913,686
7,870	19,435	9,362	1,017	538	38,222	3,539	7,352	72,764
14,459	79,212	20,954	843	605	116,073	1,974	15,403	157,492
28	26,554	2,439	2,987	----------	32,008	271	525	34,332
22,357	125,201	32,755	4,847	1,143	186,303	5,784	23,280	264,588
----------	178	480	----------	----------	658	203	2,787	4,213
87,615	436,493	226,029	25,562	8,244	784,943	72,545	275,942	1,995,947
2,415	7,763	6,206	----------	----------	16,384	508	5,994	26,460
90,030	444,256	232,235	26,562	8,244	801,327	73,053	281,936	2,022,407
9,290	21,765	15,091	1,573	1,741	49,460	3,775	28,153	104,748
9,639	45,987	45,266	----------	50	100,942	4,260	56,916	216,952
18,929	67,752	60,357	1,573	1,791	150,402	8,395	85,069	321,700
132	5,512	2,745	----------	----------	8,389	----------	648	9,159
3,096	14,672	11,729	1,085	333	30,915	1,925	8,881	75,659
292	20,774	6,821	185	----------	28,072	23	2,520	38,703
3,388	35,446	18,550	1,270	333	58,987	1,948	11,401	114,362
1,428	41,710	16,548	1,419	142	61,247	1,991	1,152	101,738
24,365	213,560	108,334	12,807	2,646	361,712	34,318	77,090	846,863
4,304	36,053	11,169	2,606	330	54,462	10,183	102,258	265,906
----------	6,308	7	----------	----------	6,315	146	687	9,985
1,627	40,596	2,307	193	----------	44,723	----------	4,793	57,389
2,975	6,094	13,883	249	106	23,307	305	2,632	30,982
4,602	52,998	16,197	442	106	74,345	451	8,112	98,356
1,006	15,572	510	956	----------	18,044	146	3,602	28,397
----------	1,664	640	----------	----------	2,304	27	1,058	6,169
----------	8,484	5,927	517	----------	14,928	237	1,869	28,595
156	16,951	1,024	1,436	----------	19,567	62	2,652	30,316
156	27,099	7,591	1,953	----------	36,799	326	5,579	65,080
92	203	94	----------	----------	389	6	----------	1,277
----------	539	441	----------	----------	980	51	242	2,852
----------	494	371	----------	----------	865	24	215	2,233
92	1,236	906	----------	----------	2,234	81	457	6,362
2,355	17,598	12,874	2,208	148	35,183	2,960	21,202	102,868
6,577	8,192	9,338	6,164	813	31,084	7,943	18,799	135,691
106	84	----------	----------	----------	190	1,978	1,879	9,086
5,561	34,562	15,930	2,443	566	59,062	4,499	28,372	160,363
971	6,468	1,353	27	----------	8,819	53	3,591	17,139
−702	−34,933	−19,096	−1,671	+227	−56,175	−1,315	−14,340	−122,990

Table 36.—Salient statistics of motor and aviation gasoline in the United States, by months

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1968													
Production:													
Gasoline produced at refineries:													
Motor gasoline	156,488	144,882	149,999	144,136	157,403	159,281	166,720	167,078	163,716	163,061	159,438	170,062	1,902,264
Aviation gasoline	2,332	2,165	2,873	2,353	2,785	2,534	3,126	2,736	2,978	2,987	2,405	2,289	31,563
Motor gasoline produced at natural gas processing plants	545	505	559	518	508	498	472	489	498	513	511	595	6,211
Total gasoline production	159,365	147,552	153,431	147,007	160,696	162,313	170,318	170,303	167,192	166,561	162,354	172,946	1,940,038
Daily average	5,141	5,088	4,949	4,900	5,184	5,410	5,494	5,494	5,573	5,373	5,412	5,579	5,301
Stocks, end of period:													
Stocks at refineries:													
Motor gasoline	212,515	216,181	215,580	202,584	196,308	194,412	186,615	179,576	188,513	186,228	191,622	204,226	204,226
Aviation gasoline	7,641	7,755	7,585	6,732	6,617	6,402	6,380	6,339	6,345	6,660	7,024	7,030	7,030
Motor gasoline stocks at natural gas processing plants	257	249	234	172	127	136	147	207	217	321	223	270	270
Total stocks	220,413	224,185	223,399	209,488	203,052	200,950	193,142	186,122	195,075	193,209	198,869	211,526	211,526
Imports: Motor gasoline	1,182	816	1,761	2,046	1,935	2,082	2,610	2,130	1,739	1,931	1,760	1,599	21,591
Exports:													
Motor gasoline	20	10	15	14	48	11	29	18	18	37	19	10	249
Aviation gasoline	52	75	388	233	52	119	186	126	178	217	84	124	1,834
Total exports	72	85	403	247	100	130	215	144	196	254	103	134	2,083
Domestic demand:													
Motor gasoline	145,478	142,535	152,920	159,744	166,119	163,737	177,559	176,658	156,988	167,649	156,394	159,595	1,925,376
Aviation gasoline	2,564	1,976	2,655	2,973	2,848	2,630	2,962	2,651	2,794	2,455	1,957	2,159	30,624
Total domestic demand	148,042	144,511	155,575	162,717	168,967	166,367	180,521	179,309	159,782	170,104	158,351	161,754	1,956,000
1969 p													
Production:													
Gasoline produced at refineries:													
Motor gasoline	157,198	149,446	160,671	151,830	164,359	163,213	174,681	176,578	171,640	174,301	172,559	179,471	1,995,947
Aviation gasoline	1,494	1,651	2,693	2,002	2,218	2,363	2,641	2,515	2,205	2,346	2,228	2,104	26,460
Motor gasoline produced at natural gas processing plants	533	487	491	459	481	439	469	476	449	464	483	514	5,745
Total gasoline production	159,225	151,584	163,855	154,291	167,058	166,015	177,791	179,569	174,294	177,111	175,270	182,089	2,028,152
Daily average	5,136	5,414	5,286	5,143	5,389	5,534	5,735	5,793	5,810	5,713	5,842	5,874	5,557
Stocks, end of period:													
Stocks at refineries:													
Motor gasoline	207,688	215,781	222,386	210,415	201,896	196,205	187,494	183,649	188,494	189,212	202,260	210,891	210,891
Aviation gasoline	6,492	6,535	6,602	5,969	5,543	5,347	5,303	5,466	5,448	5,562	5,824	6,193	6,193

Motor gasoline stocks at natural gas processing plants	284	234	209	253	238	256	278	259	310	261	278	308	308
Total stocks	214,464	222,550	229,197	216,637	207,677	201,808	193,075	189,374	194,252	195,035	208,362	217,392	217,392
Imports: Motor gasoline	2,218	1,793	2,638	1,929	1,962	1,434	2,086	1,974	1,986	1,184	1,794	1,716	22,709
Exports:													
Motor gasoline	22	12	20	21	116	72	68	152	98	52	34	52	719
Aviation gasoline	33	98	24	135	264	123	183	109	307	220	93	218	1,807
Total exports	55	110	44	156	380	195	251	261	405	272	127	270	2,526
Domestic demand:													
Motor gasoline	156,446	143,671	157,200	166,124	175,220	170,687	185,857	182,740	169,081	175,228	161,737	172,988	2,016,979
Aviation gasoline	1,999	1,510	2,602	2,500	2,380	2,436	2,502	2,243	1,916	2,012	1,873	1,517	25,490
Total domestic demand	158,445	145,181	159,802	168,624	177,600	173,123	188,359	184,983	170,997	177,240	163,610	174,505	2,042,469

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Table 37.—Production of gasoline at refineries and gas processing plants in the United States in 1969,p by districts and months

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Motor gasoline at refineries:													
East Coast	19,147	17,080	18,330	18,787	19,062	19,695	20,260	21,435	191,51	19,392	18,673	20,188	231,200
Appalachian No. 1	1,480	1,482	1,768	1,754	1,729	1,661	1,843	1,807	1,688	1,942	1,393	1,963	20,510
Appalachian No. 2	1,062	946	1,034	1,044	993	527	987	1,084	1,061	1,144	1,072	1,132	12,086
Indiana, Illinois, Kentucky, etc.	29,545	27,462	30,203	28,345	30,607	30,390	31,512	32,646	31,834	32,134	31,894	33,649	370,221
Minnesota, Wisconsin, etc	3,458	3,074	3,402	2,899	2,841	3,412	3,358	3,351	3,330	3,480	3,242	3,725	39,572
Oklahoma, Kansas, etc	15,226	14,117	15,475	14,006	15,321	15,500	16,338	16,347	16,057	17,145	16,438	16,958	188,928
Texas Inland	6,590	6,583	7,372	6,930	7,421	7,298	7,612	7,576	7,230	7,430	7,689	7,884	87,615
Texas Gulf Coast	33,049	31,868	35,084	32,141	37,005	36,274	38,339	39,332	37,740	38,230	37,894	39,537	436,493
Louisiana Gulf Coast	19,461	17,657	18,338	16,870	17,712	18,211	19,472	18,566	19,113	19,718	20,305	20,606	226,029
Arkansas, Louisiana Inland, etc	1,578	2,075	2,119	2,113	2,127	2,116	2,396	2,203	2,381	2,405	2,473	2,576	26,562
New Mexico	711	597	789	679	730	731	718	625	693	535	694	742	8,244
Rocky Mountain	5,153	5,520	5,732	5,408	5,742	5,994	6,543	6,361	6,344	6,330	6,606	6,812	72,545
West Coast	20,738	20,985	21,025	20,854	23,069	21,404	25,303	25,245	25,018	24,416	24,186	23,699	275,942
Total	157,198	149,446	160,671	151,830	164,359	163,213	174,681	176,578	171,460	174,301	172,559	179,471	1,995,947
Aviation gasoline at refineries:													
East Coast	42	88	101	86	62	65	50	53	61	119	50	54	831
Appalachian No. 1	---	---	---	---	---	---	---	---	---	---	---	---	---
Appalachian No. 2	---	---	---	---	---	---	---	---	---	---	---	---	---
Indiana, Illinois, Kentucky, etc	177	72	318	121	33	88	165	248	204	239	229	194	2,088
Minnesota, Wisconsin, etc	---	---	---	---	---	---	---	---	---	---	---	---	---
Oklahoma, Kansas, etc	72	37	84	51	50	51	67	49	51	47	49	47	655
Texas Inland	113	185	244	259	147	205	217	198	273	259	206	109	2,415
Texas Gulf Coast	429	420	626	582	720	839	948	768	677	621	556	577	7,763
Louisiana Gulf Coast	308	335	696	494	607	595	659	599	419	491	437	566	6,206
Arkansas, Louisiana Inland, etc	---	---	---	---	---	---	---	---	---	---	---	---	---
New Mexico	---	---	---	---	---	---	---	---	---	---	---	---	---
Rocky Mountain	48	31	48	46	41	38	63	33	54	26	48	32	508
West Coast	305	483	576	363	558	482	472	567	466	544	653	525	5,994
Total	1,494	1,651	2,693	2,002	2,218	2,363	2,641	2,515	2,205	2,346	2,228	2,104	26,460
Motor gasoline produced at gas processing plants:													
East Coast	---	---	---	---	---	---	---	---	---	---	---	---	---
Appalachian No. 1	---	---	---	---	---	---	---	---	---	---	---	---	---
Appalachian No. 2	---	---	---	---	---	---	---	---	---	---	---	---	---
Indiana, Illinois, Kentucky, etc	---	---	---	---	---	---	---	---	---	---	---	---	---
Minnesota, Wisconsin, etc	---	---	---	---	---	---	---	---	---	---	---	---	---
Oklahoma, Kansas, etc	3	3	---	2	4	6	3	5	2	9	2	5	44
Texas Inland	68	70	82	68	75	72	76	74	74	67	90	76	892
Texas Gulf Coast	26	22	13	24	26	12	25	24	15	23	15	23	248
Louisiana Gulf Coast	184	171	163	156	151	143	146	145	141	141	140	147	1,828
Arkansas, Louisiana Inland, etc	252	221	233	209	225	206	219	228	217	224	236	263	2,733
New Mexico	---	---	---	---	---	---	---	---	---	---	---	---	---
Rocky Mountain	---	---	---	---	---	---	---	---	---	---	---	---	---

West Coast	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	---------
Total	533	487	491	459	481	439	469	476	449	464	483	514	5,745
Grand total:													
1969	159,225	151,584	163,855	154,291	167,058	166,015	177,791	179,569	174,294	177,111	175,270	182,089	2,028,152
1968	159,365	147,552	153,431	147,007	160,696	162,313	170,318	170,303	167,192	166,561	162,354	172,946	1,940,038

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Table 38.—Consumption, production and distribution of motor gasoline in 1969,[1] by PAD districts

(Million barrels)

	PAD districts					
	I	II	III	IV	V	Total
Consumption [2]	705.8	706.5	262.9	59.1	299.4	2,033.7
Supply:						
Production [3]	251.7	610.9	790.6	72.6	275.9	2,001.7
Imports	22.1	.1	-------	-------	.5	22.7
Received from other districts:						
From I	-------	33.0	-------	-------	-------	---------
From II	9.0	-------	18.6	-------	-------	---------
From III	439.3	87.0	-------	3.7	13.7	---------
From IV	-------	4.0	-------	-------	14.6	---------
From V	-------	-------	-------	4.3	-------	---------
Total receipts from other districts	448.3	124.0	18.6	8.0	28.3	---------
Total supply	722.1	735.0	809.2	80.6	304.7	2,024.4
Stock change	−.4	−.8	+4.9	+1.0	+2.0	+6.7
Shipped to other districts	33.0	27.6	543.7	18.6	4.3	---------
Exports	-------	.1	.3	-------	.3	.7
Domestic demand	689.5	708.1	260.3	61.0	298.1	2,017.0
Difference between consumption and demand	+16.3	−1.6	+2.6	−1.9	+1.3	+16.7

[1] Apparent distribution of motor gasoline by districts is based on pipeline, tidewater, and river shipments compiled by the Bureau of Mines, and railroad shipments between PAD districts I through IV and PAD district V, from records compiled by the San Francisco office of the Bureau of Mines.
[2] Compiled from data supplied by the American Petroleum Institute.
[3] Includes motor gasoline produced at natural gas processing plants and other hydrocarbons blended.

Table 39.—Production (refinery output) and consumption of gasoline (excluding naphtha) in the United States, by States

(Thousand barrels)

State	1967		1968		1969 p	
	Production	Consumption [1]	Production	Consumption [1]	Production	Consumption [1]
Alabama	(2)	32,179	(2)	34,006	(2)	36,042
Alaska	---------	2,020	---------	2,235	---------	2,449
Arizona	---------	16,720	---------	18,088	---------	20,527
Arkansas	13,128	19,796	13,325	20,935	14,515	22,092
California	[3] 243,350	189,963	[3] 272,049	201,477	[3] 281,936	210,903
Colorado	6,821	21,702	6,993	22,944	6,736	24,445
Connecticut	---------	24,844	---------	26,408	---------	27,638
Delaware	(4)	5,752	(4)	5,776	(4)	6,024
District of Columbia	---------	5,467	---------	5,575	---------	5,670
Florida	---------	61,803	---------	67,320	---------	72,790
Georgia	---------	44,621	---------	48,285	---------	52,149
Hawaii	(3)	4,820	(3)	5,005	(3)	5,254
Idaho	---------	8,340	---------	8,617	---------	9,259
Illinois	129,482	94,642	136,576	99,696	132,838	103,067
Indiana	85,879	52,622	87,559	55,676	95,955	57,922
Iowa	---------	34,292	---------	35,143	---------	36,182
Kansas	[5] 92,215	27,699	[5] 95,898	29,114	[5] 98,123	32,619
Kentucky	[6] 22,641	29,295	[6] 22,348	30,953	[6] 24,509	32,641
Louisiana	201,780	31,277	222,477	33,027	237,515	34,532
Maine	---------	9,768	---------	10,316	---------	10,715
Maryland	---------	30,745	---------	32,945	---------	35,238
Massachusetts	---------	42,639	---------	45,156	---------	47,075
Michigan	25,664	85,379	26,478	91,128	26,560	95,956
Minnesota	17,578	38,910	22,481	41,094	25,719	43,776
Mississippi	[2] 6,463	21,192	[2] 6,368	22,417	[2] 6,767	23,905
Missouri	(5)	49,594	(5)	51,939	(5)	54,567
Montana	18,757	9,458	21,210	9,560	21,397	9,664
Nebraska	(5)	18,190	(5)	18,962	(5)	19,975
Nevada	---------	6,184	---------	6,726	---------	7,054
New Hampshire	---------	6,621	---------	7,213	---------	7,723
New Jersey	81,670	59,139	79,970	62,572	89,418	64,363
New Mexico	7,554	11,589	8,030	12,297	8,244	12,944
New York	10,881	133,159	11,831	138,401	13,686	150,120
North Carolina	---------	48,818	---------	51,502	---------	55,183
North Dakota	[7] 13,143	8,401	[7] 14,638	8,698	[7] 13,853	9,109
Ohio	97,521	94,649	101,510	100,086	104,533	105,053
Oklahoma	88,451	32,227	90,978	33,786	91,460	35,398
Oregon	---------	21,668	---------	22,766	---------	23,874
Pennsylvania	[4] 132,950	92,508	[4] 131,756	97,040	[4] 139,813	100,946
Rhode Island	---------	7,099	---------	7,596	---------	7,942
South Carolina	---------	23,890	---------	25,687	---------	27,346
South Dakota	---------	9,481	---------	9,822	---------	9,899
Tennessee	(6)	37,845	(6)	39,200	(6)	41,806
Texas	495,457	139,126	511,362	153,876	534,286	149,737
Utah	20,429	11,717	20,590	12,810	21,526	14,021
Vermont	---------	4,336	---------	4,555	---------	4,772
Virginia	(8)	42,102	(8)	45,011	(8)	48,020
Washington	(3)	31,821	(3)	33,836	(3)	35,595
West Virginia	[8] 8,732	14,171	[8] 8,965	15,120	[8] 9,624	15,603
Wisconsin	(7)	39,532	(7)	42,017	(7)	44,210
Wyoming	17,976	5,106	20,435	5,514	23,394	5,760
Total	1,838,522	1,894,918	1,933,827	2,009,928	2,022,407	2,109,554

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[1] American Petroleum Institute.
[2] Alabama included with Mississippi.
[3] Washington and Hawaii included with California.
[4] Delaware included with Pennsylvania.
[5] Nebraska and Missouri included with Kansas.
[6] Tennessee included with Kentucky.
[7] Wisconsin included with North Dakota.
[8] Virginia included with West Virginia.

Table 40.—Stocks of gasoline in the United States in 1969, by refining districts and dates

(Thousand barrels)

	Jan. 31	Feb. 28	Mar. 31	Apr. 30	May 31	June 30	July 30	Aug. 31	Sept. 30	Oct. 31	Nov. 30	Dec. 31
Motor gasoline: [1]												
East Coast	48,702	48,356	51,627	53,163	53,649	52,208	49,606	49,073	49,146	47,592	50,213	51,070
Appalachian No. 1	5,624	5,487	5,821	5,894	5,741	5,302	5,190	5,209	5,174	5,[illegible]43	5,139	5,478
Appalachian No. 2	3,278	3,245	3,477	3,708	3,559	3,308	3,319	3,233	3,339	3,106	3,417	3,190
Indiana, Illinois, Kentucky, etc	35,786	37,435	38,278	36,312	33,738	31,395	29,593	28,958	30,400	30,158	32,431	33,698
Minnesota, Wisconsin, North Dakota and South Dakota	7,737	7,837	9,449	9,417	8,825	8,892	7,627	6,292	6,345	6,303	6,817	7,103
Oklahoma, Kansas, etc	19,729	20,801	22,141	20,265	18,318	17,649	16,456	16,084	16,748	16,902	17,898	18,895
Texas Inland	8,166	8,915	9,505	8,827	8,343	7,278	6,679	6,360	6,331	6,530	7,635	8,237
Texas Gulf	27,441	29,203	28,912	23,725	21,547	22,062	21,939	22,170	22,781	24,544	26,475	27,883
Louisiana Gulf Coast	13,370	13,794	12,919	11,455	11,395	11,809	12,370	11,949	12,915	13,834	13,631	14,108
Arkansas, Louisiana Inland, etc	7,131	8,822	8,859	7,551	6,892	6,787	6,766	7,377	7,476	6,709	7,209	7,354
New Mexico	888	840	873	789	787	707	729	581	636	733	780	842
Rocky Mountain	6,929	7,770	8,350	8,071	7,512	6,953	6,296	5,395	5,414	5,579	6,873	7,880
West Coast	22,907	23,276	22,175	21,238	21,590	21,855	20,924	20,968	21,789	21,879	23,742	25,153
Total	207,688	215,781	222,386	210,415	201,896	196,205	187,494	183,649	188,494	189,212	202,260	210,891
Aviation gasoline: [1]												
East Coast	690	692	713	717	801	765	732	719	715	795	748	758
Appalachian No. 1	73	72	89	83	81	58	68	70	57	44	49	68
Appalachian No. 2	2	1	1	11	1	1	2	1	2	1	1	2
Indiana, Illinois, Kentucky, etc	1,000	874	1,104	1,031	911	719	719	777	744	795	870	1,008
Minnesota, Wisconsin, North Dakota and South Dakota	176	176	140	137	103	136	115	142	141	179	205	178
Oklahoma, Kansas, etc	265	284	320	324	296	295	264	287	282	274	313	353
Texas Inland	425	425	412	475	441	396	415	320	409	428	423	387
Texas Gulf	1,286	1,217	1,200	934	856	953	955	1,073	1,077	1,217	1,320	1,293
Louisiana Gulf Coast	1,239	1,304	1,223	1,157	963	904	857	985	872	737	727	855
Arkansas, Louisiana Inland, etc	-------	38	-------	-------	-------	41	25	-------	25	-------	25	-------
New Mexico	14	2	11	11	2	1	9	4	2	2	4	12
Rocky Mountain	97	92	115	112	120	120	180	80	93	83	100	105
West Coast	1,225	1,358	1,274	977	968	958	962	1,008	1,029	1,007	1,039	1,174
Total	6,492	6,535	6,602	5,969	5,543	5,347	5,303	5,466	5,448	5,562	5,824	6,193
Motor gasoline stocks at gas processing plants:												
East Coast	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
Appalachian No. 1	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
Appalachian No. 2	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
Indiana, Illinois, Kentucky, etc	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
Minnesota, Wisconsin, North Dakota, and South Dakota	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
Oklahoma, Kansas, etc	4	4	4	4	3	5	5	7	7	7	6	10
Texas Inland	41	40	40	27	49	47	42	28	38	35	42	43
Texas Gulf	19	19	11	19	25	11	18	30	24	32	25	35
Louisiana Gulf Coast	63	55	46	60	50	40	50	35	89	62	60	57
Arkansas, Louisiana Inland, etc	157	116	108	143	111	153	163	159	152	125	145	163
New Mexico	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------

Rocky Mountain	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
West Coast	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
Total	284	234	209	253	238	256	278	259	310	261	278	308
Total gasoline stocks:												
1969	214,464	222,550	229,197	216,637	207,677	201,808	193,075	189,374	194,252	195,035	208,362	217,392
1968	220,413	224,185	223,399	209,488	203,052	200,950	193,142	186,122	195,075	193,209	198,869	211,526

[1] Includes stocks of gasoline at refineries, bulk terminals, and pipelines.

Table 41.—Shipments of aviation fuels

(Thousand barrels)

Product and use	Shipments to PAD districts I	II	III	IV	V	U.S. total
1968						
Aviation gasoline:						
For commercial use:						
Airlines	1,455	1,073	326	130	668	3,652
Factory	110	19	31	2	18	180
General aviation	2,184	2,649	1,718	379	1,668	8,598
Total	3,749	3,741	2,075	511	2,354	12,430
For military use	4,163	2,947	5,878	405	4,854	18,247
Jet fuel:						
For commercial use:						
Airlines	76,192	40,468	15,705	5,945	57,340	195,650
Factory	1,648	524	267	------	811	3,250
General avition	2,114	1,898	959	318	1,175	6,464
Total	79,954	42,890	16,931	6,263	59,326	205,364
For military use:						
JP-4	[1] 34,683	18,873	26,429	3,170	[2] 42,833	125,988
JP-5	5,568	79	3,370	------	7,788	16,805
Other	124	117	404	------	672	1,317
Total	40,375	19,069	30,203	3,170	51,293	144,110
1969						
Aviation gasoline:						
For commercial use:						
Airlines	638	327	195	37	266	1,463
Factory	85	62	38	1	20	206
General aviation	2,581	2,556	1,639	376	1,898	9,050
Total	3,304	2,945	1,872	414	2,184	10,719
For military use	3,934	1,427	5,556	304	3,893	15,114
Jet fuel:						
For commercial use:						
Airlines	83,613	49,504	19,009	6,253	68,898	227,277
Factory	1,606	717	325	------	1,052	3,700
General aviation	3,759	1,803	923	757	1,114	8,356
Total	88,978	52,024	20,257	7,010	71,064	239,333
For military use:						
JP-4	[3] 28,868	16,904	22,537	3,688	[4] 36,872	108,869
JP-5	5,204	60	4,982	------	6,926	17,172
Other	177	162	467	------	379	1,185
Total	34,249	17,126	27,986	3,688	44,177	127,226

[1] Excludes 244,000 barrels imported directly by the military.
[2] Excludes 1,396,000 barrels imported directly by the military.
[3] Excludes 93,000 barrels imported directly by the military.
[4] Excludes 1,013,000 barrels imported directly by the military.

Definitions of terms used in this table:

Aviation gasoline—Any fuel in the gasoline boiling range for use in a piston-type aviation engine.

Jet fuel—Any fuel for use in an aviation turbine engine.

Airline—Sales to U.S. certificated air carriers, including air freight carriers, international air carriers (if delivery is made in the U.S.), and to such other air carriers as supplemental or nonscheduled carriers, air taxis, etc.

Factory—Direct sales to airframe and engine manufacturers.

General aviation—Primarily sales to distributors and airport dealers.

Military—Sales to Defense Fuel Supply Center and to other military agencies of the Government.

Table 42.—Salient statistics on kerosine in the United States, by months and districts

(Thousand barrels unless otherwise stated)

	1968							1969 p						
	Production at refineries	Yield (percent)	Production at gas-processing plants	Imports	Exports	Total stocks end of period	Domestic demand	Production at refineries	Yield (percent)	Production at gas-processing plants	Imports	Exports	Total stocks end of period	Domestic demand
By month:														
January	10,208	3.2	72	-------	39	19,250	[1] 16,256	11,148	3.6	105	111	11	19,355	15,478
February	9,602	3.2	70	-------	210	16,712	12,000	10,932	3.6	86	76	5	18,586	11,858
March	9,276	3.0	84	-------	29	16,360	9,683	10,287	3.1	88	171	15	18,909	10,208
April	7,726	2.6	73	1	15	18,583	5,562	7,162	2.3	86	-------	22	20,330	5,805
May	8,125	2.5	73	-------	15	20,912	5,854	7,015	2.2	89	106	23	21,989	5,528
June	6,811	2.2	90	31	12	23,040	4,792	7,769	2.4	92	-------	14	25,331	4,505
July	6,904	2.1	59	-------	14	25,689	4,300	7,442	2.2	105	56	6	27,289	5,639
August	7,530	2.3	104	30	12	27,188	6,153	7,516	2.2	96	-------	5	29,735	5,161
September	7,358	2.3	107	-------	15	28,036	6,602	7,317	2.2	98	243	17	30,106	7,270
October	8,634	2.7	101	-------	16	28,936	7,819	7,493	2.3	93	34	7	30,631	7,088
November	8,616	2.8	97	-------	64	27,094	10,491	7,986	2.4	86	55	22	29,429	9,257
December	9,755	3.0	97	128	172	23,480	13,422	9,721	2.8	97	113	9	26,780	12,571
Total	100,545	2.7	1,027	190	613	23,480	[1] 102,934	101,738	2.6	1,121	965	156	26,780	100,368
By refining district:														
East Coast	11,669	2.5	-------	190	30	9,808		12,180	2.5	-------	960	15	10,696	
Appalachian No. 1	1,327	2.8	-------			728		1,198	2.4	-------			592	
Appalachian No. 2	809	3.7	-------			470		824	3.6	-------			358	
Indiana, Illinois, Kentucky, etc.	17,691	2.7	-------	-------	260	4,205		17,078	2.5	-------	-------	8	4,358	
Minnesota, Wisconsin, etc.	2,638	3.9	-------			974		1,534	2.1	-------			1,132	
Oklahoma, Kansas, etc.	4,976	1.6	-------			1,385		4,534	1.4	-------			1,434	
Texas Inland	1,504	1.1	291			282	NA	1,428	1.0	199			232	NA
Texas Gulf Coast	38,716	4.6	-------			2,585		41,710	4.9	56		87	3,950	
Louisiana Gulf Coast	17,137	3.9	125	-------	271	1,623		16,548	3.6	256	-------		2,394	
Arkansas, Louisiana Inland, etc.	1,637	3.2	571			911		1,419	2.6	575			926	
New Mexico	122	.9	40			58		142	1.0	35			28	
Rocky Mountain	1,629	1.2	-------	-------	-------	289		1,991	1.4	-------	5	-------	372	
West Coast	690	.1	-------	-------	52	162		1,152	.2	-------	-------	46	308	
Total	100,545	2.7	1,027	190	613	23,480	[1] 102,934	101,738	2.6	1,121	965	156	26,780	100,368

p Preliminary. NA Not available.
[1] Domestic demand calculated using Jan. 1, 1968, total stocks of 25,265,000 barrels.

Table 43.—Salient statistics on distillate fuel oil in the United States, by months and refining districts

(Thousand barrels unless otherwise stated)

	1968								1969 p							
	Production at refineries	Yield (percent)	Production at gas processing plants	Crude used directly as distillate [1]	Imports	Exports	Total stocks, end of period	Domestic demand	Production at refineries	Yield (percent)	Production at gas processing plants	Crude used directly as distillate [1]	Imports	Exports	Total stocks end of period	Domestic demand
By month:																
January	74,258	23.4	24	58	5,352	180	119,802	119,413	69,232	22.4	139	55	7,341	70	130,609	119,246
February	74,377	24.8	89	57	6,033	124	96,869	103,365	66,279	22.1	120	53	5,973	92	106,650	96,292
March	77,212	24.6	101	65	6,444	88	93,499	87,104	73,879	22.6	138	60	7,033	118	96,563	91,079
April	64,976	21.9	97	61	4,114	154	101,174	61,419	66,580	21.6	121	54	3,523	94	99,826	66,921
May	68,684	21.4	95	54	2,645	171	115,777	56,704	67,165	20.7	135	50	2,613	115	110,925	58,749
June	68,990	21.9	109	58	3,136	61	139,517	48,492	71,137	21.6	134	52	2,221	184	132,650	51,635
July	71,624	21.6	76	61	2,930	104	168,116	45,988	73,465	21.3	129	54	2,826	108	159,081	49,935
August	70,398	21.2	138	62	2,382	81	191,391	49,624	70,838	20.7	133	54	4,296	105	183,515	50,782
September	65,958	20.7	139	60	2,735	353	205,976	53,954	68,811	21.0	112	53	3,472	119	197,653	58,191
October	65,878	20.6	152	62	2,249	79	211,847	62,391	70,365	21.4	119	57	2,297	118	207,986	62,387
November	65,914	21.4	147	55	4,048	62	204,047	77,902	72,379	22.1	132	56	3,403	75	200,969	82,912
December	71,104	21.6	141	59	6,080	90	173,158	108,183	76,733	22.2	129	56	5,885	83	171,714	111,975
Total	839,373	22.1	1,308	712	48,148	1,547	173,158	874,539	846,863	21.7	1,541	654	50,883	1,281	171,714	900,104
By refining district:																
East Coast	120,821	25.5	-----	-----	45,502	114	69,389		124,465	25.2	-----	-----	47,720	96	68,969	
Appalachian No. 1	11,759	24.7	-----				3,538		12,342	24.4	-----				3,597	
Appalachian No. 2	4,528	20.3	-----				2,261		5,129	22.3	-----				2,052	
Indiana, Illinois, Kentucky, etc.	135,746	20.3	-----				26,133		135,896	20.0	-----				23,011	
Minnesota, Wisconsin, etc.	16,780	24.8	-----	442	360	174	8,133		17,687	24.4	-----	386	1,264	9	8,168	
Oklahoma, Kansas, etc.	76,681	23.7	-----				11,403	NA	78,224	24.2	-----				12,578	NA
Texas Inland	22,840	17.0	195				1,751		24,365	17.3	165				2,047	
Texas Gulf Coast	229,489	27.2	51				23,276		213,560	25.2	119				20,516	
Louisiana Gulf Coast	102,053	23.3	196	200	1,290	471	8,444		108,334	23.4	395	197	937	389	8,064	
Arkansas, Louisiana Inland, etc.	12,258	23.8	866				5,000		12,807	23.8	862				5,118	
New Mexico	2,351	17.5	-----				200		2,646	18.6	-----				250	
Rocky Mountain	32,138	24.0	-----	70	------	4	2,677		34,318	24.3	-----	71	------	3	3,216	
West Coast	71,929	12.3	-----	-----	996	784	10,953		77,090	12.6	-----	-----	962	784	14,128	
Total	839,373	22.1	1,308	712	48,148	1,547	173,158	874,539	846,863	21.7	1,541	654	50,883	1,281	171,714	900,104

p Preliminary. NA Not available.

[1] Figures represent crude oil used as fuel on pipelines, which is considered part of the demand for distillate.

Table 44.—Salient statistics on residual fuel oil in the United States, by months and refining districts

(Thousand barrels unless otherwise stated)

	1968							1969 p						
	Production	Yield (percent)	Crude used directly as residual [1]	Imports	Exports	Stocks, end of period	Domestic demand	Production	Yield (percent)	Crude used directly as residual [1]	Imports	Exports	Stocks, end of period	Domestic demand
By month:														
January	27,697	8.7	340	49,460	1,629	58,535	82,930	27,873	9.0	371	51,384	1,669	62,957	82,361
February	24,538	8.2	329	39,766	1,473	55,074	66,621	25,126	8.4	425	41,230	1,687	59,930	68,121
March	24,726	7.9	344	44,796	2,244	60,472	62,224	25,336	7.7	349	41,374	1,708	57,188	68,093
April	22,761	7.7	476	31,380	2,083	62,830	50,176	23,595	7.7	365	38,834	1,134	60,213	58,635
May	22,658	7.1	341	27,180	2,236	66,910	43,863	21,239	6.6	345	34,220	1,685	62,570	51,762
June	19,693	6.2	343	30,311	2,174	67,566	47,517	19,403	5.9	345	29,094	1,423	62,511	47,478
July	21,249	6.4	373	30,218	1,211	72,443	45,752	19,493	5.7	353	32,289	1,099	65,144	48,403
August	21,401	6.4	320	25,755	1,900	74,312	43,707	19,250	5.6	363	34,105	1,493	66,062	51,307
September	19,432	6.1	360	31,129	1,271	75,803	48,159	19,536	6.0	377	35,100	988	65,593	54,494
October	20,366	6.4	355	32,543	1,262	76,940	50,865	19,543	6.0	361	39,001	1,642	64,225	58,631
November	23,652	7.7	341	30,413	1,043	74,041	56,262	21,439	6.5	334	33,751	1,550	62,665	55,534
December	27,641	8.4	350	36,977	1,487	67,359	70,163	24,073	7.0	346	51,229	815	60,395	77,103
Total	275,814	7.2	4,272	409,928	20,013	67,359	668,239	265,906	6.8	4,334	461,611	16,893	60,395	721,922
By refining district:														
East Coast	36,129	7.7	-------	394,528	1,546	23,597		37,703	7.6	-------	440,983	1,081	20,780	
Appalachian No. 1	4,700	9.8				274		4,554	9.0				332	
Appalachian No. 2	1,807	8.2				103		1,821	7.9				152	
Indiana, Illinois, Kentucky, etc	42,563	6.4	577	573	708	6,293		43,205	6.4	578	627	1,028	4,483	
Minnesota, Wisconsin, etc	5,930	8.7				1,051		5,890	8.1				675	
Oklahoma, Kansas, etc	5,750	1.8				876		5,830	1.8				988	
Texas Inland	4,562	3.3				2,143	NA	4,304	3.1				2,187	NA
Texas Gulf Coast	41,336	4.9				3,569		36,053	4.3				3,747	
Louisiana Gulf Coast	11,453	2.6	1,784	8,271	3,642	1,225		11,169	2.4	1,785	12,167	5,027	1,256	
Arkansas, Louisiana Inland, etc	2,282	4.4				131		2,606	4.8				145	
New Mexico	382	2.9				5		330	2.3				21	
Rocky Mountain	10,765	8.1	252	54	1	752		10,183	7.2	252	78	10	443	
West Coast	108,155	18.6	1,659	6,502	14,116	27,340		102,258	16.7	1,719	7,756	9,747	25,186	
Total	275,814	7.2	4,272	409,928	20,013	67,359	668,239	265,906	6.8	4,334	461,611	16,893	60,395	721,922

p Preliminary. NA Not available.

[1] Represents crude oil used as fuel on leases and for general industrial purposes.

Table 45.—Salient statistics on jet fuel in the United States, by months and refining districts

(Thousand barrels)

	Production			Imports			Exports			Total stocks, end of period			Domestic demand		
	Naphtha type [1]	Kerosine type	Total	Naphtha type	Kerosine type	Total	Naphtha type	Kerosine type	Total	Naphtha type [2]	Kerosine type	Total	Naphtha type	Kerosine type	Total
1968															
By month:															
January	8,800	15,269	24,069	476	2,302	2,778	143	------	143	9,263	13,653	22,916	8,907	[3] 17,193	[3] 26,100
February	8,709	15,103	23,812	689	2,981	3,670	180	------	180	9,154	13,854	23,008	9,327	17,883	27,210
March	9,541	15,802	25,343	641	1,945	2,586	219	------	219	8,486	14,275	22,761	10,631	17,326	27,957
April	10,896	15,600	26,496	613	2,650	3,263	151	------	151	8,493	14,610	23,103	11,351	17,915	29,266
May	11,241	16,291	27,532	494	2,375	2,869	194	------	194	8,670	16,505	25,175	11,364	16,771	28,135
June	9,581	15,221	24,802	1,076	1,994	3,070	154	------	154	8,443	15,196	23,639	10,730	18,524	29,254
July	9,876	17,069	26,945	480	3,260	3,740	161	------	161	9,270	15,578	24,848	9,368	19,947	29,315
August	10,257	17,260	27,517	378	3,145	3,523	239	1	240	8,593	15,840	24,433	11,073	20,142	31,215
September	11,039	16,352	27,391	464	2,749	3,213	148	------	148	9,408	15,704	25,112	10,540	19,237	29,777
October	11,985	17,318	29,303	437	3,113	3,550	105	------	105	8,765	16,071	24,836	12,960	20,064	33,024
November	10,265	15,562	25,827	473	2,430	2,903	172	------	172	9,228	15,537	24,765	10,103	18,526	28,629
December	9,252	16,639	25,891	896	2,446	3,342	225	------	225	8,904	15,373	24,277	10,247	19,249	29,496
Total	121,442	193,486	314,928	7,117	31,390	38,507	2,091	1	2,092	8,904	15,373	24,277	126,601	[3] 222,777	[3] 349,378
By refining district:															
East Coast	7,078	11,418	18,496	1,714	19,787	21,501				560	2,822	3,382			
Appalachian No. 1	838	526	1,364							58	218	276			
Appalachian No. 2	6	29	35							37	52	89			
Indiana, Illinois, Kentucky, etc	10,213	27,658	37,871							748	2,988	3,736			
Minnesota, Wisconsin, North and South Dakota	978	165	1,143	------	1,179	1,179				178	482	660			
Oklahoma, Kansas, Missouri, etc	8,661	11,402	20,063				271	------	271	871	878	1,749	NA	NA	NA
Texas Inland	10,233	9,201	19,434							627	709	1,336			
Texas Gulf	31,553	33,133	64,686							2,124	1,309	3,433			
Louisiana Gulf Coast	14,536	46,253	60,789	------	392	392				749	1,009	1,758			
Arkansas, Louisiana Inland, etc	1,729	69	1,798							391	459	850			
New Mexico	1,586	------	1,586							228	31	259			
Rocky Mountain	3,537	3,578	7,115	------	------	------				387	297	684			
West Coast	30,494	50,054	80,548	5,403	10,032	15,435	1,820	1	1,821	1,946	4,119	6,065			
Total	121,442	193,486	314,928	7,117	31,390	38,507	2,091	1	2,092	8,904	15,373	24,277	126,601	[3] 222,777	[3] 349,378
1969 p															
By month:															
January	7,781	16,704	24,485	454	2,667	3,121	1	------	1	8,738	14,176	22,914	8,400	20,568	28,968
February	8,077	17,286	25,363	590	2,761	3,351	296	------	296	8,840	16,094	24,934	8,269	18,129	26,398
March	10,079	16,748	26,827	821	3,830	4,651	89	------	89	8,445	17,123	25,568	11,206	19,549	30,755
April	9,161	18,299	27,460	190	2,620	2,810	246	------	246	8,520	18,268	26,788	9,030	19,774	28,804
May	9,729	18,083	27,812	602	3,135	3,737	101	------	101	8,654	19,663	28,317	10,096	19,823	29,919
June	10,012	18,187	28,199	267	3,470	3,737	245	------	245	8,896	19,515	28,411	9,792	21,805	31,597
July	10,709	18,535	29,244	259	3,869	4,128	66	------	66	9,320	20,536	29,856	10,478	21,383	31,861

August	9,092	18,516	27,608	505	3,714	4,219	114	------	114	8,880	21,347	30,227	9,923	21,419	31,342
September	7,950	17,149	25,099	726	4,211	4,937	323	------	323	8,863	20,003	28,866	8,370	22,704	31,074
October	7,617	18,635	26,252	186	2,336	2,522	221	------	221	9,152	20,141	29,293	7,293	20,833	28,126
November	7,176	18,448	25,624	256	4,041	4,297	139	------	139	9,058	20,473	29,531	7,387	22,157	29,544
December	7,383	20,362	27,745	278	3,751	4,029	87	------	87	8,556	19,517	28,073	8,076	25,069	33,145
Total	104,766	216,952	321,718	5,134	40,405	45,539	1,928	------	1,928	8,556	19,517	28,073	108,320	253,213	361,533
By refining district:															
East Coast	5,104	11,716	16,820	1,976	23,031	25,007				686	3,890	4,576			
Appalachian No. 1	722	573	1,295							45	333	378			
Appalachian No. 2	-------	22	22							73	190	263			
Indiana, Illinois, Kentucky, etc	7,234	30,144	37,378							700	3,155	3,855			
Minnesota, Wisconsin, North and South Dakota	1,028	1,464	2,492	------	1,771	1,771				127	703	830			
Oklahoma, Kansas, Missouri, etc	9,272	10,555	19,827				445	------	445	993	967	1,960	NA	NA	NA
Texas Inland	9,290	9,639	18,929							442	967	1,409			
Texas Gulf Coast	21,765	45,987	67,752							1,437	2,233	3,670			
Louisiana Gulf Coast	15,091	45,266	60,357	------	478	478				840	970	1,810			
Arkansas, Louisiana Inland, etc	1,591	-------	1,591							529	477	1,006			
New Mexico	1,741	50	1,791							178	123	301			
Rocky Mountain	3,775	4,620	8,395	------	------	------				328	421	749			
West Coast	28,153	56,916	85,069	3,158	15,125	18,283	1,483	------	1,483	2,178	5,088	7,266			
Total	104,766	216,952	321,718	5,134	40,405	45,539	1,928	------	1,928	8,556	19,517	28,073	108,320	253,213	361,533

p Preliminary. NA Not available.

[1] Includes naphtha-type jet fuel produced at natural gas processing plants: 1968—Louisiana Gulf, 231; Arkansas, Louisiana Inland, etc., 46; 1969—Arkansas, Louisiana Inland, etc., 18.

[2] Includes naphtha-type jet fuel stored at natural gas processing plants: 1968—Texas Inland, 1; Arkansas, Louisiana Inland, etc., 23; 1969—Arkansas, Louisiana Inland, etc., 19.

[3] Domestic demand for kerosine-type jet fuel calculated using Jan. 1, 1968, total stocks of 22,312,000 barrels.

Table 46.—Salient statistics on lubricants in the United States, by months and refining districts

(Thousand barrels unless otherwise stated)

	Production				Yield (percent)	Imports (all types)	Exports (all types)	Stocks, end of period				Domestic demand (all types)
	Bright stock	Neutral	Other grades	Total				Bright stock	Neutral	Other grades	Total	
1968												
By month:												
January	422	2,369	2,313	5,104	1.6	3	993	1,830	5,041	8,221	15,092	3,796
February	502	2,098	2,416	5,016	1.7	3	1,194	1,925	4,922	8,217	15,064	3,853
March	553	2,342	2,541	5,436	1.7	4	1,650	1,938	4,787	8,258	14,983	3,871
April	549	2,417	2,561	5,527	1.9	2	1,535	1,932	4,538	8,203	14,673	4,304
May	398	2,511	2,835	5,744	1.8	2	1,526	1,753	4,298	8,308	14,359	4,534
June	383	2,301	2,634	5,318	1.7	2	1,619	1,661	4,315	8,386	14,362	3,698
July	496	2,594	2,372	5,462	1.6	3	1,869	1,550	4,206	7,878	13,634	4,324
August	498	2,583	2,616	5,697	1.7	3	1,508	1,460	4,423	7,884	13,767	4,059
September	505	2,297	2,757	5,559	1.7	3	1,832	1,575	4,209	7,728	13,512	3,985
October	484	2,436	2,920	5,840	1.8	3	1,303	1,411	4,189	8,064	13,664	4,388
November	512	2,629	2,406	5,547	1.8	3	1,663	1,490	4,432	7,874	13,796	3,755
December	506	2,325	2,603	5,434	1.6	2	1,309	1,620	4,286	8,117	14,023	3,900
Total	5,808	28,902	30,974	65,684	1.7	33	18,001	1,620	4,286	8,117	14,023	48,467
By refining district:												
East Coast	501	2,233	3,715	6,449	1.4	17		172	713	2,654	3,539	
Appalachian No. 1	1,266	1,845	760	3,871	8.1			223	295	339	857	
Appalachian No. 2	------	250	------	250	1.2			------	38	49	87	
Indiana, Illinois, Kentucky, etc.	613	4,092	1,218	5,923	.8	14		106	558	871	1,535	
Minnesota, Wisconsin, etc.	------	------	------	------	------			------	------	43	43	
Oklahoma, Kansas, etc.	854	3,434	1,364	5,652	1.7		17,091	145	578	214	937	
Texas Inland	------	------	156	156	.1			------	------	37	37	NA
Texas Gulf Coast	1,589	9,272	17,355	28,216	3.4	2		354	1,221	2,509	4,084	
Louisiana Gulf Coast	590	5,634	1,172	7,396	1.7			54	638	257	949	
Arkansas, Louisiana Inland, etc.	------	520	1,472	1,992	3.9			------	50	378	428	
New Mexico	------	------	------	------	------			------	------	4	4	
Rocky Mountain	45	257	55	357	.3	------		13	44	31	88	
West Coast	350	1,365	3,707	5,422	1.0	------	910	553	151	731	1,435	
Total	5,808	28,902	30,974	65,684	1.7	33	18,001	1,620	4,286	8,117	14,023	48,467
1969 p												
By month:												
January	361	2,421	1,924	4,706	1.5	2	1,191	1,395	4,432	8,034	13,861	3,679
February	504	1,849	2,078	4,431	1.5	2	820	1,504	4,178	8,142	13,824	3,650
March	564	2,483	2,570	5,617	1.7	2	1,394	1,523	4,189	8,307	14,019	4,030
April	503	2,612	2,376	5,491	1.8	3	1,427	1,407	4,134	8,377	13,918	4,168
May	522	2,779	2,376	5,677	1.8	2	1,702	1,301	4,034	8,118	13,453	4,442
June	518	2,163	2,590	5,271	1.6	65	1,887	1,352	3,567	7,865	12,784	4,118
July	630	2,102	2,782	5,514	1.6	2	1,148	1,372	3,597	7,865	12,834	4,318
August	431	2,279	3,062	5,772	1.7	2	1,713	1,194	3,404	8,201	12,799	4,096
September	463	2,202	2,714	5,379	1.6	44	1,466	1,189	3,386	8,104	12,679	4,077
October	451	2,390	2,812	5,653	1.7	1	1,227	1,081	3,486	7,928	12,495	4,611
November	611	2,726	2,486	5,823	1.8	33	1,078	1,277	4,103	8,237	13,617	3,656

December	611	2,589	2,546	5,746	1.7	5	1,384	1,347	4,520	8,221	14,088	3,896
Total	6,169	28,595	30,316	65,080	1.7	163	16,437	1,347	4,520	8,221	14,088	48,741
By refining districts:												
East Coast	275	2,261	4,143	6,679	1.4	18		121	672	2,648	3,441	
Appalachian No. 1	1,202	1,904	764	3,870	7.6			198	291	419	908	
Appalachian No. 2	------	112	------	112	.5			------	61	74	135	
Indiana, Illinois, Kentucky, etc.	501	3,787	1,811	6,099	.9	4		88	620	998	1,706	
Minnesota, Wisconsin, etc.	------	------	------	------	------			------	------	46	46	
Oklahoma, Kansas, etc.	802	3,497	1,317	5,616	1.7		15,110	108	597	191	896	
Texas Inland	------	------	156	156	.1			------	------	40	40	NA
Texas Gulf Coast	1,664	8,484	16,951	27,099	3.2			234	1,210	2,400	3,844	
Louisiana Gulf Coast	640	5,927	1,024	7,591	1.6	141		76	785	312	1,173	
Arkansas, Louisiana Inland, etc.	------	517	1,436	1,953	3.6			------	44	334	378	
New Mexico	------	------	------	------	------			------	------	5	5	
Rocky Mountain	27	237	62	326	.2	------		3	38	35	76	
West Coast	1,058	1,869	2,652	5,579	.9	------	1,327	519	202	719	1,440	
Total	6,169	28,595	30,316	65,080	1.7	163	16,437	1,347	4,520	8,221	14,088	48,741

p Preliminary. NA Not available.

Table 47.—Salient statistics on liquefied gases (excluding ethane) in the United States, by months and refining districts

(Thousand barrels unless otherwise stated)

	1968								1969 p							
	Refinery production	Yield percent	Production at gas processing plants	Imports	Exports	LPG used at refineries	Total stocks, end of period	Domestic demand	Refinery production	Yield percent	Production at gas processing plants	Imports	Exports	LPG used at refineries	Total stocks, end of period	Domestic demand
By month:																
January	8,825	2.8	25,491	1,753	750	6,984	51,685	38,700	8,302	2.7	26,716	1,600	1,058	7,102	56,264	46,142
February	8,466	2.8	24,801	1,221	881	5,778	46,915	32,599	8,418	2.8	25,181	1,194	1,186	5,765	50,476	33,630
March	9,505	3.0	26,872	897	816	5,241	49,165	28,967	9,643	3.0	27,455	1,004	1,416	5,180	49,764	32,218
April	8,920	3.0	25,478	689	564	4,529	57,335	21,824	9,562	3.1	25,993	783	742	4,328	55,082	25,950
May	10,117	3.2	26,239	725	829	4,469	66,091	23,027	10,101	3.1	26,622	547	789	4,903	63,549	23,111
June	9,177	2.9	23,926	525	1,169	4,433	73,207	20,910	10,018	3.0	25,196	656	690	4,605	70,349	23,775
July	9,371	2.8	25,162	580	973	4,950	78,834	23,563	10,603	3.1	25,318	661	1,225	4,733	76,337	24,636
August	9,802	2.9	24,415	623	710	5,787	84,205	22,972	10,363	3.0	25,694	621	1,356	5,078	80,574	26,007
September	8,849	2.8	24,485	889	810	6,065	89,500	22,053	9,500	2.9	25,360	901	1,145	5,934	81,842	27,414
October	8,522	2.7	25,763	1,065	1,064	7,523	88,491	27,772	9,358	2.8	27,007	1,373	1,105	7,698	77,864	32,913
November	8,130	2.6	25,752	1,158	976	8,221	83,313	31,021	9,146	2.8	26,646	1,403	983	8,139	69,414	36,523
December	8,957	2.7	27,075	1,522	1,066	8,672	73,948	37,181	9,348	2.7	28,242	1,908	1,100	9,299	57,420	41,093
Total	108,641	2.9	305,459	11,647	10,608	72,652	73,948	330,589	114,362	2.9	315,430	12,651	12,795	72,764	57,420	373,412
By refining district:																
East Coast	15,621	3.3	4,359	669		2,031	4,384		16,741	3.4	4,179	559		2,449	4,623	
Appalachian No. 1	906	1.9				53			889	1.7				9		
Appalachian No. 2	339	1.5				106			259	1.1				127		
Indiana, Illinois, Kentucky, etc	12,389	1.9	50,431	5,077		9,342	19,930		13,080	1.9	55,114	4,291		8,773	20,067	
Minnesota, Wisconsin, etc	1,241	1.9				2,671			1,427	2.0				2,903		
Oklahoma, Kansas, etc	10,074	3.1			9,554	8,773		NA	9,630	3.0			11,602	9,390		
Texas Inland	3,386	2.5				8,091			3,388	2.4				7,870		NA
Texas Gulf Coast	33,191	3.9				19,202			35,446	4.2				19,435		
Louisiana Gulf Coast	15,637	3.6	234,116	------		9,940	48,097		18,550	4.0	239,569			9,362	31,103	
Arkansas, Louisiana Inland, etc	1,505	2.9				1,138			1,270	2.4				1,017		
New Mexico	287	2.2				539			333	2.4				538		
Rocky Mountain	1,983	1.5	7,964	2,199		2,944	303		1,948	1.4	8,260	2,896		3,539	462	
West Coast	12,082	2.1	8,589	3,702	1,054	7,822	1,234		11,401	1.9	8,308	4,905	1,193	7,352	1,165	
Total	108,641	2.9	305,459	11,647	10,608	72,652	73,948	330,589	114,362	2.9	315,430	12,651	12,795	72,764	57,420	373,412

p Preliminary.
NA Not available.

Table 48.—Salient statistics on ethane (including ethylene) in the United States, by months and refining districts

(Thousand barrels)

	1968					1969 p				
	Production			Total stocks, end of period	Domestic demand	Production			Total stocks, end of period	Domestic demand
	At gas processing plants	At refineries	Total			At gas processing plants	At refineries	Total		
By month:										
January	3,023	821	3,844	2,130	3,829	5,081	782	5,863	2,121	5,954
February	3,150	739	3,889	2,056	3,963	4,641	679	5,320	2,018	5,423
March	3,490	737	4,227	2,203	4,080	5,033	881	5,914	1,924	6,008
April	3,339	808	4,147	2,382	3,968	5,119	683	5,802	2,123	5,603
May	3,585	833	4,418	2,341	4,459	5,265	732	5,997	2,099	6,021
June	3,578	788	4,366	2,242	4,465	4,898	699	5,597	2,116	5,580
July	3,898	691	4,589	2,300	4,531	5,105	723	5,828	2,188	5,756
August	4,157	692	4,849	2,355	4,794	5,251	773	6,024	1,869	6,343
September	4,099	925	5,024	2,369	5,010	5,054	757	5,811	1,803	5,877
October	4,278	760	5,038	2,295	5,112	5,600	805	6,405	2,061	6,147
November	4,522	796	5,318	2,231	5,382	5,744	798	6,542	2,099	6,504
December	4,684	856	5,540	2,212	5,559	6,236	847	7,083	2,182	7,000
Total	45,803	9,446	55,249	2,212	55,152	63,027	9,159	72,186	2,182	72,216
By refining district:										
East Coast	------	------	------	------		------	------	------	------	
Appalachian No. 1						734	------	734		
Appalachian No. 2						------	------	------		
Indiana, Illinois, Kentucky, etc.	7,837	------	7,837	317		8,121	------	8,121	418	
Minnesota, Wisconsin, etc.						------	------	------		
Oklahoma, Kansas, etc.						454	122	576		
Texas Inland					NA	21,144	132	21,276		NA
Texas Gulf						12,647	5,512	18,159		
Louisiana Gulf Coast	37,966	8,658	46,624	1,895		16,917	2,745	19,662	1,764	
Arkansas, Louisiana Inland, etc.						1,117	------	1,117		
New Mexico						1,893	------	1,893		
Rocky Mountain	------	------	------	------		------	------	------	------	
West Coast	------	788	788	------		------	648	648	------	
Total	45,803	9,446	55,249	2,212	55,152	63,027	9,159	72,186	2,182	72,216

p Preliminary. NA Not available.

Table 49.—Statistical summary of petroleum asphalt and road oil

(Thousand short tons) [1]

	1965	1966	1967	1968	1969 p
Petroleum asphalt:					
Production	22,473	23,560	23,230	24,629	24,671
Imports (including natural)	1,145	1,110	1,172	1,134	866
Exports	71	87	77	78	84
Stocks (end of period)	2,941	3,147	3,265	3,646	3,046
Apparent domestic consumption	23,194	24,377	23,847	25,664	26,053
Petroleum asphalt shipments:					
Paving	18,307	19,648	18,867	20,690	21,333
Roofing	4,045	3,992	3,967	4,767	4,080
All other	2,832	2,798	2,969	2,922	2,743
Total	25,184	26,438	25,803	28,379	28,156
Road oil:					
Production	1,194	1,318	1,269	1,241	1,652
Stocks (end of period)	106	167	146	100	160
Apparent domestic consumption	1,193	1,257	1,290	1,287	1,592
Road oil shipments	1,189	1,045	1,033	r 1,025	1,116

p Preliminary. r Revised.

[1] Converted from barrels to short tons (5.5 barrels = 1 short ton).

Table 50.—Salient statistics on petroleum asphalt in the United States, by months and refining districts

(Thousand short tons) [1]

	1968					1969 p				
	Production	Imports (including natural)	Exports	Stocks end of period	Domestic demand	Production	Imports (including natural)	Exports	Stocks end of period	Domestic demand
By month:										
January	1,156	77	5	4,123	731	1,005	46	4	3,987	708
February	1,135	58	9	4,546	762	1,126	61	6	4,429	738
March	1,327	18	4	4,891	996	1,541	32	4	4,970	1,027
April	1,790	35	9	5,014	1,694	1,861	33	4	5,172	1,688
May	2,362	62	10	5,047	2,381	2,352	86	9	5,146	2,455
June	2,574	223	4	4,894	2,944	2,609	84	9	4,746	3,084
July	2,779	138	6	4,181	3,624	2,755	104	11	4,247	3,348
August	2,848	78	7	3,471	3,628	2,714	73	11	3,546	3,477
September	2,697	149	7	3,133	3,178	2,742	134	10	2,928	3,483
October	2,551	152	6	2,734	3,096	2,448	64	6	2,396	3,038
November	1,990	80	6	3,162	1,636	1,885	54	6	2,546	1,783
December	1,420	64	5	3,646	994	1,633	95	4	3,046	1,224
Total	24,629	1,134	78	3,646	25,664	24,671	866	84	3,046	26,053
By refining district:										
East Coast	4,996	1,000		994		4,962	798		805	
Appalachian No. 1	320			86		305			86	
Appalachian No. 2	332			101		328			88	
Illinois, Indiana, Kentucky, etc.	5,656			611		5,440			521	
Minnesota, Wisconsin, North Dakota	486	33		64		692	27		63	
Oklahoma, Kansas, etc.	2,490		50	411		2,430		59	304	
Texas Inland	1,143			111	NA	1,196			95	NA
Texas Gulf Coast	1,399			139		1,489			113	
Louisiana Gulf Coast	1,779	101		215		1,698	41		157	
Arkansas, Louisiana Inland, etc.	1,154			177		1,121			140	
New Mexico	124			20		148			34	
Rocky Mountain	1,397	------		289		1,444	------		269	
West Coast	3,353	------	28	428		3,418	------	25	371	
Total	24,629	1,134	78	3,646	25,664	24,671	866	84	3,046	26,053

p Preliminary. NA Not available.

[1] Converted from barrels to short tons (5.5 barrels = 1 short ton).

Table 51.—Salient statistics on road oil in the United States, by months and refining districts

(Short tons) [1]

	1968			1969 p		
	Production	Stocks, end of period	Domestic demand	Production	Stocks, end of period	Domestic demand
By month:						
January	40,364	160,909	25,636	47,273	124,727	22,546
February	46,182	173,636	33,455	30,909	147,091	8,545
March	82,182	212,182	43,636	91,273	214,546	23,818
April	70,364	225,455	57,091	66,182	232,545	48,183
May	123,818	254,727	94,545	142,182	254,182	120,545
June	159,818	247,818	166,727	200,909	256,546	198,545
July	202,727	215,455	235,091	233,091	236,727	252,910
August	203,272	157,455	261,273	329,818	259,273	307,272
September	144,727	136,909	165,273	219,818	210,364	268,727
October	94,182	109,636	121,455	162,727	170,545	202,546
November	39,637	94,727	54,546	78,545	157,818	91,272
December	33,818	100,000	28,545	49,273	160,000	47,091
Total	1,241,091	100,000	1,287,273	1,652,000	160,000	1,592,000
By refining district:						
East Coast	---------	---------		---------	-------	
Appalachian No. 1	112,909	2,363		106,364	2,909	
Appalachian No. 2	---------	---------		---------	-------	
Indiana, Illinois, Kentucky, etc.	232,000	5,636		578,000	42,727	
Minn., Wis., N. Dak.	38,545	---------		44,545	-------	
Oklahoma, Kansas, etc.	169,455	22,364		187,273	20,727	
Texas Inland	9,455	182	NA	19,273	182	NA
Texas Gulf Coast	20,364	364		15,273	546	
Louisiana Gulf Coast	---------	---------		---------	-------	
Arkansas, Louisiana Inland, etc.	---------	---------		---------	-------	
New Mexico	---------	---------		---------	-------	
Rocky Mountain	369,636	30,182		359,636	27,273	
West Coast	288,727	38,909		341,636	65,636	
Total	1,241,091	100,000	1,287,273	1,652,000	160,000	1,592,000

p Preliminary. NA Not available.

[1] Converted from barrels to short tons (5.5 barrels = 1 short ton).

Table 52.—Salient statistics on special naphthas in the United States, by months and refining districts

(Thousand barrels unless otherwise stated)

	1968							1969 p						
	Production at refineries	Yield (percent)	Production at gas-processing plants	Imports	Exports	Total stocks end of period	Domestic demand	Production at refineries	Yield (percent)	Production at gas-processing plants	Imports	Exports	Total stocks end of period	Domestic demand
By month:														
January	2,140	0.7	47	149	129	5,812	2,143	1,941	0.6	46	288	158	5,352	2,594
February	2,041	.7	48	2	170	5,506	2,227	2,291	.8	39	37	131	5,955	1,633
March	2,255	.7	47	95	237	5,299	2,367	2,335	.7	42	947	203	6,231	2,845
April	2,287	.8	37	2	179	5,537	1,909	2,152	.7	42	156	234	5,708	2,639
May	2,579	.8	37	73	282	5,812	2,132	2,600	.8	45	273	154	6,180	2,292
June	2,230	.7	42	64	116	5,672	2,360	2,577	.8	43	347	204	6,075	2,868
July	2,358	.7	36	273	293	5,517	2,529	2,316	.7	41	130	131	5,916	2,515
August	2,461	.7	35	2	188	5,696	2,131	2,436	.7	42	266	234	5,794	2,632
September	2,384	.8	33	2	253	5,453	2,409	2,501	.8	40	526	162	6,024	2,675
October	2,478	.8	33	198	143	5,732	2,287	2,368	.7	39	3	155	5,768	2,511
November	2,169	.7	33	275	198	5,823	2,188	2,410	.7	37	2	142	5,957	2,118
December	2,261	.7	45	264	239	5,829	2,325	2,470	.7	36	216	110	6,292	2,277
Total	27,643	.7	473	1,399	2,427	5,829	27,007	28,397	.7	492	3,191	2,018	6,292	29,599
By refining district:														
East Coast	1,044	.2	------	1,281	521	1,416		734	.1	------	2,190	518	1,380	
Appalachian No. 1	354	.7	------			94		372	.7	------			85	
Appalachian No. 2	397	1.8	------			30		293	1.3	------			37	
Indiana, Illinois, Kentucky, etc	3,651	.5	------			989		3,821	.6	------			1,002	
Minnesota, Wisconsin, etc	------	------	------	13	258	60		------	------	------	12	251	69	
Oklahoma, Kansas, etc	1,801	.5	41			165		1,385	.4	29			180	
Texas	980	.7	38			116	NA	1,006	.1	43			136	NA
Texas Gulf Coast	14,427	1.7	------			1,870		15,572	1.8	------			2,366	
Louisiana Gulf Coast	568	.1	------	105	1,374	80		510	.1	------	953	1,081	117	
Arkansas, Louisiana Inland, etc	859	1.7	394			173		956	1.8	420			191	
New Mexico	------	------	------			1		------	------	------			------	
Rocky Mountain	144	.2	------	------	3	24		146	.1	------	------	1	33	
West Coast	3,418	.6	------	------	271	811		3,602	.6	------	36	167	696	
Total	27,643	.7	473	1,399	2,427	5,829	27,007	28,397	.7	492	3,191	2,018	6,292	

p Preliminary.
NA Not available.

Table 53.—Salient statistics on wax in the United States, by types, months, and refining districts

(Thousand barrels)[1]

	Production				Imports (all types)	Exports (all types)	Stocks, end of period				Domestic demand (all types)
	Micro-crystalline	Fully refined	Other	Total			Micro-crystalline	Fully refined	Other	Total	
1968											
By month:											
January	94	183	175	452	------	107	192	430	414	1,036	354
February	100	231	142	473	------	105	189	425	438	1,052	352
March	124	246	127	497	1	125	199	432	416	1,047	378
April	93	259	148	500	6	128	190	499	390	1,079	346
May	109	231	144	484	1	146	181	446	388	1,015	403
June	87	297	145	529	------	153	176	499	377	1,052	339
July	110	237	170	517	1	159	193	456	403	1,052	359
August	102	228	156	486	2	134	186	457	404	1,047	359
September	102	208	153	463	6	149	171	421	397	989	378
October	109	232	144	485	------	107	166	402	390	958	409
November	90	255	174	519	------	152	165	376	386	927	398
December	89	203	190	482	------	123	170	341	490	1,001	285
Total	1,209	2,810	1,868	5,887	17	1,588	170	341	490	1,001	4,360
By refining district:											
East Coast	298	1,042	666	2,006	14		30	100	79	209	
Appalachian No. 1	233	41	231	505			25	31	154	210	
Appalachian No. 2	------	30	23	53			------	5	------	5	
Indiana, Illinois, Kentucky, etc	37	242	134	413			14	17	129	160	
Minnesota, Wisconsin, etc	------	------	------	------	------		------	------	------	------	
Oklahoma, Kansas, etc	249	263	63	575		1,480	48	22	9	79	
Texas Inland	80	------	------	80			18	------	------	18	NA
Texas Gulf Coast	235	579	424	1,238			17	46	87	150	
Louisiana Gulf Coast	66	306	84	456	3		13	49	17	79	
Arkansas, Louisiana Inland, etc	------	------	------	------			------	------	------	------	
New Mexico	------	------	------	------			------	------	------	------	
Rocky Mountain	11	60	18	89			5	33	15	53	
West Coast	------	247	225	472	------	108	------	38	------	38	
Total	1,209	2,810	1,868	5,887	17	1,588	170	341	490	1,001	4,360
1969 p											
By month:											
January	85	263	90	438	19	46	167	376	434	977	435
February	70	187	209	466	13	84	152	344	435	931	441
March	123	249	263	635	2	134	164	343	482	989	445
April	98	239	210	547	21	145	163	356	522	1,041	371
May	145	242	249	636	24	166	182	354	531	1,067	468
June	96	258	160	514	14	134	185	380	471	1,036	425
July	108	188	189	485	------	160	167	337	484	988	373
August	116	234	184	534	13	163	174	360	496	1,030	342
September	100	231	150	481	26	115	188	359	441	988	434

October	108	242	191	541	------	149	158	299	489	946	434
November	146	218	171	535	13	158	211	320	467	998	338
December	82	301	167	550	13	167	164	360	473	997	397
Total	1,277	2,852	2,233	6,362	158	1,621	164	360	473	997	4,903
By refining district:											
East Coast	331	1,037	657	2,025	12		29	125	45	199	
Appalachian No. 1	252	44	280	576			18	11	151	180	
Appalachian No. 2	------	14	------	14			------	4	------	4	
Indiana, Illinois, Kentucky, etc	37	228	141	406	------		3	19	125	147	
Minnesota, Wisconsin, etc	------	------	------	------			------	------	------	------	
Oklahoma, Kansas, etc	262	256	51	569		1,523	49	23	8	80	
Texas Inland	92	------	------	92			19	------	------	19	NA
Texas Gulf Coast	203	539	494	1,236			26	55	86	167	
Louisiana Gulf Coast	94	441	371	906	146		19	60	41	120	
Arkansas, Louisiana Inland, etc	------	------	------	------			------	------	------	------	
New Mexico	------	------	------	------			------	------	------	------	
Rocky Mountain	6	51	24	81	------		1	21	17	39	
West Coast	------	242	215	457	------	98	------	42	------	42	
Total	1,277	2,852	2,233	6,362	158	1,621	164	360	473	997	4,903

p Preliminary. NA Not available.

1 Conversion factor: 280 pounds to the barrel.

Table 54.—Salient statistics on petroleum coke in the United States, by months and refining districts

(Thousand barrels unless otherwise stated)

	1968							1969 p						
	Marketable	Production catalyst	Total	Yield (percent)	Exports	Stocks end of period	Domestic demand	Marketable	Production catalyst	Total	Yield (percent)	Exports	Stocks end of period	Domestic demand
By month:														
January	3,766	3,910	7,676	2.4	1,096	6,709	6,692	3,537	3,870	7,407	2.4	971	6,490	6,141
February	3,542	3,944	7,486	2.5	1,565	6,487	6,143	3,790	3,621	7,411	2.5	1,264	6,495	6,142
March	3,772	4,149	7,921	2.5	1,464	6,518	6,426	4,127	4,248	8,375	2.5	1,341	6,307	7,222
April	3,648	3,771	7,419	2.5	1,414	6,088	6,435	4,389	3,980	8,369	2.7	2,061	6,545	6,070
May	3,850	4,011	7,861	2.5	1,827	6,095	6,027	4,221	4,224	8,445	2.6	1,924	6,591	6,475
June	3,687	4,118	7,805	2.5	1,407	6,297	6,196	4,311	4,546	8,857	2.7	2,139	6,908	6,401
July	3,824	4,354	8,178	2.5	1,673	6,299	6,503	4,243	4,812	9,055	2.6	1,982	6,570	7,411
August	3,937	4,524	8,461	2.6	1,709	6,407	6,644	4,359	4,400	8,759	2.6	2,636	6,175	6,518
September	3,918	4,216	8,134	2.6	1,671	6,597	6,273	4,348	4,324	8,672	2.6	2,335	5,655	6,857
October	3,987	4,125	8,112	2.5	1,750	6,163	6,796	4,684	4,293	8,977	2.7	1,576	6,124	6,932
November	3,995	3,888	7,883	2.5	1,802	6,200	6,044	4,857	4,278	9,135	2.8	2,197	6,184	6,878
December	3,897	4,357	8,254	2.5	2,119	6,195	6,140	5,140	4,266	9,406	2.7	2,604	5,198	7,788
Total	45,823	49,367	95,190	2.5	19,497	6,195	76,319	52,006	50,862	102,868	2.6	23,030	5,198	80,835
By refining district:														
East Coast	5,512	7,254	12,766	2.7		687		5,612	7,817	13,429	2.7		782	
Appalachian No. 1	3	144	147	.4		------		------	147	147	.2		------	
Appalachian No. 2	------	88	88	14		------		------	96	96	14		------	
Indiana, Illinois, Kentucky, etc	8,578	9,953	18,531	2.8		847		8,340	9,833	18,173	2.7		468	
Minnesota, Wisconsin, etc	2,101	800	2,901	4.3		61		2,181	856	3,037	4.2		86	
Oklahoma, Kansas, etc	4,043	4,398	8,441	2.6	9,177	62		4,020	4,621	8,641	2.7	9,053	132	
Texas Inland	471	1,818	2,289	1.7		1	NA	211	2,144	2,355	1.7		1	NA
Texas Gulf Coast	3,968	13,383	17,351	2.1		16		4,357	13,241	17,598	2.1		213	
Louisiana Gulf Coast	4,977	5,881	10,858	2.4		465		7,047	5,827	12,874	2.8		287	
Arkansas, Louisiana Inland, etc	1,395	752	2,147	4.1		251		1,514	694	2,208	4.1		322	
New Mexico	------	192	192	1.5		------		------	148	148	1.1		------	
Rocky Mountain	1,234	2,038	3,272	2.4		1,567		899	2,061	2,960	2.1		1,558	
West Coast	13,541	2,666	16,207	2.8	10,320	2,238		17,825	3,377	21,202	3.5	13,977	1,349	
Total	45,823	49,367	95,190	2.5	19,497	6,195	76,319	52,006	50,862	102,868	2.6	23,030	5,198	80,835

p Preliminary. NA Not available.
[1] Conversion factor: 5.0 barrels to the short ton.

Table 55.—Production of miscellaneous finished oils in the United States in 1969, by districts and classes

(Thousand barrels)

District	Absorption	Petrolatum	Specialty oils	Petrochemicals	Other products	Total
East Coast	-------	-------	1,104	404	277	1,785
Appalachian No. 1	7	85	27	-------	36	155
Appalachian No. 2	-------	-------	14	-------	-------	14
Indiana, Illinois, Kentucky, etc	38	60	462	625	90	1,275
Minnesota, Wisconsin, North Dakota, and South Dakota	-------	-------	-------	122	-------	122
Oklahoma, Kansas, etc	179	278	605	-------	354	1,416
Texas Inland	172	-------	38	886	47	1,143
Texas Gulf	49	400	1,320	3,847	901	6,517
Louisiana Gulf	366	64	-------	1,127	162	1,719
Arkansas, Louisiana Inland	123	-------	-------	10	17	150
Rocky Mountain, New Mexico	4	36	-------	17	-------	57
West Coast	25	19	1,105	1,924	518	3,591
Total:						
1969	963	942	[1] 4,675	8,962	2,402	17,944
1968	3,422	1,125	4,243	7,311	2,995	19,096

[1] Specialty oils include: Insulating, 135; medicinal, 304; rust preventatives, 3; sand-frac, 38; spray oils, 290; and other, 3,905.

Table 56.—Crude, refined, and unfinished oils imported into the United States, by months [1]

(Thousand barrels)

Year and class	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1968													
Crude petroleum	30,537	28,152	35,506	32,459	37,462	40,212	45,717	43,243	42,474	45,912	40,779	49,870	472,323
Petroleum products:													
Motor gasoline	1,182	816	1,761	2,046	1,935	2,082	2,610	2,130	1,739	1,931	1,760	1,599	21,591
Jet fuel:													
Naphtha type	476	689	641	613	494	1,076	480	378	464	437	473	896	7,117
Kerosine type	2,302	2,981	1,945	2,650	2,375	1,994	3,260	3,145	2,749	3,113	2,430	2,446	31,390
Total	2,778	3,670	2,586	3,263	2,869	3,070	3,740	3,523	3,213	3,550	2,903	3,342	38,507
Liquefied gases:													
Butane	1,003	596	394	230	318	226	339	394	520	521	658	821	6,020
Propane	750	625	503	459	407	299	241	229	369	544	500	701	5,627
Total	1,753	1,221	897	689	725	525	580	623	889	1,065	1,158	1,522	11,647
Kerosine	-------	-------	-------	1	-------	31	-------	30	-------	-------	-------	128	190
Distillate fuel oil	5,352	6,033	6,444	4,114	2,645	3,136	2,930	2,382	2,735	2,249	4,048	6,080	48,148
Residual fuel oil	49,460	39,766	44,796	31,380	27,180	30,311	30,218	25,755	31,129	32,543	30,413	36,977	409,928
Special naphthas	149	2	95	2	73	64	273	2	2	198	275	264	1,399
Lubricants	3	3	4	2	2	2	3	3	3	3	3	2	33
Wax	-------	-------	1	6	1	-------	1	2	6	-------	-------	-------	17
Asphalt	422	319	101	195	339	1,225	756	429	821	836	441	352	6,236
Unfinished oils	1,987	2,341	1,838	2,079	2,467	2,529	3,426	2,464	2,703	2,789	2,357	2,370	29,350
Total petroleum products	63,086	54,171	58,523	43,777	38,236	42,975	44,537	37,343	43,240	45,164	43,358	52,636	567,046
Total crude and products	93,623	82,323	94,029	76,236	75,698	83,187	90,254	80,586	85,714	91,076	84,137	102,506	1,039,369
1969 p													
Crude petroleum	35,442	36,537	45,654	43,568	44,137	40,960	43,209	44,887	42,364	45,042	43,775	48,274	513,849
Petroleum products:													
Motor gasoline	2,213	1,793	2,638	1,929	1,962	1,434	2,086	1,974	1,986	1,184	1,794	1,716	22,709
Jet fuel:													
Naphtha type	454	590	821	190	602	267	259	505	726	186	256	278	5,134
Kerosine type	2,667	2,761	3,830	2,620	3,135	3,470	3,869	3,714	4,211	2,336	4,041	3,751	40,405
Total	3,121	3,351	4,651	2,810	3,737	3,737	4,128	4,219	4,937	2,522	4,297	4,029	45,539
Liquefied gases:													
Butane	780	555	629	452	323	449	458	409	608	856	814	1,067	7,400
Propane	820	639	375	331	224	207	203	212	293	517	589	841	5,251
Total	1,600	1,194	1,004	783	547	656	661	621	901	1,373	1,403	1,908	12,651
Kerosine	111	76	171	-------	106	-------	56	-------	243	34	55	113	965
Distillate fuel oil	7,341	5,973	7,033	3,523	2,613	2,221	2,826	4,296	3,472	2,297	3,403	5,885	50,883
Residual fuel oil	51,384	41,230	41,374	38,834	34,220	29,094	32,289	34,105	35,100	39,001	33,751	51,229	461,611
Petrochemical feedstocks	-------	-------	-------	-------	-------	-------	-------	-------	40	-------	-------	-------	40
Special naphthas	288	37	947	156	273	347	130	266	526	3	2	216	3,191

Lubricants	2	2	2	3	2	65	2	2	44	1	33	5	163
Wax	19	13	2	21	24	14	-------	13	26	-------	13	13	158
Asphalt	255	333	175	181	474	464	573	403	734	352	294	523	4,761
Unfinished oils	2,184	3,583	2,723	2,556	2,459	2,844	2,761	3,520	4,056	2,806	3,724	4,792	38,008
Total petroleum products	68,518	57,585	60,720	50,796	46,417	40,876	45,512	49,419	52,065	49,573	48,769	70,429	640,679
Total crude and products	103,960	94,122	106,374	94,364	90,554	81,836	88,721	94,306	94,429	94,615	92,544	118,703	1,154,528

p Preliminary.
1 Imports of crude and unfinished oils reported to the Bureau of Mines; imports of petroleum products compiled from records of the U.S. Department of Commerce.

Table 57.—Crude oil and petroleum products imported into the United States, by country and receiving district

(Thousand barrels)

Country and PAD district	Crude oil [1]	Gasoline	Special naphtha	Kerosine	Distillate fuel oil [2]	No. 4 distillate fuel oil [3]	Residual fuel oil [2]	Military jet fuel	Commercial jet fuel	Propane	Butane	Asphalt	Unfinished oils [1]	Lubricants	Wax	Petrochemical feedstocks	Total
1968																	
North America:																	
Canada	169,418	576	21	2	1,529	------	1,869	278	------	5,460	5,961	228	1	23	2	------	185,368
Mexico	------	------	------	------	------	------	5,807	------	------	------	1	------	10,793	------	3	------	16,604
Total	169,418	576	21	2	1,529	------	7,676	278	------	5,460	5,962	228	10,794	23	5	------	201,972
Central America and Caribbean:																	
Bahamas	------	------	------	------	------	------	292	------	------	------	------	------	------	------	------	------	292
Haiti	------	------	------	------	------	------	474	------	------	------	------	------	------	------	------	------	474
Leeward and Windward Islands	------	------	------	------	96	------	------	------	------	------	------	------	------	------	------	------	96
Netherland Antilles	------	323	866	------	11,052	6,727	109,373	2,067	14,450	------	------	3,367	2,859	------	------	------	144,357
Panama	------	350	------	------	357	------	230	103	346	------	------	------	1,077	------	------	------	2,463
Puerto Rico	------	17,900	------	------	6,042	------	477	------	------	------	------	------	------	------	------	------	24,419
Trinidad and Tobago	------	13	106	------	2,976	2,086	55,752	2,144	5,043	------	------	10	3,102	------	------	------	69,146
Virgin Islands	------	1,898	------	188	7,153	240	17,095	------	------	------	------	------	2,175	------	------	------	28,509
Total	------	20,484	972	188	27,676	9,053	183,693	4,314	19,839	------	------	3,377	9,213	------	------	------	269,756
South America:																	
Argentina	------	------	------	------	80	------	4,679	------	------	------	------	------	------	------	------	------	4,759
Bolivia	6,866	------	------	------	------	------	------	------	------	------	------	------	18	------	------	------	6,884
Brazil	------	------	------	------	------	------	66	------	------	------	------	------	------	------	------	------	66
Chile	1,975	------	------	------	------	------	------	------	------	------	------	------	59	------	------	------	2,034
Colombia	11,981	------	------	------	800	45	5,936	------	------	------	------	------	141	------	------	------	18,858
Peru	------	------	------	------	------	------	------	------	------	------	------	------	263	------	------	------	263
Venezuela	125,737	530	406	------	16,345	9,521	160,723	2,525	10,178	167	57	2,278	5,444	------	------	------	324,390
Total	146,559	530	406	------	17,225	9,566	171,404	2,525	10,178	167	57	2,278	5,925	------	------	------	357,254
Europe:																	
Belgium	------	1	------	------	128	------	918	------	------	------	------	------	------	------	------	------	1,047
Denmark	------	------	------	------	------	------	------	------	------	------	------	------	27	------	------	------	27
France	------	------	------	------	------	------	1,233	------	------	------	------	------	------	------	------	------	1,233
Germany, West	------	------	------	------	------	------	189	------	------	------	------	------	------	2	12	------	203
Italy	------	------	------	------	766	260	19,190	------	241	------	------	------	------	------	------	------	20,197
Netherlands	------	------	------	------	------	------	5,071	------	------	------	------	328	662	7	------	------	6,068
Rumania	------	------	------	------	------	------	317	------	------	------	------	------	------	------	------	------	317
Spain	------	------	------	------	527	------	5,453	------	------	------	------	------	253	------	------	------	6,233
United Kingdom	------	------	------	------	207	207	9,655	------	221	------	------	25	------	1	------	------	10,109
Total	------	1	------	------	1,628	467	42,026	------	462	------	------	353	942	10	12	------	45,434

Middle East:																	
Abu Dhabi	5,605	------	------	------	------	------	------	------	------	------	------	------	231	------	------	------	5,836
Bahrain	------	------	------	------	------	------	1,007	------	456	------	------	------	------	------	------	------	1,463
Iran	21,154	------	------	------	------	------	653	------	289	------	------	------	287	------	------	------	22,383
Kuwait	15,863	------	------	------	------	------	------	------	------	------	------	------	1,741	------	------	------	17,604
Neutral Zone	10,749	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	10,749
Saudi Arabia	18,959	------	------	------	90	------	2,577	------	31	------	------	------	217	------	------	------	21,874
Total	72,330	------	------	------	90	------	4,237	------	776	------	------	------	2,476	------	------	------	79,909
Africa:																	
Algeria	1,944	------	------	------	------	------	107	------	------	------	------	------	------	------	------	------	2,051
Canary Islands	------	------	------	------	------	------	------	------	135	------	------	------	------	------	------	------	135
Gabon	------	------	------	------	------	------	422	------	------	------	------	------	------	------	------	------	422
Ivory Coast	------	------	------	------	------	------	363	------	------	------	------	------	------	------	------	------	363
Libya	41,591	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	41,591
Nigeria	3,131	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	3,131
United Arab Republic	10,795	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	10,795
Total	57,461	------	------	------	------	------	892	------	135	------	------	------	------	------	------	------	58,488
Asia:																	
Japan	------	------	------	------	------	------	------	------	------	------	1	------	------	------	------	------	1
Sumatra	26,555	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	26,555
Total	26,555	------	------	------	------	------	------	------	------	------	1	------	------	------	------	------	26,556
Total imports	472,323	21,591	1,399	190	48,148	19,086	409,928	7,117	31,390	5,627	6,020	6,236	29,350	33	17	------	1,039,369
Imports by PAD districts:																	
District I	263,866	20,426	1,281	190	45,502	19,086	394,528	1,714	19,787	606	63	5,500	21,987	17	14	------	775,481
District II	78,365	175	13	------	360	------	573	------	1,179	2,762	2,315	182	1	14	------	------	85,939
District III	641	1	105	------	1,290	------	8,271	------	392	------	------	554	109	2	3	------	11,368
District IV	10,058	------	------	------	------	------	54	------	------	1,018	1,181	------	------	------	------	------	12,311
District V	119,393	989	------	------	996	------	6,502	5,403	10,032	1,241	2,461	------	7,253	------	------	------	154,270
1969 p																	
North America:																	
Canada	203,298	444	20	36	2,653	27	2,482	------	48	5,038	7,359	194	200	16	3	------	221,791
Mexico	------	------	------	------	------	------	5,805	------	------	------	------	------	9,018	------	2	------	14,825
Total	203,298	444	20	36	2,653	27	8,287	------	48	5,038	7,359	194	9,218	16	5	------	236,616
Central America and Caribbean:																	
Leeward and Windward Islands	------	------	------	------	------	------	211	------	------	------	------	------	------	------	------	------	211
Netherland Antilles	------	183	1,042	------	14,556	10,755	120,319	1,550	17,872	------	------	2,390	5,963	------	------	------	163,875
Panama	------	331	------	------	287	------	660	48	887	------	------	------	1,772	------	------	------	3,985
Puerto Rico	------	20,709	------	------	5,407	------	------	------	112	------	------	------	------	------	------	40	26,268
Trinidad and Tobago	------	------	953	------	3,360	2,980	61,792	2,307	7,164	------	------	9	2,900	138	------	------	78,623
Virgin Islands	------	825	------	929	6,321	------	24,641	273	------	------	------	------	9,564	------	------	------	42,553
Total	------	22,048	1,995	929	29,931	13,735	207,623	4,178	26,035	------	------	2,399	20,199	138	------	40	315,515

See footnotes at end of table.

Table 57.—Crude oil and petroleum products imported into the United States, by country and receiving district—Continued

(Thousand barrels)

Country and PAD district	Crude oil[1]	Gasoline	Special naphtha	Kerosine	Distillate fuel oil[2]	No. 4 Distillate fuel oil[3]	Residual fuel oil[2]	Military jet fuel	Commercial jet fuel	Propane	Butane	Asphalt	Unfinished oils[1]	Lubricant	Wax	Petrochemical feedstocks	Total
South America:																	
Argentina	------	------	------	------	------	------	342	------	------	------	------	------	------	------	------	------	342
Bolivia	5,331	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	5,331
Chile	1,464	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	1,464
Colombia	15,551	------	146	------	530	------	9,052	------	------	------	------	------	146	------	------	------	25,425
Peru	216	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	216
Venezuela	111,722	216	438	------	14,774	11,498	174,689	822	9,518	213	40	1,924	4,874	------	143	------	319,373
Total	134,284	216	584	------	15,304	11,498	184,083	822	9,518	213	40	1,924	5,020	------	143	------	352,151
Europe:																	
Belgium	------	------	------	------	146	------	3,849	------	------	------	------	------	------	2	------	------	3,997
France	------	------	------	------	133	133	3,304	------	------	------	1	------	------	------	------	------	3,438
Italy	------	------	------	------	1,285	960	24,426	------	1,459	------	------	------	162	------	------	------	27,332
Germany, West	------	------	------	------	------	------	------	------	------	------	------	------	------	------	10	------	10
Netherlands	------	------	172	------	610	219	11,174	------	236	------	------	237	483	6	------	------	12,918
Rumania	------	------	------	------	565	564	1,016	------	------	------	------	------	------	------	------	------	1,581
Spain	------	------	------	------	------	------	4,424	------	110	------	------	------	------	------	------	------	4,534
United Kingdom	------	1	------	------	136	136	6,093	25	493	------	------	------	627	1	------	------	7,376
U.S.S.R.	------	------	------	------	120	120	620	------	------	------	------	------	------	------	------	------	740
Yugoslavia	------	------	------	------	------	------	252	------	------	------	------	------	------	------	------	------	252
Total	------	1	172	------	2,995	2,132	55,158	25	2,298	------	1	237	1,272	9	10	------	62,178
Middle East:																	
Abu Dhabi	5,051	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	5,051
Bahrain	------	------	------	------	------	------	1,803	86	526	------	------	------	------	------	------	------	2,415
Iran	15,306	------	302	------	------	------	------	------	957	------	------	------	313	------	------	------	16,878
Kuwait	12,539	------	------	------	------	------	------	------	------	------	------	------	1,656	------	------	------	14,195
Neutral Zone	15,864	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	15,864
Qatar	191	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	191
Saudi Arabia	12,665	------	118	------	------	------	3,069	------	------	------	------	------	------	------	------	------	15,852
Total	61,616	------	420	------	------	------	4,872	86	1,483	------	------	------	1,969	------	------	------	70,446
Africa:																	
Algeria	358	------	------	------	------	------	363	------	------	------	------	------	------	------	------	------	721
Angola	424	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	424
Gabon	------	------	------	------	------	------	402	------	------	------	------	------	------	------	------	------	402
Ivory Coast	------	------	------	------	------	------	527	------	------	------	------	------	------	------	------	------	527
Libya	48,862	------	------	------	------	------	291	------	------	------	------	------	------	------	------	------	49,153
Nigeria	17,958	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	17,958
United Arab Republic	14,778	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	14,778

Total	82,380	------	------	------	------	------	1,583	------	------	------	------	------	------	------	------	------	83,963
Asia:																	
Japan	------	------	------	------	------	------	5	23	1,023	------	------	------	330	------	------	------	1,381
Sumatra	32,271	------	------	------	------	------	------	------	------	------	------	7	------	------	------	------	32,278
Total	32,271	------	------	------	------	------	5	23	1,023	------	------	7	330	------	------	------	33,659
Total imports	513,849	22,709	3,191	965	50,883	27,392	461,611	5,134	40,405	5,251	7,400	4,761	38,008	163	158	40	1,154,528
Imports by PAD districts:																	
District I	269,007	22,112	2,190	960	47,720	27,392	440,983	1,976	23,031	494	65	4,386	28,217	18	12	------	841,171
District II	88,434	126	12	------	1,264	------	627	------	1,771	2,348	1,943	150	51	4	------	------	96,730
District III	------	------	953	------	937	------	12,167	------	478	------	------	225	1,034	141	146	40	16,121
District IV	12,714	------	------	5	------	------	78	------	------	1,489	1,407	------	------	------	------	------	15,693
District V	143,694	471	36	------	962	------	7,756	3,158	15,125	920	3,985	------	8,706	------	------	------	184,813

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1 Imports of crude and unfinished oils reported to the Bureau of Mines; imports of refined products compiled from records of the U.S. Department of Commerce.
2 Includes quantities imported duty free for supply of vessels and aircraft engaged in foreign trade.
3 Included in distillate fuel oil.

Table 58.—Petroleum oils, crude and refined, exported from the United States, including shipments to territories and possessions, by months [1]

(Thousand barrels)

Year and class	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1968													
Crude petroleum	250	283	41	144	87	226	2	86	76	111	402	94	1,802
Refined products:													
Gasoline: [2]													
Motor	20	10	15	14	48	11	29	18	18	37	19	10	249
Aviation	52	75	388	233	52	119	186	126	178	217	84	124	1,834
Total gasoline	72	85	403	247	100	130	215	144	196	254	103	134	2,083
Jet fuel:													
Naphtha-type	143	180	219	151	194	154	161	239	148	105	172	225	2,091
Kerosine-type	------	------	------	------	------	------	------	1	------	------	------	------	1
Total jet fuel	143	180	219	151	194	154	161	240	148	105	172	225	2,092
Liquefied gases:													
Butane	75	73	35	29	109	148	38	118	39	104	143	273	1,184
Propane	105	244	254	62	62	371	292	86	188	418	268	192	2,542
Butane-propane mix	570	564	527	473	658	650	643	506	583	542	565	601	6,882
Total liquefied gases	750	881	816	564	829	1,169	973	710	810	1,064	976	1,066	10,608
Kerosine	39	210	29	15	15	12	14	12	15	16	64	172	613
Distillate fuel oil	180	124	88	154	171	61	104	81	353	79	62	90	1,547
Residual fuel oil	1,629	1,473	2,244	2,083	2,236	2,174	1,211	1,900	1,271	1,262	1,043	1,487	20,013
Petrochemical feedstocks	147	225	354	229	58	373	144	47	533	330	261	94	2,795
Special naphthas	129	170	237	179	282	116	293	188	253	143	198	239	2,427
Lubricants	993	1,194	1,650	1,535	1,526	1,619	1,869	1,508	1,832	1,303	1,663	1,309	18,001
Wax	107	105	125	128	146	153	159	134	149	107	152	123	1,588
Coke	1,096	1,565	1,464	1,414	1,827	1,407	1,673	1,709	1,671	1,750	1,802	2,119	19,497
Asphalt	28	47	21	51	56	25	32	37	38	32	31	31	429
Miscellaneous	62	68	82	92	98	67	107	106	117	65	84	101	1,049
Total refined	5,375	6,327	7,732	6,842	7,538	7,460	6,955	6,816	7,386	6,510	6,611	7,190	82,742
Total crude and refined	5,625	6,610	7,773	6,986	7,625	7,686	6,957	6,902	7,462	6,621	7,013	7,284	84,544
1969 p													
Crude petroleum	------	220	176	93	216	1	------	144	83	162	240	101	1,436
Refined products:													
Gasoline: [2]													
Motor	22	12	20	21	116	72	68	152	98	52	34	52	719
Aviation	33	98	24	135	264	123	183	109	307	220	93	218	1,807
Total gasoline	55	110	44	156	380	195	251	261	405	272	127	270	2,526
Jet fuel (naphtha-type)	1	296	89	246	101	245	66	114	323	221	139	87	1,928

Liquefied gases:													
Butane	116	356	515	77	96	76	304	579	443	132	105	285	3,084
Propane	258	130	219	75	177	97	263	130	126	442	296	199	2,412
Butane-propane mix	684	700	682	590	516	517	658	647	576	531	582	616	7,299
Total liquefied gases	1,058	1,186	1,416	742	789	690	1,225	1,356	1,145	1,105	983	1,100	12,795
Kerosine	11	5	15	22	23	14	6	5	17	7	22	9	156
Distillate fuel oil	70	92	118	94	115	184	108	105	119	118	75	.83	1,281
Residual fuel oil	1,669	1,687	1,708	1,134	1,685	1,423	1,099	1,493	988	1,642	1,550	815	16,893
Petrochemical feedstocks	537	355	337	281	422	259	156	299	349	370	234	250	3,849
Special naphthas	158	131	203	234	154	204	131	234	162	155	142	110	2,018
Lubricants	1,191	820	1,394	1,427	1,702	1,887	1,148	1,713	1,466	1,227	1,078	1,384	16,437
Wax	46	84	134	145	166	134	160	163	115	149	158	167	1,621
Coke	971	1,264	1,341	2,061	1,924	2,139	1,982	2,636	2,335	1,576	2,197	2,604	23,030
Asphalt	20	31	25	24	50	47	62	59	58	34	31	22	463
Miscellaneous	46	59	90	107	69	72	93	84	74	90	63	72	919
Total	5,833	6,120	6,914	6,673	7,580	7,493	6,487	8,522	7,556	6,966	6,799	6,973	83,916
Total crude and refined	5,833	6,340	7,090	6,766	7,796	7,494	6,487	8,666	7,639	7,128	7,039	7,074	85,352

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[1] Compiled from records of U.S. Department of Commerce.
[2] Includes benzol, natural gasoline, and antiknock compounds.

Table 59.—Crude petroleum and products exported from the United States, by countries of destination and shipments to and exports from territories and possessions

(Thousand barrels)

	Crude petroleum	Gasoline	Naphtha	Jet fuel	Kerosine	Distillate oil	Residual oil	Lubricating oil	Asphalt	Liquefied petroleum gases	Wax	Coke	Petrochemical feedstocks	Miscellaneous products	Total
1968															
North America:															
Canada	5	140	380	------	r 456	r 453	6,812	2,096	64	410	112	2,861	207	135	r 14,131
Mexico	114	88	203	14	(1)	53	1,665	671	135	7,677	226	369	8	31	11,254
Trinidad and Tobago	283	1	27	------	------	------	------	13	1	------	4	------	1	1	331
Other	------	90	231	4	r 1	10	474	414	23	82	118	47	45	16	r 1,555
Total	402	319	841	18	r 457	r 516	8,951	3,194	223	8,169	460	3,277	261	183	r 27,271
South America:															
Argentina	------	(1)	2	------	(1)	185	1	136	(1)	462	2	(1)	3	1	792
Brazil	------	345	30	------	2	------	7	1,752	29	377	95	103	155	82	2,977
Chile	------	------	2	------	1	------	(1)	235	2	26	25	------	1	13	305
Colombia	------	1	4	------	(1)	1	(1)	42	1	(1)	78	------	2	11	140
Peru	------	(1)	1	------	------	2	395	157	2	22	16	(1)	2	4	601
Other	------	16	27	------	1	2	(1)	186	12	1	49	1	4	24	323
Total	------	362	66	------	4	190	403	2,508	46	888	265	104	167	135	5,138
Europe:															
Belgium-Luxembourg	------	(1)	12	------	1	------	------	605	2	25	7	r 815	9	13	r 1,489
France	(1)	1	49	------	1	------	89	60	17	114	51	554	502	12	1,450
Germany, West	------	137	275	------	25	6	139	420	2	(1)	213	445	146	30	1,838
Greece	------	7	1	------	(1)	------	------	24	(1)	(1)	(1)	r 120	1	(1)	r 153
Italy	------	5	17	------	1	20	754	490	13	(1)	73	1,634	8	47	3,062
Netherlands	------	263	255	------	(1)	702	149	665	1	(1)	35	1,057	377	25	3,529
Norway	------	------	(1)	------	------	------	(1)	26	(1)	------	2	1,136	2	5	1,171
Spain	------	(1)	23	------	------	------	105	32	(1)	50	17	406	279	17	929
Sweden	------	(1)	1	------	------	------	(1)	157	2	------	10	159	79	12	420
United Kingdom	352	15	334	------	17	217	1,290	1,090	2	1,345	35	r 270	147	76	r 5,190
Other	------	r 86	2	r 265	(1)	164	1	131	3	(1)	40	151	r 12	16	r 871
Total	352	r 514	969	r 265	45	1,109	2,527	3,700	42	1,534	483	r 6,747	r 1,562	253	r 20,102
Africa:															
Congo (Kinshasa)	------	(1)	3	------	(1)	------	(1)	47	1	------	(1)	------	2	(1)	53
South Africa, Republic of	------	163	47	------	1	------	321	358	5	2	89	r 30	33	38	r 1,087
Other	------	273	10	------	7	------	1	221	11	(1)	59	273	9	22	886
Total	------	436	60	------	8	------	322	626	17	2	148	r 303	44	60	r 2,026
Asia:															
India	------	20	1	------	1	------	1	1,955	(1)	1	3	30	1	65	2,078

Indonesia	------	(1)	(1)	------	------	------	------	154	(1)	(1)	(1)	------	(1)	7	161
Japan	1,048	8	618	------	59	18	7,493	2,415	1	1	68	8,509	235	141	20,614
Philippines	------	(1)	24	------	2	------	------	378	2	(1)	25	------	4	21	456
Turkey	------	23	1	------	1	------	------	694	------	------	(1)	------	4	19	742
Other	(1)	5	64	------	3	1	2	1,644	17	(1)	55	267	26	50	2,134
Total	1,048	56	708	------	66	19	7,496	7,240	20	2	151	8,806	270	303	26,185
Oceania:															
Australia	------	15	83	------	r 9	4	4	308	2	4	59	r 260	443	69	r 1,290
French Pacific Islands	------	71	1	r 12	r 22	340	306	4	(1)	(1)	------	------	(1)	(1)	756
New Zealand	------	(1)	23	------	1	------	(1)	68	(1)	2	10	------	5	35	144
Other	------	------	(1)	------	1	1	------	8	7	1	(1)	------	(1)	(1)	18
Total	------	86	107	r 12	r 33	345	310	388	9	7	69	260	478	104	r 2,208
Grand total	1,802	r 1,773	2,751	r 295	613	r 2,179	20,009	17,656	357	10,602	1,576	r 19,497	r 2,782	1,038	r 82,930
Shipments from the United States to territories and possessions:															
Puerto Rico	1	154	26	(1)	------	3	4	329	74	7	12	(1)	13	11	r 634
Virgin Islands	------	r 42	3	(1)	------	11	------	6	1	2	------	------	------	(1)	r 65
Other [2]	------	510	------	1,797	------	415	------	13	2	------	------	------	------	------	2,737
Total	1	r 706	29	1,797	------	429	4	r 348	r 77	9	12	(1)	13	11	r 3,436
Exports from Puerto Rico to foreign countries	(1)	396	r 353	(1)	------	[1] 1,061	(1)	3	5	3	------	------	------	(1)	r 1,821
Total net shipments from the United States	1,803	r 2,083	r 2,427	r 2,092	613	r 1,547	20,013	r 18,001	r 429	r 10,608	1,588	r 19,497	r 2,795	1,049	r 84,545
1969															
North America:															
Canada	30	302	364	13	15	1,066	7,302	1,811	127	838	119	3,403	520	137	16,047
Mexico	1	103	71	20	1	74	1,811	620	126	7,997	270	554	38	26	11,712
Trinidad and Tobago	220	(1)	11	(1)	------	------	------	14	(1)	------	6	------	1	1	253
Other	------	59	47	------	1	71	1,378	591	25	119	106	42	17	22	2,478
Total	251	464	493	33	17	1,211	10,491	3,036	278	8,954	501	3,999	576	186	30,490
South America:															
Argentina	------	(1)	4	------	(1)	------	(1)	603	(1)	923	5	------	18	1	1,554
Brazil	------	(1)	243	------	------	------	101	1,257	9	617	46	121	36	106	2,536
Chile	------	------	1	------	1	------	1	211	3	29	28	(1)	2	9	285
Colombia	------	3	4	2	(1)	1	------	72	(1)	------	82	------	1	21	186
Peru	------	(1)	(1)	------	------	4	600	122	(1)	(1)	10	------	1	3	740
Other	------	37	24	(1)	2	32	21	174	31	1	54	126	3	23	528
Total	------	40	276	2	3	37	723	2,439	43	1,570	225	247	61	163	5,829

See footnotes at end of table.

Table 59.—Crude petroleum and products exported from the United States, by countries of destination and shipments to and exports from territories and possessions—Continued

(Thousand barrels)

	Crude petroleum	Gasoline	Naphtha	Jet fuel	Kerosine	Distillate oil	Residual oil	Lubricating oil	Asphalt	Liquefied petroleum gases	Wax	Coke	Petrochemical feedstocks	Miscellaneous products	Total
Europe:															
Belgium-Luxembourg	(1)	(1)	35	------	1	------	------	535	3	27	11	915	55	22	1,604
France	------	(1)	68	------	(1)	(1)	81	74	30	13	43	452	694	5	1,460
Germany, West	------	94	128	------	17	23	(1)	282	1	(1)	324	1,230	151	19	2,269
Greece	------	7	------	------	(1)	------	(1)	11	(1)	------	(1)	199	1	(1)	218
Italy	------	498	16	------	1	31	889	290	4	(1)	71	1,402	197	34	3,433
Netherlands	------	272	227	------	1	299	(1)	280	(1)	(1)	22	1,700	614	20	3,435
Norway	------	(1)	(1)	------	------	------	------	23	1	------	2	915	2	1	944
Spain	------	1	3	------	------	------	105	28	5	968	20	722	371	14	2,237
Sweden	------	(1)	2	------	------	------	(1)	139	3	------	10	378	196	8	736
United Kingdom	430	107	1,196	(1)	38	1	1,266	587	1	701	49	311	123	41	4,851
Other	------	81	1	98	(1)	145	1	115	3	22	31	151	9	12	669
Total	430	1,060	1,676	98	58	499	2,342	2,364	51	1,731	583	8,375	2,413	176	21,856
Africa:															
Congo	------	(1)	2	------	------	------	(1)	20	1	------	1	------	1	1	26
South Africa, Republic of	------	------	86	------	(1)	------	338	295	5	2	54	34	24	36	874
Other	------	112	13	------	6	42	142	282	10	------	44	268	9	21	949
Total	------	112	101	------	6	42	480	597	16	2	99	302	34	58	1,849
Asia:															
India	------	(1)	2	------	1	------	------	1,894	------	1	8	71	2	14	1,993
Indonesia	------	(1)	(1)	------	------	------	------	200	1	------	(1)	------	(1)	11	212
Japan	755	5	479	------	32	75	2,665	2,732	4	513	78	9,509	106	116	17,069
Philippines	------	(1)	18	------	5	------	------	461	1	------	14	------	4	18	521
Turkey	------	------	2	------	------	------	------	540	(1)	------	(1)	------	5	15	562
Other	------	117	101	193	1	22	12	1,566	14	(1)	40	75	43	64	2,248
Total	755	122	602	193	39	97	2,677	7,393	20	514	140	9,655	160	238	22,605
Oceania:															
Australia	------	1	59	------	5	------	2	216	1	5	57	450	579	49	1,424
French Pacific Islands	------	75	(1)	------	23	130	51	7	(1)	1	------	------	(1)	------	287
New Zealand	------	(1)	17	------	(1)	------	(1)	35	1	4	11	------	6	38	112
Other	------	(1)	(1)	------	------	------	(1)	2	3	(1)	------	------	(1)	------	5
Total	------	76	76	------	28	130	53	260	5	10	68	450	585	87	1,828
Grand total	1,436	1,874	3,224	326	151	2,016	16,766	16,089	413	12,781	1,616	23,028	3,829	908	84,457

Shipments from the United States to territories and possessions:															
Puerto Rico	------	123	18	------	(1)	2	1	282	70	16	17	33	18	13	593
Virgin Islands	------	76	------	------	------	16	137	19	------	4	1	------	1	(1)	254
Other [2]	------	489	1	1,527	3	380	------	12	2	------	------	------	------	------	2,414
Total	------	688	19	1,527	3	398	138	313	72	20	18	33	19	13	3,261
Exports from Puerto Rico to foreign countries:	------	46	1,227	------	(1)	1,048	134	5	13	3	2	------	(1)	(1)	2,478
Total net shipments from United States [3]	1,436	2,516	2,016	1,853	154	1,366	16,770	16,397	472	12,798	1,632	23,061	3,848	921	85,240

r Revised.
[1] Less than ½ unit.
[2] Data reported by shippers to the Bureau of Mines.
[3] The figures shown in this table may vary from export data shown in other sections of this chapter because of late changes in Bureau of Census data which could not be incorporated into the other tables.

Table 60.—World production of crude petroleum by countries

(Thousand barrels)

Country	1967	1968	1969 p
North America:			
Canada	351,292	379,396	407,499
Cuba e	756	800	700
Mexico	133,042	142,257	149,661
Trinidad and Tobago	64,995	66,904	57,429
United States	3,215,742	3,329,042	3,371,751
South America:			
Argentina	114,673	125,488	130,082
Bolivia	14,527	14,974	14,759
Brazil	53,515	58,785	63,966
Chile	12,369	13,695	13,350
Colombia	68,877	63,435	76,776
Ecuador	2,272	1,815	1,567
Peru	25,857	27,135	26,330
Venezuela	1,292,876	1,319,340	1,311,832
Europe:			
Albania	6,593	7,573	8,000
Austria	18,725	18,900	19,235
Bulgaria	3,642	4,015	2,755
Czechoslovakia	1,424	1,450	1,500
France	20,640	19,585	18,217
Germany, West	57,257	57,655	56,888
Hungary	12,864	14,398	13,185
Italy	11,010	10,262	10,083
Netherlands	15,438	14,620	13,782
Poland	3,339	3,525	3,248
Rumania	98,424	99,013	98,722
Spain	r 612	1,093	1,405
U.S.S.R.[1]	2,100,000	2,252,000	2,395,000
United Kingdom	r 646	591	562
Yugoslavia	17,655	18,473	19,991
Africa:			
Algeria	r 297,715	325,055	338,015
Angola	3,880	5,401	17,441
Congo (Brazzaville)	376	341	e 300
Gabon	25,203	33,630	36,431
Libya	636,504	948,519	1,134,839
Morocco	738	620	410
Nigeria	116,519	52,854	197,168
Tunisia	17,068	24,539	25,394
United Arab Republic[2]	39,547	62,206	e 95,000
Asia:			
Bahrain	25,370	27,598	27,774
Brunei	37,961	44,664	45,624
Burma	r 4,580	5,634	6,085
China, mainland e	80,300	110,000	146,000
India	42,190	43,552	51,724
Indonesia	186,231	219,912	271,001
Iran	947,678	1,039,366	1,231,828
Iraq	445,821	550,098	553,999
Israel[3]	8,687	14,831	e 18,000
Japan	5,520	5,476	5,502
Kuwait	836,719	886,125	940,041
Kuwait-Saudi Arabia Neutral Zone	151,461	156,720	163,134
Malaysia (Sarawak)	328	1,521	3,286
Mongolia e	90	90	90
Muscat and Oman	23,030	87,854	119,710
Pakistan	3,636	3,305	3,500
Qatar	118,083	124,220	129,845
Saudi Arabia	948,110	1,035,773	1,092,322
Syria	----------	9,720	16,800
Taiwan	246	421	581
Thailand	14	26	16
Trucial States[4]	139,467	181,756	218,723
Turkey	19,515	22,235	25,556
Oceania:			
Australia	r 7,600	13,877	15,805
New Zealand	3	2	e 2
Total	r 12,889,252	14,104,250	15,220,221

e Estimate. p Preliminary. r Revised.
[1] U.S.S.R. in Asia (including Sakhalin) included with U.S.S.R. in Europe.
[2] Excludes Israeli production of Egyptian oilfields.
[3] Includes estimates of Israeli production of Egyptian oilfields.
[4] All production from Abu Dhabi except 125,000 barrels from Dubai in 1969.

Phosphate Rock

By John W. Sweeney [1]

The domestic phosphate rock industry in 1969 was in a period of austerity. The industry pared costs by selling and/or closing mines, fertilizer manufacturing plants, and fertilizer distribution facilities, to maintain operating and production efficiencies. Decreases were noted in all categories presented in table 1 for the year with the exception of imports and apparent consumption. A significant fact, however, was that marketable production decreased considerably, while that sold or used by producers remained about the same as the previous year. This may indicate that the phosphate operations were under closer control as marketable production was in closer balance with that sold or used. In 1969, marketable production was 3 percent greater than that sold or used; whereas, in the period from 1966 through 1968, it was 7 percent, 5 percent, and 10 percent greater, respectively. Price erosion was still evident. This was caused by overcapacity in the industry, coupled with another poor spring planting season, resulting in excessive inventories which caused price cutting.

[1] Mining engineer, Knoxville Office of Mineral Supply Knoxville, Tenn.

Table 1.—Salient phosphate rock statistics

(Thousand short tons and thousand dollars)

	1965	1966	1967	1968	1969
United States:					
Mine production	84,305	112,960	128,973	148,336	121,712
Marketable production	29,482	39,044	39,770	41,251	37,725
Value	$193,323	$261,092	$265,947	$250,692	$208,689
Average per ton	$6.55	$6.69	$6.69	$6.08	$5.53
Sold or used by producers	29,039	36,443	37,835	37,319	36,730
Value	$188,590	$245,182	$251,163	$228,347	$204,409
Average per ton	$6.49	$6.73	$6.64	$6.12	$5.57
Imports for consumption	148	178	139	116	140
Value	$2,980	$4,256	$3,261	$2,679	$3,554
Average per ton	$20.14	$23.91	$23.46	$23.09	$25.42
Exports [1]	7,323	9,248	10,072	12,099	11,336
P_2O_5 content	2,313	2,803	3,290	3,917	3,685
Value	$51,109	$65,952	$69,479	$75,653	$62,288
Average per ton	$6.98	$7.13	$6.90	$6.25	$5.49
Consumption, apparent [2]	21,864	27,373	27,902	25,336	25,534
World: Production	70,298	83,194	85,914	92,500	NA

NA Not available.
[1] From table 6.
[2] Measured by sold or used plus imports minus exports.

DOMESTIC PRODUCTION

Marketable production of phosphate rock decreased 8 percent in quantity and 17 percent in value from that of 1968. Production from Florida and North Carolina in 1969 accounted for 79 percent of the total domestic output; the Western States produced 12 percent, and Tennessee and Alabama, 9 percent. Florida and North Carolina production and the Western States production decreased 9 percent and 11 percent, respectively, from that of 1968; whereas, Tennessee and Alabama output increased 4 percent.

Phosphate rock was produced in nine States from 62 mines in 1969, with Florida continuing as the leading producer. Land-pebble phosphate rock was produced in Florida by Agrico Chemical Co., American

Cyanamid Co., W. R. Grace & Co., International Minerals & Chemical Corp., Minerals Recovery Corp., Mobil Chemical Co., Occidental Chemical Co., Swift & Co., U.S.S. Agri-Chemicals Inc., and U.S. Phosphoric Products Co. Soft-rock phosphate was produced in Florida by Howard Phosphate Co., M. W. Kellogg Co., Loncala Phosphate Co., Soil Builders, Inc., and Sun Phosphate Co. Monsanto Co. produced phosphate rock in Alabama for the first time in over 70 years. Cuyama Phosphate Corp. produced a low-grade phosphate rock in California. Phosphate rock was produced in Idaho by Monsanto Chemical Co., J. R. Simplot Co., and Stauffer Chemical Co.,; in Tennessee by Hooker Chemical Co., Mobil Chemical Co., Monsanto Co., Stauffer Chemical Co., Tennessee Valley Authority (TVA), and M. C. West, Inc.; and in North Carolina by Texas Gulf Sulphur Co.

American Cyanamid Co. announced plans to double the production capacity of its Chicora mine. The new facilities will include a washer and flotation plant and a second 45-cu-yd dragline. The expansion is expected to be completed in early 1971 and will replace production from its Sydney operations, which are expected to close in mid-1970. During the year, the company deeded 1,160 acres of land to the Alafia River Basin Board of the Southwest Florida Water Management District. About 770 acres of this area will be a lake which will serve as a water reservoir for the Alafia River Basin. The lake will be surrounded by 390 acres of reclaimed mining land

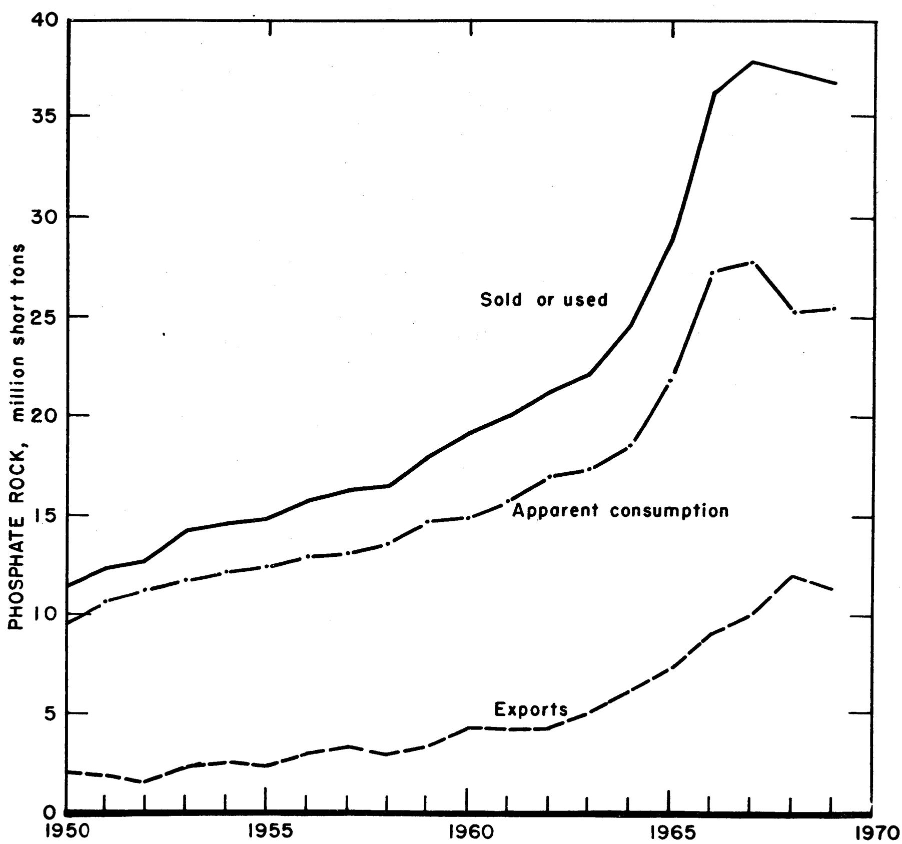

Figure 1.—Phosphate rock (solid or used), apparent consumption, and exports.

Table 2.—Production of phosphate rock in the United States, by States
(Thousand short tons and thousand dollars)

State	Mine production		Mine production used directly		Washer production		Marketable production		
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Value
1968									
Florida [1]	135,891	17,690	29	6	33,004	10,628	33,032	10,634	$193,319
Tennessee	6,777	1,456	685	169	2,464	657	3,149	826	23,628
Western States [2]	5,668	1,443	3,879	1,002	1,191	381	5,070	1,383	33,746
Total [3]	148,336	20,589	4,592	1,177	36,658	11,667	41,251	12,843	250,692
1969									
Florida [1]	111,178	15,711	92	28	29,838	9,575	29,930	9,603	160,777
Tennessee [4]	5,648	1,080	533	128	2,741	730	3,274	858	18,888
Western States [2]	4,886	1,253	3,539	905	982	318	4,521	1,223	29,024
Total [3]	121,712	18,044	4,164	1,061	33,561	10,623	37,725	11,684	208,689

[1] Includes North Carolina.
[2] Includes California, Idaho, Montana, Utah, and Wyoming.
[3] Data may not add to totals shown because of independent rounding.
[4] Includes Alabama.

which will be used for recreation. American Cyanamid announced a new procedure for using slimes in land reclamation. It is anticipated that this procedure will permit the phosphate industry to use these waste products to reconstruct mined-out land and recover large volumes of water that would normally be bound to the slimes.[2]

W. R. Grace & Co.'s mining and fertilizer manufacturing operations were hampered by a strike from May 21 to October 13, 1969. The company's Bonny Lake mine did not operate during this period; however, chemical facilities were operated from July 5 to October 13 using phosphate rock from stockpiles. The company purchased additional phosphate reserves in Manatee County during the year. Grace also added 400 acres to its water recirculation system and spent $1.4 million in water pollution abatement equipment to improve waste water quality to circumvent pollution problems.

International Minerals & Chemical Corp. (IMC) sold its Bonnie phosphate chemicals complex to C. F. Chemicals, Inc. The sale included phosphate fertilizer plants and sulfuric acid plants on a 2,800-acre site west of Bartow, Fla.; the plants have an annual production capacity of approximately 1 million tons of concentrated phosphate fertilizers. IMC will continue to supply phosphate rock to C. F. Chemicals, Inc., Bartow Phosphate Works (formally IMC's Bonnie complex), and purchase chemicals from them. It will also continue to own and sell the products from their phosphate feed ingredients plant there. IMC exchanged certain Florida phosphate properties with Mobil Chemical Co. and purchased Mobil's Clear Springs processing facility. The company also made capital improvements at its Noralyn and Kingsford phosphate rock plants. These improvements are expected to increase IMC's basic phosphate rock production capacity by approximately 25 percent, improve quality control, and increase its mineral reserve position in the Florida phosphate fields.

Occidental Chemical Co. (Oxychem) announced plans for construction of a new defluorinated phosphate plant adjacent to its Suwannee River phosphate mine and chemicals complex near White Springs, Fla. The plant will cost approximately $6 million. Completion is scheduled for late 1970, and the facility will produce at an initial rate of 100,000 tons of defluorinated phosphate per year. This facility will consume an estimated 135,000 tons of phosphate rock annually.

Swift & Co. was an anomaly in the phosphate industry in 1969. The company operated both of their mines on a 7-day schedule; erected an additional dragline at their Watson mine and installed additional wet rock storage facilities. During the year, Swift acquired the assets of the farm fertilizer business of Mobil Chemical Co. The transaction involved most of Mobil's retail

[2] Timberlake, Richard C. Building Land With Phosphate Waste. Mining Engineering, v. 21, December 1969, pp. 38–40.

fertilizer assets, which included its liquid and chemically mixed fertilizer operations and its marketing force. Swift will assume control of about 65 blending operations, 15 mixed goods plants, and six redistribution warehouses, employing a total of 1,400 persons.

TVA offered at public auction 4,400 acres in Citrus and Marion Counties, Fla., which were originally acquired as phosphate reserves.

U.S.S. Agri-Chemicals, Inc. added a fluosilicic acid recovery system to its existing Florida fertilizer manufacturing facilites. The fluosilicic acid product will be used in Alcoa's aluminum fluoride plant, which is scheduled for construction in early 1970.

Monsanto Chemical Co. mined phosphate rock in Limestone County, Ala. for use at their Columbia, Tenn., operations. This is the first phosphate rock production from Alabama since 1900.

Cuyama Phosphate Corp. reported phosphate rock production from their Cuyama, Calif., operations. The California deposits are low-grade, about 5 percent P_2O_5. Yet, close proximity to markets has made this material economic.[3]

According to a study by the Georgia Department of Mines, Mining and Geology, a large phosphate deposit near Savannah, Ga. shows potential for producing approximately 4.8 million cubic yards of matrix containing an average 22.5 percent B.P.L.[4] Kerr-McGee Corp. conducted some exploratory work on their phosphate rock reserves near Savannah. The Georgia State Mineral Leasing Commission declined the company a lease to mine 25,000 acres of off-shore phosphate because of possible damage to the coastal ecology.

Texas Gulf Sulphur Co. (TGS) completed the third year of operation at its Lee Creek mine and fertilizer plant complex near Aurora, N.C. The company awarded Wellman-Lord, Inc. a contract to build a new superphosphoric acid production facility at the Lee Creek complex. The facility is scheduled for completion in 1970. A comprehensive report on the TGS Lee Creek complex was published.[5]

The deepwater terminal at Morehead City, N.C., built to handle bulk phosphate rock shipments from the TGS Lee Creek complex became fully operational during the year. The terminal costing $11.4 million includes a 1,000-foot-long dock, a 106,000-ton dry storage warehouse, a large bucket wheel reclaimer, and conveyor designed to handle 3,000 tons of phosphate rock per hour.

Monsanto Chemical Co. operated their Ballard mine and began production from their new Henry mine, 5 miles north of Ballard, Idaho. Production from the Henry mine is expected to replace that from the Ballard sometime in 1970. Production was used for the company's elemental phosphorus plant at Soda Springs, Idaho.

Mountain Fuel Supply Co. closed their phosphate washing and calcining plants at Conda, Idaho, July 1, 1969.

Stauffer Chemical Co. reopened its mine and beneficiation plant at Vernal, Utah, which had been closed since April 1968; the mine has an approximate capacity of 300,000 tons per year. The company also announced plans to reactivate its phosphate pulverizing mill at Phoston, Utah. In addition, Stauffer opened their new Wooley Valley mine near Soda Springs, Idaho; the phosphate rock was shipped to their Silver Bow, Mont., elemental phosphorus plant.

CONSUMPTION AND USES

Apparent consumption of phosphate rock was 1 percent greater in 1969, continuing an upward trend in consumption after faltering in 1968.

Phosphate rock producers sold or used 2 percent less than they did in 1968. The domestic production sold or used was for the following: Phosphoric acid, 39 percent; electric furnace phosphorus, 27 percent; triple superphosphate, 15 percent; ordinary superphosphate, 14 percent; and other uses 5 percent. Domestic phosphate rock sold or used in 1969 by producers for phosphoric acid (wet process), electric furnace phosphorus, and triple superphosphate increased 3 percent, 10 percent and 2 per-

[3] Utley, Harry F. First California Production of Phosphate Rock Under Way. Pit and Quarry, v. 62, No. 1, July 1969, pp. 186–187.

[4] Furlow, James W. Stratigraphy and Economic Geology of the Eastern Chatham County Phosphate Deposit. Dept. of Mines, Mining and Geol., Geol. Survey Bull. No. 82, 1969, 40 pp.

[5] Trauffer, Walter E. Texas Gulf's New Phosphate Mine, Mill and Fertilizer Materials Complex at Lee Creek, N.C. Pit and Quarry, v. 61, No. 7, January 1969, pp. 124–138.

cent, respectively, over that of 1968, while ordinary superphosphate and other uses decreased 5 percent and 33 percent, respectively, below that of 1968.

According to a journal article, an additional 19 million tons of plant nutrients (N, P_2O_5, and K_2O) could be used annually in North America if the rates of fertilizer suggested by agricultural authorities in the United States and Canada were followed.[6]

Table 3.—Florida phosphate rock sold or used by producers, by kinds

(Thousand short tons and thousand dollars)

Year	Rock	P_2O_5 content	Value: Total	Value: Average per ton	Rock	P_2O_5 content	Value: Total	Value: Average per ton
	Hard rock				Soft rock			
1965	77	27	$684	$8.88	31	6	$221	$7.13
1966	49	17	437	8.92	45	9	293	6.51
1967	--	--	---	----	36	7	266	7.42
1968	--	--	---	----	30	6	224	7.47
1969	--	--	---	----	30	6	221	7.34
	Land pebble				Total [1]			
1965	21,388	6,949	$138,744	$6.49	21,496	6,982	$139,649	$6.50
1966 [2]	28,043	9,077	184,075	6.56	28,137	9,103	184,805	6.57
1967 [2]	29,796	9,646	193,283	6.49	29,832	9,654	193,548	6.49
1968 [2]	29,571	9,504	173,190	5.86	29,601	9,510	173,413	5.86
1969 [2]	28,835	9,307	155,197	5.38	28,865	9,313	155,418	5.38

[1] Data may not add to totals shown because of independent rounding.
[2] Includes North Carolina.

Table 4.—Tennessee phosphate rock sold or used by producers

Year	Rock	P_2O_5 content	Value: Total	Value: Average per ton
1965	2,969	772	$22,385	$7.54
1966	3,076	799	23,497	7.64
1967	3,032	808	22,494	7.42
1968	3,065	807	23,646	7.71
1969 [1]	3,193	851	18,192	5.70

[1] Includes Alabama.

A Bureau of Mines report was published indicating that there will be a substantial increase in consumption of the three important fertilizer and chemical raw materials by the year 1980.[7] The same author presented a paper discussing the farm revolution and the demand for fertilizers.[8]

[6] Commercial Fertilizer and Plant Food Industry. 19,000,000 Tons More Fertilizer Use. V. 119, No. 3, September 1969, pp. 29–30.
[7] Hee, Olman. A Statistical Analysis of U.S. Demand for Phosphate Rock, Potash, and Nitrogen. BuMines Inf. Circ. 8418, 1969, 55 pp.
[8] Hee, Olman. The Farm Revolution and The Demand for Fertilizers. Paper presented at the Annual Meeting of the American Institute of Mining, Metallurgical, and Petroleum Engineers at Washington, D. C., February 1969.

Table 5.—Phosphate rock sold or used by producers in the United States, by grades and States

(Thousand short tons)

Year and grade B.P.L. content [4] (percent)	Florida [1]: Rock	Florida [1]: P_2O_5 content	Tennessee [2]: Rock	Tennessee [2]: P_2O_5 content	Western States: Rock	Western States: P_2O_5 content	Total [3] United States: Rock	Total [3] United States: P_2O_5 content
1968								
Below 60	44	10	2,214	563	2,884	720	5,142	1,293
60–66	1,519	435	753	212	19	6	2,291	653
66–70	11,949	3,698	-----	---	951	292	12,900	3,990
70–72	2,612	836	98	32	559	177	3,269	1,045
72–74	7,005	2,314	-----	---	95	31	7,099	2,345
Plus 74	6,471	2,218	-----	---	146	50	6,616	2,267
Total [3]	29,601	9,510	3,065	807	4,653	1,276	37,319	11,594
1969								
Below 60	48	11	2,261	582	2,856	697	5,165	1,291
60–66	1,570	472	880	253	261	75	2,710	799
66–70	11,827	3,694	44	14	572	176	12,443	3,884
70–72	1,822	590	8	3	799	256	2,629	848
72–74	8,101	2,682	-----	---	184	62	8,285	2,744
Plus 74	5,497	1,864	-----	---	-----	-----	5,497	1,864
Total [3]	28,865	9,313	3,193	851	4,672	1,266	36,730	11,431

[1] Includes North Carolina.
[2] Includes Alabama (1969).
[3] Data may not add to totals shown because of independent rounding.
[4] Bone phosphate of lime, $Ca_3(PO_4)_2$.

Table 6.—Phosphate rock sold or used by producers, by uses and States

(Thousand short tons)

Use	Florida [1]		Tennessee [2]		Western States		Total United States [3]	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
1968								
Domestic:								
Agricultural	18,054	r 5,769	-----	---	1,030	328	19,084	r 6,097
Industrial	365	109	3,065	807	2,706	663	6,136	1,580
Total [3]	18,419	r 5,878	3,065	807	3,736	991	25,220	r 7,677
Exports	11,182	r 3,632	-----	---	917	285	12,099	r 3,917
Total [3]	29,601	9,510	3,065	807	4,653	1,276	37,319	11,594
1969								
Domestic:								
Agricultural	17,501	5,629	-----	---	1,039	328	18,540	5,958
Industrial	553	166	3,193	851	3,107	772	6,853	1,789
Total [3]	18,054	5,795	3,193	851	4,146	1,100	25,393	7,747
Exports	10,811	3,519	-----	---	525	166	11,336	3,685
Total [3]	28,865	9,313	3,193	851	4,672	1,266	36,730	11,431

r Revised.
[1] Includes North Carolina.
[2] Includes Alabama (1969).
[3] Data may not add to totals shown because of independent rounding.

Table 7.—Phosphate rock sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1968			1969		
	Rock	P_2O_5 content	Value	Rock	P_2O_5 content	Value
Domestic:						
Phosphoric acid (wet process)	9,532	2,979	$52,685	9,839	3,113	$53,081
Electric furnace phosphorus	6,117	1,574	42,032	6,758	1,759	39,794
Triple superphosphate	3,858	1,271	23,166	3,934	1,289	21,970
Ordinary superphosphate	3,708	r 1,207	21,118	3,524	1,150	18,799
Nitraphosphate; Direct application to the soil; Stock and poultry feed; Fertilizer filler; Other fertilizers; Other uses	2,006	646	13,693	1,338	436	8,478
Total [1]	25,221	r 7,677	152,694	25,393	7,747	142,122
Exports	12,099	r 3,917	75,653	11,336	3,685	62,288
Grand total [1]	37,319	11,594	228,347	36,730	11,431	204,409

r Revised.
[1] Data may not add to totals shown because of independent rounding.

STOCKS

Producers' yearend stocks of marketable phosphate rock decreased 2 percent from those of 1968. Stock held by Florida and North Carolina producers increased slightly; stocks held by the Western States producers declined markedly.

Table 8.—Producer stocks of marketable phosphate rock, December 31

(Thousand short tons)

Source	1968		1969	
	Rock r	P_2O_5 content	Rock	P_2O_5 content
Florida [1]	11,454	r 3,653	11,626	3,653
Tennessee [2]	76	r 21	218	49
Western States	2,414	r 618	1,853	574
Total [3]	13,943	4,292	13,697	4,276

r Revised.
[1] Includes North Carolina.
[2] Includes Alabama (1969).
[3] Data may not add to totals shown because of independent rounding.

PRICES

Prices as quoted by Oil, Paint and Drug Reporter for various grades of Florida land-pebble phosphate rock are shown in table 9. Actual prices on Florida land-pebble and North Carolina concentrate are not published because prices are usually agreed upon through direct negotiation between buyer and seller: the negotiated price is usually lower than the quoted prices. Price cutting on contracts was again evident in 1969 as an oversupply situation prevailed. Average reported prices decreased 9 percent in 1969 from those of 1968 and 17 percent from the high of 1967.

Tennessee phosphate rock is not offered on the open market; therefore, no quoted market price is available. Table 4 shows the value of Tennessee phosphate rock sold or used by producers. Previous to 1969, the total value and the average price per ton reported by Tennessee producers was for an agglomerated product used as the furnace charge in the manufacture of elemental phosphorus. The 1969 figure presented in table 4 reflects the value of the Tennessee phosphate rock before agglomeration or the marketable product value equivalent to phosphate rock produced in other areas.

Table 9.—Prices of Florida land-pebble, underground, washed and dried phosphate rock, in bulk, carlots, at mine, in 1969

(Per short ton)

Grade, percent B.P.L.[1]	Price
66 to 68	$6.50
68 to 70	7.50
70 to 72	8.15
74 to 75	9.20
76 to 77	10.20

[1] 1.0 percent B.P.L. (bone phosphate of lime also known as tricalcium phosphate) = 0.458 percent P_2O_5.

Source: Oil, Paint and Drug Reporter.

FOREIGN TRADE

According to the Bureau of Census, U.S. Department of Commerce, total U.S. exports of phosphate rock declined 6 percent from that of 1968. While export tonnage declined, price declines were even more noticable. The average value per ton for Florida phosphate rock exported was $7.51, 52 cents less than that of 1968; the total average value per ton for U.S. phosphate rock exported was $7.69, 96 cents less than the previous year. Japan, Canada, Italy, and West Germany were the major purchasers of U.S. phosphate rock. Of these, Japan, West Germany, and Italy decreased their purchases by 26 percent, 16 percent, and 1 percent, respectively. Only Canada increased its purchases.

In addition to the exports of superphosphates presented in table 11, the United States also exports a considerable amount of multinutrient phosphatic fertilizers in the form of ammonium phosphates. These materials are reported in table 5 of the Nitrogen chapter.

Of the 140,000 tons of phosphate rock imported (chiefly for use as animal feed supplement) 80 percent came from the Netherlands Antilles, 17 percent from Mexico, and the remainder from Canada.

Table 10.—U.S. exports of phosphate rock, by grades and countries

(Thousand short tons and thousand dollars)

Grade and destination	1968		1969	
	Quantity	Value	Quantity	Value
Florida phosphate rock:				
Australia	628	$6,281	112	$1,011
Austria	180	1,411	139	974
Belgium-Luxembourg	335	2,147	414	3,116
Brazil	296	2,725	259	2,312
Canada	1,382	11,606	1,713	13,967
Chile	64	531	7	42
Colombia	24	160	20	120
El Salvador	14	90	13	83
France	223	1,598	312	2,174
Germany, West	1,424	9,741	1,189	8,005
India	299	2,093	307	2,254
Italy	1,368	9,711	1,359	9,305
Japan	2,759	23,742	2,048	17,259
Korea, South	495	3,405	604	4,131
Malaysia	12	217	------	------
Mexico	368	2,745	766	5,010
Netherlands	224	2,104	319	2,097
New Zealand	115	1,156	16	161
Norway	23	184	17	134
Peru	10	77	8	55
Philippines	150	1,210	183	1,280
Spain	270	1,919	345	2,567
Sweden	11	96	------	------
United Kingdom	292	2,535	119	1,151
Uruguay	23	240	11	99
Other	63	1,029	127	882
Total	11,052	88,753	10,407	78,189
Other phosphate rock: [1]				
Afghanistan	------	------	5	363
Belgium-Luxembourg	1	46	(2)	20
Brazil	8	170	(2)	22
Canada	924	13,635	726	6,301
France	(2)	1	(2)	6
Germany, West	(2)	13	46	385
Iran	15	1,130	6	553
Japan	14	201	2	20
Mexico	1	21	56	439
Netherlands	35	208	21	167
Norway	20	138	89	711
Other	13	243	11	242
Total	1,031	15,806	962	9,229
Grand total	12,083	104,559	11,369	87,418

[1] Includes colloidal matrix, sintered matrix, soft phosphate rock, and Tennessee, Idaho, and Montana rock.
[2] Less than ½ unit.

Table 11.—U.S. exports of superphosphates (acid phosphates), by countries

(Thousand short tons and thousand dollars)

Destination	1968 Quantity	1968 Value	1969 Quantity	1969 Value
Algeria	14	$473	------	------
Argentina	7	314	6	$260
Australia	9	385	5	179
Belgium-Luxembourg	53	1,660	11	350
Brazil	136	5,643	138	5,917
Burma	64	4,599	------	------
Canada	110	5,139	50	2,706
Chile	165	5,567	127	4,270
Colombia	44	1,942	48	1,796
Costa Rica	9	338	5	226
Dominican Republic	7	258	7	271
Ecuador	5	301	4	258
France	32	1,118	38	1,385
Germany, West	18	589	20	713
Indonesia	119	7,877	33	1,397
Italy	21	859	20	729
Jamaica	2	92	4	93
Japan	37	1,479	30	1,148
Korea, South	144	5,488	2	131
Malaysia	9	473	18	823
Mexico	25	1,054	1	101
Nansei and Nanpo Islands	3	100	1	36
Netherlands	87	3,325	91	3,871
Nicaragua	------	------	6	328
Pakistan	84	3,784	20	899
Poland and Danzig	------	------	24	866
Singapore	8	383	11	516
Spain	2	141	29	1,176
Turkey	11	427	34	1,150
Uruguay	9	480	35	1,244
Venezuela	(1)	2	3	119
Yugoslavia	45	1,400	11	386
Other	10	669	15	578
Total	1,289	56,359	847	33,922

[1] Less than ½ unit.

Table 12.—U.S. imports for consumption of phosphate rock and phosphatic fertilizers

(Thousand short tons and thousand dollars)

Fertilizer	1968 Quantity	1968 Value	1969 Quantity	1969 Value
Phosphates, crude and apatite	116	$2,679	140	$3,554
Phosphatic fertilizers and fertilizer materials	44	2,222	83	3,976
Ammonium phosphates, used as fertilizers	247	17,264	245	16,625
Bone ash, bone dust, bone meal and bones, crude, steamed, or ground	5	357	4	298
Manures, including guano	(1)	16	------	------
Basic slag	------	------	(1)	(1)
Dicalcium phosphate	21	1,176	14	605

[1] Less than ½ unit.

WORLD REVIEW

Algeria.—The development of the Djebel Onk deposits are planned to replace the exhausted reserves at El Kouif. The modern plant at Djebel Onk, which started production in 1966, produces 75 percent B.P.L. phosphate from crude ore averaging 56–57 percent B.P.L.[9]

Angola.—Pickands Mather & Co. received a concession from the Portuguese Government for phosphate prospecting in the Cabinda district. Companhia Fosfatos de Angola conducted an exploration program on its Cabinda phosphate concession. Initial investigations showed phosphate reserves of approximately 15 million tons.

[9] Mining Magazine. Mining in Algeria. V. 121, No. 2, August 1969, p. 123.

Australia.—Broken Hill South, Ltd. announced reserves of 2 billion tons of phosphate rock averaging 17 percent P_2O_5. Two-thirds of the reserves are in northwest Queensland; the remaining reserves are 200 miles north of Mt. Isa. An engineering feasibility study to determine the most economical method of mining the deposit was conducted. Amad NL, the exploration subsidiary of Mineral Securities Australia (MSA), claims to have discovered further reserves of phosphate rock in Australia's Northern Territory. Reserves have been estimated at 66.5 million tons averaging over 20 percent B.P.L., plus an additional 14.5 million tons averaging less than 20 percent B.P.L. Amad NL is one of a number of companies holding prospecting licenses in the area adjoining the northern Queensland phosphate area.

Table 13.—World production of phosphate rock by countries

(Thousand short tons)

Country [1]	1967	1968	1969 p
North America:			
United States	39,770	41,251	37,725
Mexico	60	29	NA
Netherlands Antilles [2]	128	103	NA
South America:			
Brazil:			
Apatite	143	159	NA
Phosphate rock	37	3	NA
Chile (guano)	18	24	NA
Peru (guano)	r 71	36	NA
Venezuela e	33	66	66
Europe:			
France (phosphatic chalk)	r 72	e 33	e 33
Poland e	105	105	110
U.S.S.R.:			
Apatite (marketable concentrate 39 percent P_2O_5)	e 9,700	[3] 10,692	e 11,574
Sedimentary rock (marketable concentrate 19–25 percent P_2O_5) e	8,270	8,820	9,645
Africa:			
Algeria	218	403	441
Morocco	10,962	11,587	11,753
Senegal:			
Aluminum phosphate	167	132	NA
Calcium phosphate	1,229	1,212	NA
Seychelles Islands (guano) [2]	4	3	NA
South Africa, Republic of	1,490	1,726	e 1,819
Togo	1,238	1,515	NA
Tunisia	3,097	3,796	NA
Uganda (apatite)	162	e 157	NA
United Arab Republic	753	1,588	NA
Asia:			
China, mainland e	1,100	1,100	1,213
Christmas Island (Indian Ocean) [2]	1,113	1,247	1,301
India:			
Apatite	13	7	10
Phosphate rock	------	------	76
Indonesia e	11	11	NA
Israel	e 661	856	1,087
Jordan	1,364	1,280	e 1,281
Korea, North (apatite) e	276	331	331
Vietnam, North:			
Apatite e	1,100	1,100	1,100
Phosphate rock e	55	55	55
Oceania:			
Australia	13	6	NA
Nauru Island [2]	1,981	2,485	2,423
Ocean Island [2]	500	582	622
Total [4]	r 85,914	r 92,500	NA

e Estimate. p Preliminary. r Revised. NA Not available.
[1] Small quantities of phosphate rock also produced in Belgium, Cambodia, Colombia, Southern Rhodesia, and Tanzania and guano in Argentina, Philippines and South-West Africa.
[2] Exports.
[3] Reported in Soviet sources.
[4] Total is of listed figures only.

Belgium.—Occidental Chemical Processes Corp., a subsidiary of Occidental Petroleum Corp., awarded a contract to Woodall-Duckham Ltd. (W-D) to construct a 100-ton-per-day superphosphoric acid plant for Société de Prayon S.A. at its plant in Engis, Belgium. The plant will use the Oxy-Nordac process.

Brazil.—It is reported that a new seven-plant fertilizer complex near Santos, Brazil, will go on stream in December 1969. The $70 million project was organized as Ultrafértil SA, a joint venture between Quimica "66" Ltd. (Phillips Petroleum Co.), COTIL SA (Igel Group), and the International Finance Corp.

Canada.—Electric Reduction Company of Canada, Ltd.'s (ERCO) $40 million elemental phosphorus plant at Long Harbour, Newfoundland, went on stream in 1969. The company converts Florida phosphate rock to elemental phosphorus, which is shipped to Britain for further processing. The plant was closed for several months during the year due to environmental problems.[10]

Colombia.—Colombian Mining Enterprise (Colminas) signed a contract with Pan American Consulting Ltd. for the turn-key construction of a normal superphosphate plant at Ventaquemada, Boyacá Department, with an annual capacity of 77,000 tons. The plant is estimated to cost $458,000.

India.—New phosphate deposits with estimated reserves of over 11 million tons averaging more than 30 percent P_2O_5 were found in the Jhamar-Kotra area, 28 km southeast of Udaipur City. Test work on this material proved favorable, and the Rajasthan Directorate of Mines and Geology started mining in mid-1969. The operation has a production capacity of 1,100 tons per day.

Substantial phosphate deposits have been outlined near Pathargara, in Bihar, India. The ore is mined by hand methods at a rate of 2,000 to 3,000 tons per month from small-scale open pit operations. The estimated reserves are 11 million tons, averaging 15 percent P_2O_5.[11]

An article was published on the occurrence and pertrologic character of phosphate rock in the Pithoragarh District, Uttar Pradesh.[12]

Israel.—The American Israel Phosphate Corp. announced development of a $14 million phosphate mine at Ein Yhav in the Negev Desert area. Initial production is scheduled for 1972. The firm expects a phosphate rock output of 600,000 tons per year of 32 percent P_2O_5 content, and 250,000 tons per year with a 35-percent P_2O_5 content. Almost all of the phosphate rock will be exported to Far East countries via the port of Eilat.

Arad Chemical Industries, Ltd., announced they will construct a $39 million phosphoric acid plant near Arad, 15 miles from the southern shore of the Dead Sea. The plant is expected to produce 166,000 tons of phosphoric acid per year, employ new production processes, and use hydrochloric acid derived from Dead Sea brines.[13]

Mexico.—Fertilizantes Fosfatados Mexicanos, S.A. (FFM) announced plans to mine 100,000 tons of phosphate rock from a deposit near Carbonera, Nuevo Leon. This venture would reduce Mexico's dependence on the United States for phosphate rock, especially that from Florida, which exported 369,000 tons to Mexico in 1968.

Morocco.—The Moroccan phosphate rock industry is controlled by a government monopoly known as the Office Chérifien des Phosphates. Current production is from two mining areas; about 2.5 million tons of 70 percent B.P.L. rock was produced from Youssoufia, and about 8.4 million tons of 82 percent B.P.L. rock from Khouribga. Expansion plans indicate that by 1972 output from both operations will reach 15.8 million tons per year. In addition to the mines mentioned, a new mine is being developed at Ben Guerir. Production at this mine is expected to start in 1972 and will have an initial production of 2 million tons, increasing to 3 million tons by 1975. The long-term production goal from Ben Guerir is 10 million tons per year. Reserves at Ben Guerir are estimated at 900 million tons with a 70 percent B.P.L. grade after washing. An article describing Morocco's phosphate rock industry was published.[14]

Nauru.—The partner governments of the Nauru Phosphate Commissioners and the

[10] Industrial Minerals. The Effluent Society. No. 22, July 1969, pp. 7, 39.

[11] Mining Magazine. India-Phosphate Deposits Outlined in Bihar Could Support Large-Scale Mining. V. 121, No. 6, December 1969, pp. 465–467.

[12] Singh, Rajendra. A Brief Note on the Occurrence and Petrologic Characters of Phosphate Rock in Pithoragarh District, Utter Pradesh. Mines, Metals & Fuels, v. 17 No. 3, March 1969, pp. 73–74.

[13] Chemical Age (London). Israeli Phosphoric Plant Nears Completion Using New Process in Bid for World Fertilizer Market. V. 99, No. 2603, June 6, 1969, p. 11.

[14] Mining Magazine. Phosphate in Morocco. V. 120, No. 6, June 1969, pp. 394–401.

Republic of Nauru reached a compromise agreement for supplying Nauru phosphate after June 1970. Nauru will supply 1.75 million tons in 1970–71 at $12.30 per ton (the present price is $12.00 per ton) and 1.35 million tons in 1971–72, for which a price has yet to be agreed upon. After 1972–73, the Nauruan Government will negotiate directly with the Commissioners rather than with the partner governments. The Commissioners have agreed to ship rock in vessels owned or chartered by Nauru, and have agreed to Nauru selling rock to countries other than Australia, New Zealand, and Britain.

Netherlands.—Farbwerke Hoechst AG announced plans to construct a third elemental phosphorus furnace, of 30,000-ton-per-year capacity at its Hoechst Vlissingen N.V. plant at Flushing. The first phosphorus furnace was commissioned in April 1968, and the second furnace is expected to be in full production in 1970. The phosphorus produced is converted to phosphoric acid and sodium tripolyphosphate at Flushing. Each furnace has a 30,000-ton-per-year capacity.[15]

Senegal.—Compagnie Sénégalaise des Phosphates de Taiba announced a $12 million expansion of its operations that will increase production capacity from 1.3 to 1.6 million tons of phosphate rock by mid-1970.

Spanish Sahara.—Exploitation of the phosphate rock deposits discovered in the Spanish Sahara by Empresa Nacional Minera del Sahara appears imminent. Agreement was reached with an engineering consortium headed by the German engineering company Krupp. These deposits discovered 6 years ago have calculated reserves of 1,700 million tons of phosphate rock. The plan proposed by Krupp is to construct port facilities near El Aaiun for shipment of the rock. A conveyor belt system 100 km long will be constructed from Vad-Bu-Crac to the port; the belt will move 16 million tons of rock per year. The first customers for the rock will be the Spanish fertilizer producers currently importing rock from North Africa, Florida, and Egypt.[16]

Tunisia.—S. A. Heurtey of Paris and the Compagnie des Phosphates et du Chemin de Fer de Gafsa signed an agreement, whereby Heurtey will carry out design and engineering for the development of new phosphate deposits at Gafsa. The total investment will be about $40 million. In 1969, Tunisian production was about 3.2 million tons per year, of which 2.5 million tons was exported. The new development envisages a production of 7.5 million tons by 1974.[17]

A paper was published describing experimental work using Gafsa phosphate rock in fertilizers.[18]

United Arab Republic.—The Soviet government reportedly granted Egypt a credit of $57.5 million to finance the first stage of a project to exploit the large phosphate rock reserves of the country. The grant will be used to build a plant near Aswan to produce 40,000 tons per year of elemental phosphorus.[19]

Several papers were published describing research on Egyptian phosphate ores.[20]

TECHNOLOGY

During 1969, technical papers were published on the occurrence of arsenic and color-causing components in Florida land-pebble phosphate rock[21], and on the physical and chemical factors in the formation of marine apatite.[22]

A project was conducted in south Georgia to determine the existence, preliminary

[15] Chemical Age (London). Hoechst Will Build Third Phosphorous Furnace at Flushing. V. 99, No. 2624, Oct. 31, 1969, p. 9.

[16] European Chemical News. Krupp Will Open up Sahara Phosphate. V. 16, No. 401, Oct. 10, 1969, p. 22.

[17] Chemical Age (London). Heurtey Contract for $40 M Tunisian Phosphate Project. V. 99, No. 2630, Dec. 12, 1969, p. 30.

[18] Fertilizer Feed & Pesticide Journal (London). Experiments With Gafsa Phosphate. V. 66, No. 11, November 1969, p. 22.

[19] Chemical Age (London). U.S.S.R. Loan for Egyptian Phosphorus Venture. V. 99, No. 2630, Dec. 12, 1969, p. 27.

[20] Mining Magazine. Anionic Flotation of Nile Valley Phosphate Ores. V. 121, No. 3, September 1969, pp. 183–191. Calcination of Calcaveous Phosphate Ores, pp. 195–201.

[21] Stow, S. H. The Occurrence of Arsenic and the Color-Causing Components in Florida Land-Pebble Phosphate Rock. Econ. Geol., v. 64, No. 6, September–October 1969, pp. 667–671.

[22] Gulbrandsen, R. A. Physical and Chemical Factors in the Formation of Marine Apatite. Econ. Geol. v. 64, No. 4, June–July 1969, pp. 365–380.

quality-quantity data and approximate location of phosphate deposits that may have economic potential.[23]

The use of fluidized-bed reactors for calcining and drying phosphate rock at several western operations and at TGS's Aurora, N.C., operation was described. The report also shows typical flowsheets of fluidized beds for calcining and drying phosphate rock, and calcining and drying cost evaluations.[24]

A series of three articles examined phosphoric acid technology; processes for producing wet-process and furnace-grade phosphoric acid; and predictions on economic and trends in the industry. The articles conclude that the worldwide need for fertilizer remains a real factor, and gives assurance that there will be long-term growth in the industry.[25]

New phosphoric acid processes were introduced by B. D. Bohna & Co., San Francisco, Calif. The processes use ammonium sulfate to digest phosphate rock, giving products of ammonium phosphate and gypsum. The ammonium phosphate can then be treated with sulfuric acid to produce a concentrated 75 percent phosphoric acid.[26]

A process showing how oxygen injected into rotary kilns nodulizing phosphate ore can increase phosphate production by 15 percent was described. The new process also reduces fuel requirements by 10 percent and increases the nodules bulk density by 25 percent.[27]

Three technical articles were presented describing how polyphosphates are revolutionizing fertilizers. The articles review the chemistry of polyphosphates and their use in fertilizer mixtures. Data are given on the production, properties, and use of polyphosphate base materials.[28]

The Tennessee Valley Authority (TVA) began publishing a monthly bulletin in 1968 entitled "Fertilizer Abstracts." It contains selected information on the technology, marketing, and use of fertilizers. Selection of the abstracts are based primarily on the objectives of the fertilizer research and development program of the National Fertilizer Development Center, Muscle Shoals, Ala.

Studies were conducted by the Bureau of Mines at the Tuscaloosa Metallurgy Research Laboratory, Tuscaloosa, Ala., to improve beneficiation techniques on phosphate ores. The object of one study was to investigate and develop new or improved beneficiation techniques for recovering phosphate concentrates from the low-grade siliceous and calcareous Tennessee phosphate ores. The other study investigated methods for beneficiating Florida land-pebble phosphate. The objectives were to develop new processes for increasing recovery of the phosphate fines, which in turn would decrease the formation of washer slimes and make their disposal less of a problem.

The Bureau of Mines developed cost estimates for the disposal of phosphate rock washer slimes by pond settling from a study of the method used at International Minerals & Chemical Corp. (IMC), Noralyn Phosphate Operations, Polk County, Fla. Data were obtained by basing phosphate production and slime generation statistics on plant capacity rather than on actual company records. Cost estimates, prepared as a guide in evaluating alternative disposal methods and in identifying needed areas of research, could be applicable to any Florida plant using the same disposal method. To conserve mineral resources and to improve environmental conditions, the Bureau recommended further research directed toward developing alternative methods of disposal, including the recovery of water and P_2O_5 values from the slimes.[29]

A Bureau of Mines study on the phos-

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[23] Georgia Institute of Technology. South Georgia Minerals Program, Phospate. Georgia Div. Conserv., Dept. Mines and Geol., Project Rept. 11, 1969, 165 pp.

[24] Minerals Processing. Fluidized Bed Process of Phosphate Rock. V. 10, October 1969, pp. 13–17.

[25] Bowers, Q. D., Bryant Fitch, and R. L. Kulp. A New Look at Phosphoric Acid. Pt. I-Introduction to Phorphoric Acids. Farm Chem., v. 132, No. 2 February 1969, pp. 38, 40, 43, 44, 46,; Pt. II-Phosphoric Acid Processes, No. 3, March 1969, pp. 48, 50, 52, 54, 56; Pt. III-Economics and Trends, No. 4, pp. 48, 50, 53, 56.

[26] Chemical Week. A New Phosphoric Acid Process. V. 104, No. 23, June 7, 1969, p. 50.

[27] Chemical Week. Oxygen Brings New Life to Old Phosphorus Kilns. V. 104, No. 24, June 14, 1969, pp. 36–37.

[28] Fleming, J. D. Polyphosphates are Revolutionizing Fertilizers. Pt. I-What Polyphosphates Are. Farm Chem., v. 132, No. 8, August 1969, pp. 30–36. Siegel, M. R. and R. D. Young. Polyphosphates are Revolutionizing Fertilizers. Pt. II-Base Materials. V. 132, No. 9, September 1969, pp. 41–47. Achorn, F. P., and W. C. Scott. Polyphosphates are Revolutionizing Fertilizers. Pt. III-Polyphosphates in Mixtures. V. 132, No. 12, December 1969, pp. 46, 48, 50, 52, 102.

[29] Boyle, J. R. Waste Disposal Costs of a Florida Phosphate Operation. BuMines Inf. Circ. 8404, 1969, 24 pp.

phate industry in the southeastern United States and its relationship to world mineral fertilizer demand was being conducted by the Knoxville Office of Mineral Supply. Publication of this paper is scheduled for mid-1970. The report shows that the southeastern phosphate industry composed of the States of Florida, Tennessee, and North Carolina, is the leading domestic and world producer of phosphate rock. The report emphasizes size and organization, production capacity, transportation, and marketing of the southeastern phosphate product. Factors affecting the supply-demand relationship of the southeastern phosphate industry and world phosphate production-consumption relationships are analyzed and related to the southeastern phosphate industry. Past trends are projected and the future role of the southeastern phosphate industry is analyzed to determine its ability to supply the United States and rest-of-the-world phosphate requirements in 1985 to 2000. The projections show that southeastern resources are ample to supply domestic and export requirements at the projected rates of consumption well beyond the year 2000.

Platinum-Group Metals

By Charles D. Hoyt[1] and J. Patrick Ryan[2]

The most significant event of 1969 for the platinum-group metals was the general softening of prices within the industry, despite a $10 increase in the platinum producer price in early November. For the long-term world supply outlook an event of major importance was the Rustenberg group's announcement that total reserves of platinum available in the South African Bushveld Igneous Complex were estimated at 200 million ounces for exploitation over the next 30 years.

Estimates of world output indicate a modest decrease primarily due to extended strikes in Canada which reduced Canadian production of byproduct platinum-group metals by an estimated 100,000 ounces. The Republic of South Africa continued its steady expansion and will have an estimated output of over 1 million ounces by mid-1970. Further expansion is planned to achieve a production level of 1.2 million ounces by early 1972.

U.S. imports were down almost 31 percent, but exports increased by almost 27 percent compared with 1968. U.S. consumption was 7 percent below 1968.

[1] Physical scientist, Division of Nonferrous Metals.
[2] Mining engineer, Office of Assistant Director, Mineral Supply.

Table 1.—Salient platinum-group metals statistics

(Troy ounces)

	1965	1966	1967	1968	1969
United States:					
Mine production[1]	35,026	51,423	16,365	14,793	21,586
Value	$2,041,102	$3,106,993	$1,428,863	$1,500,603	$2,094,607
Refinery production:					
New metal	61,723	73,615	29,663	12,305	17,875
Secondary metal	108,525	103,321	365,799	329,455	371,659
Exports (except manufactures)	103,097	205,456	279,852	395,157	501,064
Imports for consumption	1,172,643	1,352,256	1,321,278	1,773,984	1,225,651
Stocks Dec. 31: Refiner, importer, dealer	926,373	1,129,604	869,211	802,711	1,077,478
Consumption	1,186,701	1,675,795	1,334,296	1,367,911	1,357,344
World: Production	2,968,890	3,039,449	3,175,309	3,393,749	3,386,851

[1] From crude platinum placers and byproduct platinum-group metals recovered largely from domestic gold and copper ores.

Legislation and Government Programs.—In May 1969, the Office of Emergency Preparedness (OEP) increased the stockpile objective for platinum by 220,000 ounces to 555,000 ounces so that instead of having a 115,000-ounce surplus, the stockpile of platinum at yearend was 105,000 ounces below the objective.

On July 1, 1969, General Services Administration (GSA) entered into a contract for 200,000 troy ounces of palladium to be delivered by June 30, 1970. Deliveries as of December 31, 1969, totaled 135,431 troy ounces.

Table 2.—Government inventory of platinum-group metals, December 31, 1969

(Troy ounces)

Metal	National stockpile	Supplemental stockpile	Objective
Iridium	[1] 17,072		17,000
Palladium	334,269	747,680	1,300,000
Platinum	[2] 400,036	49,999	555,000
Ruthenium	-------	2,500	---------

[1] Excludes 184 ounces nonstockpile grade.
[2] Includes 165,908 ounces reserved for upgrading and 36 ounces nonstockpile material.

The contract entered into on May 9, 1969, for furnishing 862 troy ounces of iridium was completed on August 26, 1969.

A contract was entered into March 17 1969, to refine 200,000 ounces of Government-owned platinum. Deliveries under this contract, as of December 31, 1969, totaled 34,092 troy ounces.

DOMESTIC PRODUCTION

Refinery output of new metal increased 45 percent, and the production of secondary metals was up 13 percent. Domestic output is derived as a byproduct of copper refining, and from the mining of Alaskan placers.

Toll refining of platinum-group metals decreased 4 percent in 1969 to a total of 2,245,796 ounces, of which 89 percent was of used materials and the balance virgin material. The total amounts treated in 1969 by toll refining were the following with 1968 amounts in parentheses: Platinum—1,207,559 (1,184,590 ounces); palladium—945,106 (1,055,470 ounces); rhodium—73,139 (73,350 ounces); iridium—9,186 (11,810 ounces); osmium—2,197 (2,920 ounces) and ruthenium—8,609 (9,020 ounces).

Table 3.—New platinum-group metals recovered by refiners in the United States by sources

(Troy ounces)

Year and source	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1965	25,247	26,339	2,628	1,199	4,858	1,452	61,723
1966	30,048	31,367	3,979	1,533	5,650	1,038	73,615
1967	20,296	8,262	754	151	189	11	29,663
1968:							
From domestic sources:							
Crude platinum; gold and copper refining	4,816	5,275	454	95	36	6	10,682
From foreign crude platinum	1,486	83	-----	-----	54	-----	1,623
Total	6,302	5,358	454	95	90	6	12,305
1969:							
From domestic sources:							
Crude platinum; gold and copper refining	8,702	8,224	570	135	70	11	17,712
From foreign crude platinum	------	163	-----	-----	-----	-----	163
Total	8,702	8,387	570	135	70	11	17,875

Table 4.—Secondary platinum-group metals recovered in the United States

(Troy ounces)

Year	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1965	53,562	50,025	960	763	2,590	625	108,525
1966	49,563	50,009	402	728	2,434	185	103,321
1967	126,377	215,162	7,748	2,377	11,505	2,630	365,799
1968	115,587	195,620	2,127	672	12,176	3,273	329,455
1969	126,822	227,763	2,250	208	11,743	2,873	371,659

CONSUMPTION AND USES

Consumption of platinum-group metals, as indicated by sales to consuming industries, decreased slightly in 1969 compared with the 1968 total. Platinum sales were down 11 percent from the previous year owing largely to the decline in demand by petroleum refiners, but sales of palladium were up 5 percent over 1968 owing to increased use in the electrical industry.

Rhodium sales increased 12 percent in 1969 compared with 1968; sales of iridium and ruthenium gained 51 and 64 percent, respectively, compared with 1968. Osmium sales were down slightly compared with those in 1968.

The chemical, petroleum, and electrical industries accounted for 77 percent of the total platinum-group metals consumed in both 1968 and 1969. Total platinum sales in 1969 were distributed among petroleum refining (11.4 percent), manufacturers of organic and inorganic chemicals (34 percent), and electrical and electronic equipment manufacturers (21.8 percent). The bulk of palladium sales were to the electrical equipment manufacturers (57 percent) and chemical manufacturers (28.3 percent). The minor platinum-group metals —rhodium, iridium, and ruthenium—are used primarily as alloys with platinum and palladium.

Estimates of the distribution of demand among the total Western world for newly mined platinum over the period 1965–69 were 30 percent to the chemical industry, 25 percent to petroleum catalytic uses, 20 percent to electrical and allied industries, 10 percent to glass manufacture, and the remaining 15 percent distributed among various uses including jewelry and medical applications. These estimates were presented by the Rustenburg group.

In the chemical industry, one of the major uses for platinum (alloyed with 10 percent rhodium) is as a catalyst in nitric acid production for use in producing nitrate fertilizers. New uses for platinum as an oxidation catalyst are evolving in the rapidly growing pollution control field. There has been continued extensive use of platinum with rhenium added (which improves performance) in the petroleum industry as a reforming catalyst.

Palladium is widely employed as a catalyst in hydrogenation reactions used by the chemical, dyestuff, and pharmaceutical industries.

Platinum (alloyed with rhodium) finds major use within the electrical industry in such applications as light duty contacts, electric furnace windings, thermocouples, cobalt-platinum permanent magnets, resistance thermometers, and precision potentiometers. Thick film electronic applications using platinum, palladium, and ruthenium are increasing. Palladium has its major use within the electrical industry for telephone contacts. Glassmaking refractory equipment is coated with a thin layer of platinum sheet to prevent contamination of the molten glass. Glass fiber manufacturing employs rhodium-platinum bushings as part of its production equipment.

A new ruthenium plating bath developed by Johnson, Matthey & Co. Ltd. gives bright adherent and pore-free deposits at high-cathode efficiencies. Under optimum conditions, cathode efficiencies of over 90 percent were obtained. Electrodeposited ruthenium has numerous applications in light-duty electrical contacts where mechanical wear is a problem, particularly for sliding surfaces such as slip rings.[3]

A 10-percent iridium-platinum alloy is used by Devices Implants Ltd. in fabricating its fixed-rate heart pacemaker. The new alloy is entirely unaffected by the corrosive environment of the body.[4]

A new platinized ceramic honeycomb catalyst designated THT was developed by Matthey Bishop, Inc., for the combustion and elimination or organic fumes that may become a health hazard. The company states that the low-pressure drop, attrition resistance, and high activity of the catalyst make it unusually suitable for a wide range of processes requiring air pollution control. Catalytic combustion using platinum or platinum alloys generally permits the oxidation reaction to take place at a much lower temperature than is required by the direct flame combustion technique, thus reducing fuel costs. The new catalyst is particularly effective in the abatement of pollution from nitrogen oxides and carbon monoxide emitted from a wide variety of industrial processes. The catalyst also is used effectively on diesel engines operating in mines and on other internal combustion engines using nonleaded fuel.[5]

Platinum-clad tantalum anodes introduced by Sel-Rex Corp. for gold and rhodium electroplating are reported to offer, at reduced costs, the same performance and life as solid platinum anodes. The tantalum base is an excellent electrical conductor that will accept high voltages and will not contaminate the bath.[6]

Platinum-coated columbium anodes are being used to provide corrosion protection

[3] Bradford, C. W., M. J. Cleare, and H. Middleton. A New Ruthenium Plating Bath. Platinum Metals Rev., v. 13, No. 3, July 1969, pp. 90–92.

[4] Platinum Metals Review (London). Iridium-Platinum in Heart Pacemaker. V. 13, No. 4, October 1969, p. 140.

[5] Acres, G. J. K. Platinum Catalysts for the Control of Air Pollution. Platinum Metals Rev., v. 14, No. 1, January 1970, pp. 2–10.

[6] American Metal Market. Platinum-Clad Tantalum Mesh Anodes Available. V. 77, No. 25, Feb. 5, 1970, p. 14.

for the largest U.S. floating drydock under construction at Bethlehem Steel's San Francisco shipyard. Control of corrosion will be provided for the outer underwater hull areas by a Capac cathodic protection system designed and constructed by Engelhard Minerals & Chemicals Corp.[7]

[7] American Metal Market. Platinum-Columbium Anodes Protect Floating Dry Dock. V. 77, No. 24, Feb. 4, 1970, p. 9. Iron Age. There's Platinum Under That Dry Dock. Feb. 12, 1970, p. 27.

Table 5.—Platinum-group metals sold to consuming industries in the United States

(Troy ounces)

Year and industry	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1965	411,435	717,085	9,554	1,634	38,910	8,083	1,186,701
1966	690,787	894,212	10,993	1,836	69,688	8,279	1,675,795
1967	633,864	621,141	12,086	1,823	54,952	10,430	1,334,296
1968:							
Chemical	157,677	228,318	2,047	907	14,507	3,037	406,493
Petroleum	161,050	22,683	565	1	201	4	184,504
Glass	47,935	10	11	-----	7,441	------	55,397
Electrical	117,256	329,012	2,716	12	9,514	1,991	460,501
Dental and medical	24,903	61,636	390	533	38	371	87,871
Jewelry and decorative	40,184	17,797	2,998	50	7,059	3,568	71,656
Miscellaneous	31,150	62,023	716	109	6,016	1,475	101,489
Total	580,155	721,479	9,443	1,612	44,776	10,446	1,367,911
1969:							
Chemical	175,436	214,508	6,171	873	18,060	8,696	423,744
Petroleum	58,602	1,337	1,328	-----	2,341	9	63,617
Glass	63,350	3,891	232	-----	10,839	------	78,312
Electrical	112,589	430,258	2,154	5	10,788	2,057	557,851
Dental and medical	22,266	52,326	709	555	339	218	76,413
Jewelry and decorative	36,161	21,837	2,941	-----	5,622	1,915	68,476
Miscellaneous	47,174	34,581	683	39	2,155	4,299	88,931
Total	515,578	758,738	14,218	1,472	50,144	17,194	1,357,344

Table 6.—Refiner, importer, and dealer stocks of platinum-group metals in the United States, December 31

(Troy ounces)

Year	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1965	422,804	427,450	18,374	1,502	44,531	11,712	926,373
1966	459,669	574,651	20,677	2,559	57,737	14,311	1,129,604
1967	327,919	460,624	17,410	2,802	47,275	13,181	869,211
1968	322,932	393,882	15,127	2,402	55,097	13,271	802,711
1969	370,675	608,716	14,505	2,873	55,833	24,876	1,077,478

STOCKS

During the year, stocks of platinum-group metals held by refiners and dealers increased collectively about 34 percent and, except for iridium, were up individually in percent as follows: Platinum, 15; palladium 55; osmium, 20; rhodium, 13; and ruthenium, 87.5. Iridium stocks were down 4 percent.

Yearend stocks of platinum and palladium held in Mercantile Exchange depositories totaled 7,100 and 117,500 ounces, respectively, an increase of 1,300 ounces of platinum but a decrease of 189,000 ounces of palladium during the year.

PRICES

The producer price of platinum was advanced $10 per ounce in November to $130–$135, but prices of other platinum-group metals declined during the year. Producers cut the price of palladium four times during the year for a total reduction of $8 per ounce, from $45–$47 in January to $37–$39 in November. The price of iridium was reduced $25 per ounce to a range of $160–$165 at yearend; rhodium also was reduced $25 by producers to $220–$225; ruthenium was reduced $5 in November to $50–$55 an ounce.

Although platinum remained in tight supply, premium prices quoted by dealers declined sharply during the year, which reduced the spread between producer and dealer quotations from $160 to $47 per ounce. Palladium continued in ample supply with dealers quoting discounts ranging up to $4.50 an ounce. The dealer price of the minor platinum-group metals with the exception of osmium were also quoted at discounts from the producer prices.

The merchant market price of platinum opened the year at $280 per ounce and declined to $260 by March 1, to $240 by April 1, then to $200 by May 1. The price dropped to $170 in June, reached a low of $165 early in August, then advanced in late August to $180, reflecting the influence of the strike against The International Nickel Co., Inc. The price fell $3 per ounce in November, closing the year at $177.

A pooling arrangement by petroleum refiners helped to stabilize demand and lower the price of platinum in the merchant market. The pool arrangement permitted a member company, which needed more platinum than was available from its producer allocations, to borrow from another member, with excess platinum to be repaid in platinum out of the borrowers later producer allocation.

Dealer quotations on palladium trended downward in a range below the producer price. Opening at $42.50–$43.50, the dealer price was cut to $40.25–$40.50 in March, to $36.50–$37.50 in June and held steady until December when prices were again reduced to $35.50–$36.

Dealer quotations on iridium declined from $180–$185 in January to $172–$175 in June, and to $160–$165 in September, closing the year at $160–$162. Osmium prices were lowered from $230–$250 in January to $225–$250 in July to $200–$250 in November. Similarly, the price of rhodium was gradually reduced from $242–$245 in January to $239–$241 in March, to $232–$235 in June to $220–$225 in September, and to $215–$220 in November. The price of ruthenium remained unchanged at $45.

The futures market for platinum declined in harmony with merchant quotes. The Mercantile Exchange quotation for 4-months delivery moved down from $256.80 at the beginning of January to $165.50 at yearend. Palladium quotations for 3-months delivery declined from $41.40 to $32.50 per ounce during the year.

FOREIGN TRADE

U.S. imports of platinum-group metals collectively dropped 31 percent below the record high of 1968. Platinum imports were up almost 7 percent; palladium was down 46 percent; osmium, down 18 percent; rhodium imports were off 42 percent, and ruthenium was off 43 percent, compared with imports in 1968. Imports of iridium in 1969 increased 8 percent over those of 1968. Of the total metals imported almost 52 percent was palladium and 43 percent was platinum. The United Kingdom shipped about one-half of the total platinum-group metals imported into the United States; 24 percent came from the Soviet Union with the balance distributed among Western European countries, Canada, and Colombia.

Table 7.—U.S. exports of platinum-group metals, by countries

Year and destination	Platinum (ore, concentrates, waste and scrap, and platinum unworked or partly worked)		Palladium, rhodium, iridium, osmiridium, ruthenium, and osmium (unworked or partly worked, n.e.c.)	
	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)
1967	161,585	$19,248	118,267	$9,772
1968:				
Argentina	7	1	1,258	54
Australia	------	------	3,230	146
Belgium-Luxembourg	30,961	1,622	2,647	85
Brazil	583	28	1,332	133
Canada	1,675	183	16,454	746
France	11,274	1,355	4,175	483
Germany, West	66,596	10,961	51,498	7,791
Hong Kong	------	------	664	33
Italy	12,006	1,410	16,562	1,500
Japan	21,928	4,581	26,898	2,515
Mexico	916	65	5,754	250
Netherlands	19,853	3,322	8,570	979
Netherlands Antilles	------	------	484	52
Spain	------	------	1,438	75
Switzerland	2,061	89	16,682	940
United Kingdom	54,973	7,356	13,786	2,711
Other	165	24	727	29
Total	222,998	30,997	172,159	18,522
1969:				
Argentina	------	------	318	14
Australia	------	------	2,159	90
Belgium-Luxembourg	40,796	2,172	6,167	222
Brazil	252	48	1,751	120
Canada	726	84	13,650	563
France	12,008	1,433	7,108	485
Germany, West	64,486	11,893	134,171	6,824
Hong Kong	771	124	39	2
Italy	7,941	994	23,533	1,388
Japan	22,958	4,185	32,642	2,742
Mexico	429	63	3,591	160
Netherlands	19,794	2,975	14,661	896
Spain	18	1	1,120	46
Switzerland	3,116	311	29,912	1,904
United Kingdom	49,879	6,024	5,751	850
Other	395	49	922	49
Total	223,569	30,356	277,495	16,355

Table 8.—U.S. imports for consumption of platinum-group metals

Year	Troy ounces	Value (thousands)
1967	1,321,278	$92,120
1968 r	1,773,984	125,692
1969	1,225,651	94,193

r Revised.

Table 9.—U.S. imports for consumption of platinum-group metals, by countries

Year and country	Unwrought											
	Grains and nuggets (platinum)		Sponge (platinum)		Sweepings, waste, and scrap		Iridium		Palladium		Rhodium	
	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)
1968:												
Australia	---	---	---	---	9,447	$1,107	---	---	---	---	---	---
Belgium-Luxembourg	---	---	r 1,652	$209	6,021	538	---	---	2,830	$137	9	$1
Canada	6	$1	1,947	178	18,907	1,047	2,000	$380	78,550	3,067	16,270	3,646
Colombia	19,664	3,723	1,200	218	1,113	75	---	---	---	---	---	---
France	---	---	---	---	320	23	---	---	15,292	748	---	---
Germany, West	74	16	1,252	145	60	13	---	---	4,828	228	167	40
Japan	1,359	364	497	144	8	1	---	---	17,860	706	---	---
Mexico	r 737	r 162	---	---	3,703	81	---	---	r 299	r 16	---	---
Netherlands	---	---	701	161	154	27	---	---	63,017	2,713	326	81
Norway	3,950	895	2,200	535	---	---	---	---	4,410	193	---	---
South Africa, Republic of	---	---	---	---	3,195	224	---	---	---	---	---	---
Spain	---	---	---	---	---	---	---	---	10,669	437	---	---
Sweden	350	76	---	---	2,741	120	---	---	350	16	---	---
Switzerland	51	10	1,766	404	---	---	5	1	26,196	1,096	2,897	389
U.S.S.R.	1,252	324	3,521	945	---	---	---	---	419,543	18,574	4,118	1,033
United Kingdom	36,327	4,419	288,826	r 34,052	1,737	203	3,498	637	424,556	18,616	17,239	3,678
Other	1,202	233	---	---	r 7,289	402	---	---	---	---	---	---
Total	r 64,972	r 10,223	r 303,562	r 36,991	r 54,695	3,861	5,503	1,018	r 1,068,400	r 46,547	41,026	8,868
1969:												
Australia	205	34	---	---	7,622	867	---	---	---	---	---	---
Belgium-Luxembourg	494	89	5,447	767	73,564	1,350	---	---	731	30	114	34
Canada	165	26	10,874	1,375	19,580	1,254	2,497	438	27,994	1,524	12,654	2,995
Colombia	18,951	3,192	8,735	1,501	2,598	323	---	---	---	---	---	---
France	---	---	147	25	3	(1)	---	---	---	---	---	---
Germany, West	120	15	4,822	593	(1)	1	---	---	1,849	73	245	42
Japan	---	---	---	---	1,720	448	1	(1)	8,112	345	---	---
Mexico	44	13	---	---	4,907	182	---	---	---	---	---	---
Netherlands	---	---	847	141	2,574	169	---	---	25,410	1,457	978	236
Norway	3,345	618	1,755	328	---	---	---	---	3,225	115	300	34
South Africa, Republic of	---	---	125	21	5,503	414	---	---	---	---	179	27
Spain	---	---	---	---	---	---	---	---	---	---	---	---
Switzerland	---	---	3,457	430	---	---	---	---	6,196	293	249	60
U.S.S.R.	3,253	895	---	---	---	---	---	---	3,778	150	2,620	622
United Kingdom	40,433	4,733	286,585	28,484	933	32	3,440	589	171,569	6,697	20,738	4,565
Other	550	126	---	---	8,049	382	---	---	525	20	---	---
Total	67,560	9,741	272,794	33,665	27,053	5,422	5,938	1,027	249,389	10,704	38,077	8,615

See footnotes at end of table.

Table 9.—U.S. imports for consumption of platinum-group metals, by countries—Continued

Year and country	Unwrought				Semimanufactured								Total	
	Ruthenium		Other platinum-group metals		Platinum		Palladium		Rhodium		Other platinum-group metals			
	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)
1968:														
Australia	--	--	--	--	80	$17	--	--	--	--	--	--	9,527	$1,124
Belgium-Luxembourg	--	--	110	$16	--	--	--	--	--	--	--	--	r 10,622	901
Canada	3,800	$140	10	1	1,589	193	828	$38	3,000	$65	208	$6	127,115	8,762
Colombia	--	--	5,488	907	--	--	--	--	--	--	--	--	27,465	4,923
France	--	--	--	--	--	--	3,219	149	--	--	--	--	18,831	920
Germany, West	--	--	1,628	81	7,452	590	--	--	85	21	3,052	125	18,598	1,259
Japan	--	--	--	--	1,728	376	9,168	372	--	--	--	--	30,620	1,963
Mexico	--	--	--	--	105	20	87	4	--	--	--	--	4,931	283
Netherlands	--	--	25	5	7	1	4,970	231	--	--	--	--	69,200	3,219
Norway	--	--	--	--	1,200	202	200	8	--	--	--	--	11,960	1,833
South Africa, Republic of	--	--	3,548	634	--	--	--	--	--	--	--	--	6,743	858
Spain	--	--	--	--	--	--	--	--	--	--	--	--	10,669	437
Sweden	--	--	--	--	--	--	--	--	--	--	--	--	3,441	212
Switzerland	--	--	--	--	1,298	315	147	7	--	--	--	--	32,360	2,222
U.S.S.R.	--	--	990	212	306	66	54,489	2,403	26,905	1,406	--	--	511,124	24,963
United Kingdom	r 9,362	314	9,923	1,737	54,912	6,392	23,808	1,032	--	--	2,099	98	r 872,287	r 71,178
Other	--	--	--	--	--	--	--	--	--	--	--	--	r 8,491	r 635
Total	r 13,162	454	21,722	3,593	68,677	8,172	96,916	4,244	29,990	1,492	5,359	229	r 1,773,984	r 125,692
1969:														
Australia	--	--	--	--	--	--	--	--	--	--	--	--	7,827	901
Belgium-Luxembourg	--	--	88	14	94	24	--	--	5	1	--	--	80,537	2,309
Canada	--	--	--	--	577	30	--	--	--	--	200	8	74,541	7,650
Colombia	--	--	1,200	184	--	--	--	--	--	--	--	--	31,484	5,200
France	--	--	3,669	607	--	--	--	--	--	--	--	--	3,819	632
Germany, West	--	--	--	--	4,119	545	--	--	--	--	--	--	11,155	1,269
Japan	--	--	15	1	--	--	13,767	555	--	--	--	--	23,615	1,349
Mexico	--	--	--	--	24	6	--	--	--	--	--	--	4,975	201
Netherlands	--	--	--	--	--	--	--	--	--	--	--	--	29,809	2,003
Norway	--	--	38	8	2,225	428	2,413	91	--	--	--	--	13,301	1,622
South Africa, Republic of	--	--	487	82	367	45	--	--	--	--	--	--	6,661	589
Spain	--	--	--	--	--	--	16,076	563	--	--	--	--	16,076	563
Switzerland	--	--	1,906	92	359	45	2,229	92	--	--	--	--	14,396	1,012
U.S.S.R.	--	--	--	--	10,206	1,970	266,097	9,857	3,233	407	978	161	290,165	14,062
United Kingdom	7,540	390	3,729	638	40,278	4,925	82,001	3,122	149	36	275	21	607,670	54,232
Other	26	1	470	70	--	--	--	--	--	--	--	--	9,620	599
Total	7,566	391	11,602	1,696	58,249	8,018	382,583	14,280	3,387	444	1,453	190	1,225,651	94,193

r Revised.
[1] Less than ½ unit.

WORLD REVIEW

Total world production of platinum-group metals was down slightly in 1969 because of severe declines in Canadian output due to strikes in the nickel industry. There were increases in output by the two major producers, the U.S.S.R. and the Republic of South Africa, which continued its program of expansion.

Canada.—The Canadian output of platinum-group metals in 1969 declined to 266,100 ounces, a drop of almost 220,000 from 1968. Most of Canada's production comes as byproduct of nickel mining and refining in the Sudbury district of Ontario. Strikes in this district during 1969 reduced the output of the platinum-group by about 100,000 ounces. The International Nickel Company of Canada Ltd. (INCO) was proceeding with the development of five new mines and announced plans for a new mill and refinery. Falconbridge Nickel Mines, Ltd., is preparing to bring a large new mine into production soon. Slimes from INCO's Port Colborne refinery are shipped to Acton, England, for platinum-group recovery. Falconbridge ships nickel-copper matte to its refinery in Kristiansand, Norway, and slimes from this refinery go to the Newark, N.J., plant of Engelhard Industries for final extraction by refining. With the forthcoming Sudbury area expansion of nickel output by the two major producers, increasing amounts of the platinum-group metals will be available.

Table 10.—World production of platinum-group metals

(Troy ounces)

Country	1967	1968	1969 p
North America:			
Canada:			
Platinum and platinum group metals	401,263	485,891	266,100
United States: [1]			
Placer platinum and from domestic gold and copper refining	16,365	14,793	21,586
South America:			
Colombia:			
Placer platinum	e r 19,000	22,280	27,805
Europe:			
U.S.S.R.:			
Placer platinum and from platinum-nickel-copper ores e	1,900,000	2,000,000	2,100,000
Africa:			
Ethiopia:			
Placer platinum	282	349	343
South Africa, Republic of:			
Platinum-group metals from platinum ores e	825,000	850,000	950,000
Osmiridium from gold ores e	7,000	14,000	14,000
Asia:			
Japan:			
Palladium from refineries	3,327	3,651	3,877
Platinum from refineries	3,072	2,785	3,140
Total [2]	3,175,309	3,393,749	3,386,851

e Estimate. p Preliminary. r Revised.
[1] U.S. imports include platinum group metals from other countries not listed as indigenous producers.
[2] Totals are of listed figures only.

Colombia.—International Mining Corp. operated five dredges during the year in the Choco district and recovered 11,880 ounces of platinum from washing 17.1 million cubic yards of placer gravels, compared with 13,049 ounces from 15.5 million yards in 1968. Dredgeable reserves at year-end totaled 180.6 million cubic yards with an average value of 17.8 cents per yard in gold and platinum, compared with 163.7 million cubic yards averaging 18.8 cents per yard in 1968. Reserves were calculated at $170 per ounce for platinum at the end of 1969 and $200 at the end of 1968. The company reported that it moved a newly acquired 8-cubic-foot dredge to the Nariño area in December. It is scheduled to begin production in April 1970.

South Africa, Republic of.—Output of platinum-group metals continued to expand in 1969 for the seventh consecutive year, with a gain of almost 12 percent over 1968 output. Nearly all the platinum-group metals were produced from platinum ores; however, a small amount of osmiridium was recovered as a byproduct of gold ores.

Rustenburg Platinum Mines Ltd. (Rustenburg), announced that its program designed to increase mine production of platinum to an annual rate of 850,000 ounces was completed by midyear and that the corresponding flow of refined metal will become available during the calendar year 1970. The further expansion of productive facilities, announced in 1968, which would increase output to 1 million ounces of platinum, was advanced during the year and is expected to be fully operational by mid-1970 with refined output at this rate becoming available to the market early in 1971.

Rustenburg announced in August that it had decided to embark on a further expansion program designed to increase the company's annual productive capacity to 1.2 million ounces of platinum to be completed early in 1972. The new expansion program by Rustenburg is being carried out at the Union Section. The facilities at Matte Smelters Pty. Ltd. at Rustenburg will also be extended. The new platinum metals refinery of Rustenburg and Johnson Matthey at Wadesville began operation in October. The refinery, an extension to Johnson Matthey's existing Wadesville plant, will in addition to platinum, produce all the other platinum-group metals. Capacity of the extended refinery has been designed to accommodate a major part of the expanded platinum output of Rustenburg.

The refinery will handle converter matte produced by Matte Smelters (Pty.) Ltd. from Rustenburg flotation concentrate. The converter matte contains approximately 46 percent nickel, 28 percent copper, and about 50 ounces per ton of platinum-group metals. The matte is treated in the following two steps: Removal of nickel and copper to produce a rich, platinum-group metal concentrate, followed by chemical treatment of this concentrate to separate and purify the individual metals. A detailed description of the process was described in a recent technical presentation.[8] Before the Wadesville plant extension was commissioned the entire platinum-group metal concentrate resulting from Matte Smelter's operations was sent to Johnson Matthey's refinery in England for final concentration and separation of metals.

Rustenburg disclosed during the year that at least 200 million ounces of platinum is potentially available for exploitation in the Bushveld Igneous Complex. The estimate takes into account the effects of price inflation and of deep mining and its impact on working costs.

Impala Platinum Ltd., a subsidiary of Union Corp. Ltd., began production operations at an initial rate of 100,000 ounces per year as its Bafokeng mine. Union Corp. Ltd., announced that productive capacity at Bafokeng is to be increased to 180,000 ounces by the second half of 1970.

Anglo-Transvaal Consolidated is developing its Middlepunt Farm property in the Lydenburg area for initial production of 15,000 ounces of platinum per year. A treatment plant was built to produce gravity and flotation concentrates containing platinum-group metals, nickel, copper, and gold. First shipments of gravity concentrates and matte to overseas refiners were made in the last quarter of 1969.

TECHNOLOGY

Tests conducted by Engelhard Minerals & Chemical Corp. on fission-product rhodium, which was supplied by the Atomic Energy Commission (AEC) from Hanford reactor fuel-processing wastes, indicated that fission-product rhodium should be usable as an alloy component for platinum in ammonia oxidation without significant carryover of radioactivity into the final product. A substantial aging period would be required before either rhodium or ruthenium could be accepted for common applications. However, special procedures in handling and use may permit the use of rhodium in some applications. It was further established that although each of the fission-produced elements contained radioactive isotopes, those of palladium are so weak in energy and long in half-life that such palladium may be acceptable for some conventional applications. Nuclear power can therefore be seriously considered as a source of very substantial quantities of useful platinum-group metals. By 1982 it is expected that spent fuel will

[8] Papademetriou, T., and J. R. Grasso. Recovery of Precious Metals From South African Matte. Englehard Industries Tech. Bull., v. 10, No. 4, March 1970, p. 121.

yield 48,200 ounces per year of rhodium and 96,400 ounces per year of palladium.[9]

The literature on platinum metals was greatly enriched in 1969 by a U.S. Geological Survey publication. This highly competent and comprehensive work is a summary report on the geology of the platinum deposits of the world and contains an extensive bibliography of 500–600 references. Copies may be obtained from the U.S. Government Printing Office, Washington, D.C. for $1.75.[10]

Engelhard Minerals & Chemicals Corp. reported that its research on fuel cell technology has resulted in the development of a power source and a complete power system based on a platinum catalyst. The power source is intended for mobile power supply units; the complete system can provide power over a long term for unattended operations such as microwave relays, television repeater stations, unmanned weather stations, buoys, and other remote installations.

In the field of air pollution, Engelhard reported the availibility of a precious-metal catalytic device to control exhaust fumes from engines fueled with unleaded gasoline, diesel fuel, or liquid petroleum gas. As more lead-free gasoline becomes available, automobiles can be equipped with these devices to remove pollutants from their exhaust streams.[11]

A new series of catalysts introduced by Engelhard, the E–500's, are reported to be particularly efficient in producing lead-free gasoline. The growth in use of these catalysts will depend upon the compression ratios adopted in future automotive engine design and makeup of the fuels for such engines.[12]

An interesting application emphasizing reliability of performance is the use of 10 percent rhodium-platinum contacts in microrelays, which are an integral part of an automatic landing system for a British aircraft manufacturer. The alloy used is in the form of a wire 0.017 inch in diameter, goldplated to 150 microinches, and sealed within a glass pellet.[13]

Engelhard Minerals & Chemical Corp. continuously reviews the precious metals literature and publishes summary information. It was indicated that approximately 545 patents resulting from research involving precious metals were granted during 1969.[14] Almost half of the patents awarded were for catalytic applications.

The research laboratories of Johnson Matthey & Co. Ltd. have developed a complete range of noble metal screen printing inks for thick film circuits. These circuits can be cofired within the same time-temperature cycle, which is claimed to simplify and reduce the cost of circuit production.[15]

In this era of increased dangers from airliners being hijacked or sabotaged, an unusual patent was granted for an automatic bomb detector. The detection is based on ethylene glycol dinitrate vapor whose presence can be detected with a device which contains three concentric cylinders made from platinum or gold.[16]

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[9] Rohrman, Chas. A. Nuclear Power Contributions to the Resources of Platinum Group Metals. Paper presented at the National Meeting American Chemical Society—Symposium on platinum-group metals, New York, Sept. 9, 1969.

[10] Mertie, John B., Jr. Economic Geology of the Platinum Metals. Geol. Survey Prof. Paper 630, 1969, p. 120.

[11] Metals Week. Checking Exhaust Fumes With Platinum. May 26, 1969, p. 23.

[12] Metals Week. Engelhard Offers New Platinum Catalvst. May 12, 1969, p. 22.

[13] Platinum Metals Review. U.S. Patent Index. V. 14, No. 1, January 1970, p. 13.

[14] Engelhard Industries Technical Bulletin. V. 10, No. 4, March 1970, pp. 171–172.

[15] Kerridge, F. E., G. S. Iles, and Q. N. Collier. Interconnections for Thick Film Circuits. Platinum Metals Rev., v. 13, No. 3, July 1969, pp. 86–89.

[16] Englehard Industries Technical Bulletin. V. 10, No. 1, June 1969, p. 22.

Potash

By Donald E. Eilertsen [1]

Apparent consumption and imports of potash materials into the United States during 1969, 8.1 and 4.0 million tons, respectively, continued to smash records. Sales of domestic potassium salts, 5.3 million tons, were slightly below the record of 1966; and the average value of $14.62 per short ton for potassium salts sold by producers was the lowest since 1935. The downward trend in domestic production of marketable potassium salts since 1966 was reversed in 1969.

Table 1.—Salient potash statistics
(Thousand short tons and thousand dollars)

Item	1965	1966	1967	1968	1969
United States					
Production of potassium salts, marketable	5,401	5,701	5,649	4,769	4,918
Approximate K_2O equivalent	3,140	3,320	3,299	2,722	2,804
Value	$129,767	$122,210	$105,313	$75,664	$73,572
Sales of potassium salts by producers	5,027	5,377	5,363	5,091	5,340
Approximate K_2O equivalent	2,931	3,133	3,126	2,913	3,069
Value at plant	$121,161	$116,340	$100,566	$81,620	$78,062
Average value per ton	$24.10	$21.64	$18.75	$16.03	$14.62
Imports for consumption of potash materials	1,867	2,544	2,929	3,658	3,978
Approximate K_2O equivalent	1,108	1,491	1,708	2,172	2,340
Value	$52,675	$71,821	$73,649	$78,077	$67,034
Exports of potash materials	1,099	1,053	1,175	1,336	1,259
Approximate K_2O equivalent	648	621	693	748	709
Value	$42,494	$38,159	$39,896	$43,467	$37,773
Apparent consumption of potassium salts [1]	5,795	6,868	7,117	r 7,413	8,059
Approximate K_2O equivalent	3,391	4,003	4,141	r 4,337	4,700
World: Production, marketable:					
Approximate K_2O equivalent	15,128	16,059	17,353	17,856	18,311

r Revised.
[1] Measured by sold or used plus imports minus exports.

Legislation and Government Programs.—The Department of the Treasury informed the U.S. Tariff Commission on August 22 that potassium chloride from Canada, France, and West Germany was being sold or likely to be sold in the United States at less than fair value. Later, the Commission held hearings on the matter under the Antidumping Act of 1921, as amended; and on November 21 announced that potassium chloride from the three countries will become subject to special dumping duties.[2] At yearend, discussions on tariff assessments were underway.

The depletion allowance rate of 15 percent on foreign and domestic production of potash for tax purposes was lowered to 14 percent for taxable years starting after October 9, 1969.

[1] Physical scientist, Intermountain Field Operation Center, Denver, Colo.
[2] U.S. Tariff Commission. Potassium Chloride (Muriate of Potash) from Canada, France and West Germany—Determination of Injury in Investigation Nos. AA1921–58, 59 and 60 Under the Antidumping Act. 1921, as Amended. TC Pub. 303, November 1969, 32 pp.
———. Tariff Commission Reports Its Determination in Antidumping Investigations of Potassium Chloride From Canada, France, and West Germany. News Release, Nov. 21, 1969, 1 p.

DOMESTIC PRODUCTION

The downward trend in the production of marketable potassium salts since 1966 was stopped in 1969. Output increased 3 percent over 1968 to 4.9 million short tons, but was still 13.7 percent below the record established in 1966. New Mexico's production—4.1 million short tons—of marketable potassium salts represented an increase of 2 percent over 1968; the State accounted for 84 percent of the national output. The average grade of New Mexico's mine production of potassium ore was 18.4 percent K_2O compared with 18.1 percent in 1968. The drop in domestic potash production from 1966 to 1969 continued to be attributed largely to imports of potassium muriate from Canada.

Twelve firms in five States produced potash raw materials. They were Duval Corp., International Minerals & Chemical Corp., Kerr-McGee Corp., National Potash Co., Potash Co. of America, Southwest Potash Corp., United States Potash & Chemical Co. (from mines in New Mexico), American Potash & Chemical Corp., (from brine in California), Marquette Cement Manufacturing Co. (as byproduct in the manufacture of cement in Maryland), The Dow Chemical Co. (from brine in Michigan), and Texas Gulf Sulphur Co. and Kaiser Aluminum & Chemical Corp. (from operations in Utah).

Statistical data on production and sales of potash in the United States and New Mexico are reported for the first time in 6-month periods to facilitate more detailed analysis.

The Dow Chemical Co. revealed the existence of huge sylvite reserves in central Michigan. Geologists found sylvite beneath an area of 13,000 square miles. No production is planned at present.

Table 2.—Marketable potassium salts produced and sold or used in the United States, in 1969, by product

(Thousand short tons and thousand dollars)

Muriate of potash, 60-percent K_2O minimum	Production			Sold or used		
	Gross weight	K_2O equivalent	Value [1]	Gross weight	K_2O equivalent	Value
	January–June 1969					
Standard	951	583	$11,179	1,162	711	$13,999
Coarse	618	377	8,707	725	442	10,223
Granular	323	195	4,689	498	302	7,236
Total [2]	1,892	1,156	24,576	2,385	1,456	31,458
Other potassium salts [3] [4]	661	303	13,622	665	289	13,242
Grand total [2]	2,552	1,458	38,198	3,050	1,744	44,700
	July–December 1969					
Standard	821	503	$8,912	822	502	$8,973
Coarse	579	354	7,652	579	353	7,595
Granular	377	229	5,104	394	239	5,331
Total [2]	1,777	1,085	21,668	1,796	1,094	21,899
Other potassium salts [3] [4]	589	261	13,706	494	231	11,463
Grand total [2]	2,366	1,346	35,374	2,290	1,325	33,362

[1] Derived from reported value of "Sold or used."
[2] Data may not add to totals shown because of independent rounding.
[3] Figures for refined muriate and manure salts are included with potassium sulfate and potassium-magnesium.
[4] Includes sulfate manufactured from captive production of muriate.

Table 3.—Crude potassium salts produced, and marketable salts produced and sold or used in New Mexico

(Thousand short tons and thousand dollars)

Period	Crude salts [1] (mine production)		Marketable potassium salts					
			Production			Sold or used		
	Gross weight	K_2O equivalent	Gross weight	K_2O equivalent	Value [2]	Gross weight	K_2O equivalent	Value
1968:								
January-June	7,290	1,333	2,008	1,126	$32,638	2,456	1,386	$40,274
July-December	7,801	1,403	2,043	1,163	30,767	1,970	1,124	29,924
Total [3]	r 15,092	r 2,737	4,051	2,289	63,406	4,425	2,511	70,198
1969:								
January-June	7,962	1,472	2,117	1,194	31,742	2,591	1,466	37,641
July-December	7,558	1,389	2,014	1,133	30,293	1,842	1,055	27,222
Total [3]	15,519	2,861	4,131	2,327	62,034	4,433	2,521	64,863

r Revised.
1 Sylvite and langbeinite.
2 Derived from reported value of "Sold or used."
3 Data may not add to totals shown because of independent rounding.

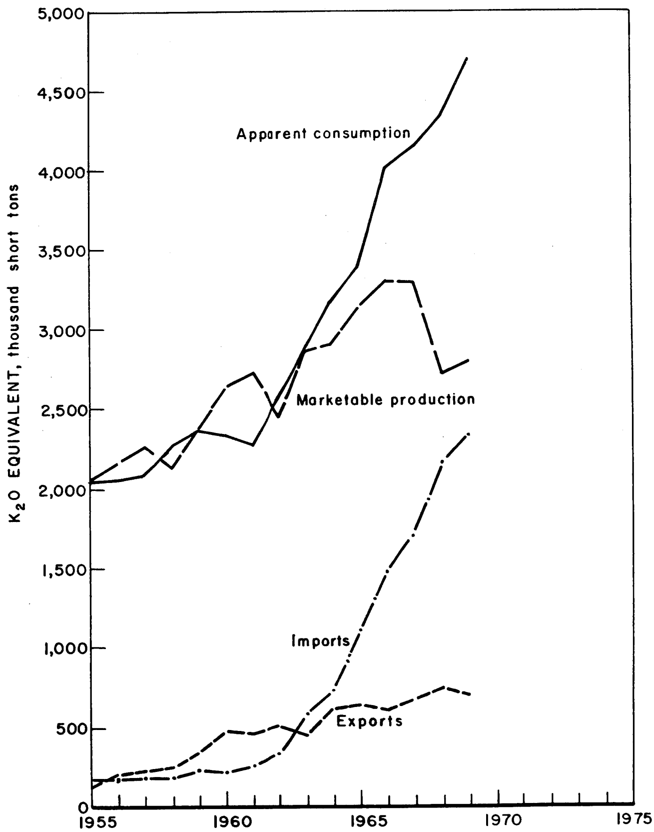

Figure 1.—Marketable production, apparent consumption, exports, and imports of potassium salts measured in K_2O equivalent.

CONSUMPTION AND USES

The apparent consumption of potassium salts in the United States, measured by sales plus imports minus exports, exceeded 8 million tons for the first time and continued to break records.

Deliveries of potash, both domestic and imported, for agricultural and chemical uses in the United States, totaling 4.63 million tons (K_2O equivalent), was the largest on record. Potash deliveries for agricultural purposes soared above the 4-million-ton level for the first time and accounted for 95.1 percent of the total. Illinois, Iowa, Indiana, and Ohio accounted for 35.8 percent of deliveries for agriculture, while New York continued to be the leading recipient of potash for chemical purposes.

A new potassium-based powder for extinguishing fires was reportedly being produced on a pilot-plant scale in the United Kingdom. The powder, obtained by reacting urea with potassium bicarbonate, is white, nontoxic, and 16 times more effective in fighting fires than conventional sodium bicarbonate.[3]

[3] Phosphorus and Potassium. New Plants and Projects, United Kingdom. No. 43, September–October 1969, p. 34.

Table 4.—Deliveries of potash salts in 1969, by State of destination

(Short tons K_2O equivalent)

Destination	Agricultural potash	Chemical potash	Destination	Agricultural potash	Chemical potash
Alabama	116,432	28,963	Montana	2,616	------
Arizona	1,123	45	Nebraska	40,451	427
Arkansas	80,413	507	Nevada	---------	1,060
California	49,101	9,369	New Hampshire	459	53
Colorado	7,390	436	New Jersey	12,024	1,715
Connecticut	3,694	379	New Mexico	1,959	892
Delaware	18,905	14,249	New York	53,639	75,645
District of Columbia	360	------	North Carolina	134,596	742
Florida	251,538	1,157	North Dakota	8,966	------
Georgia	234,153	695	Ohio	277,697	6,620
Hawaii	22,980	------	Oklahoma	17,319	203
Idaho	7,398	------	Oregon	14,543	903
Illinois	568,207	26,041	Pennsylvania	46,839	3,771
Indiana	329,014	5,093	Rhode Island	1,980	728
Iowa	397,485	1,252	South Carolina	90,396	155
Kansas	32,456	1,266	South Dakota	7,918	70
Kentucky	92,604	18,053	Tennessee	110,598	61
Louisiana	61,654	627	Texas	204,326	11,188
Maine	19,398	73	Utah	835	114
Maryland	89,718	1,687	Vermont	114,847	16
Massachusetts	3,388	349	Virginia	2,897	68
Michigan	151,627	1,971	Washington	25,576	2,244
Minnesota	259,197	751	West Virginia	3,281	5,990
Mississippi	67,374	2	Wisconsin	185,241	203
Missouri	172,015	1,822	Wyoming	1,209	423
			Total	[1] 4,397,836	[2] 228,078

[1] Distribution of K_2O—1,391,494 tons as standard muriate, 1,612,571 tons as coarse muriate, 940,250 tons as granular muriate, 256,055 tons as soluble muriate, and 197,466 tons as sulfates.

[2] Distribution of K_2O—205,242 tons as muriate, 17,009 tons as soluble muriate, and 5,827 tons as sulfates.

Source: American Potash Institute, Inc., Atlanta, Ga.

STOCKS

Producers' yearend stocks of marketable potassium salts were 723,000 short tons—38.5 percent smaller than those in 1968 and 51.8 percent lower than the high of 1.5 million short tons set in 1967. Yearend stocks of imported potash are not available.

Table 5.—Yearend stocks of marketable potassium salts in the United States
(Thousand short tons)

Year	Number of producers	Stocks, Dec. 31	
		Gross weight	K_2O equivalent
1965	12	892	504
1966	12	1,215	690
1967	12	1,501	863
1968	13	1,175	676
1969	12	723	392

PRICES

Prices of various potassium materials are shown in tables 6, 7, and 8. In general, the prices of potassium muriate produced in New Mexico, Utah, and Canada dropped sharply by yearend, whereas those for California muriate advanced. Prices of agricultural potassium sulfate increased sharply by yearend, while prices of chemical-grade potassium chloride and mine-run salts were steady throughout the year.

Table 6.—Prices for potassium products in 1969 [1]

Product	Jan. 1	Feb. 7	Aug. 15	Sept. 5	Sept. 26	Oct. 24	Dec. 12	Dec. 19	Dec. 31
Potassium chloride, chemical-grade (95 to 99 percent KCl), per short ton	$28.00	--------	--------	--------	--------	--------	--------	--------	$28.00
Potassium muriate, per unit-ton: [2]									
Standard (60 percent K_2O minimum):									
General prices	$0.30–.38	$0.22–.38	(3)	--------	--------	--------	--------	--------	--------
New Mexico and Utah	--------	--------	$0.22–.23	--------	--------	--------	$0.21–.33	$0.21–.335	$0.21–.335
Trona, Calif.	--------	--------	.37	--------	--------	--------	--------	.42	.42
Saskatchewan, Canada	--------	--------	.195–.21	$0.20–.21	--------	--------	.19–.314	--------	.19–.314
Coarse:									
General prices	.33–.42	.25–.42	(3)	--------	--------	--------	--------	--------	--------
New Mexico and Utah	--------	--------	.25–.26	--------	--------	--------	.26–.37	.27–.375	.27–.375
Trona, Calif.	--------	--------	.40	--------	--------	--------	--------	.46	.46
Saskatchewan, Canada	--------	--------	.225–.24	.23–.24	--------	--------	.25–.351	--------	.25–.351
Granular:									
General prices	.365	.27–.365	(3)	--------	--------	--------	--------	--------	--------
New Mexico and Utah	--------	--------	.27–.28	--------	--------	--------	.28–.39	.29–.395	.29–395
Saskatchewan, Canada	--------	--------	.245–.26	.225–.24	--------	--------	.27–.37	--------	.27–.37
Potassium sulfate (per unit-ton): [2] Agricultural (50 percent K_2O minimum):									
Standard:									
General price	.60	--------	--------	--------	$0.75–.95	(3)	--------	--------	--------
Carlsbad, N. Mex.	--------	--------	--------	--------	--------	$0.80	--------	--------	.80
Granular:									
General price	.68	--------	--------	--------	.85–1.03	(3)	--------	--------	--------
Carlsbad, N. Mex.	--------	--------	--------	--------	--------	.90	--------	--------	.90
Potassium manure salt (20 percent K_2O minimum) [2]	.1765	--------	--------	--------	--------	--------	--------	--------	.1765

[1] Bulk, carlots, works.
[2] 20 pounds of equivalent K_2O.
[3] Discontinued quoting general prices.

Source: Oil, Paint and Drug Reporter.

Table 7.—Bulk prices for potash [1]

(Cents per unit K_2O)

Product	1969 Jan.	1969 Feb. 1	1969 July 1 F.o.b. Carlsbad	1969 July 1 F.o.b. Potasco	1969 Oct. 1	1969 Dec. 1 F.o.b. Carlsbad	1969 Dec. 1 F.o.b. Saskatoon, Sask.
Muriate, 60 percent K_2O minimum:							
Standard	29	22	23	21	----	21	19
Coarse	33	25	26	24	----	27	25
Granular	35	27	28	26	----	29	27
Sulfate of potash (50 percent K_2O minimum):							
Standard	70	75	75	75	80	----	----
Mine run salts (20 percent K_2O minimum)	17.65	----	----	----	----	----	----

[1] Carlots, f.o.b. cars Carlsbad, N. Mex., or Potasco, Saskatchewan, Canada, unless otherwise specified.

Source: Potash Company of America, Division of Ideal Basic Industries, Inc.

Table 8.—Bulk prices for California potash [1]

(Cents per unit K_2O)

Product	1969 Jan.	1969 Feb.-May	1969 July-Dec.	1970 Jan.-June [2]
Muriate (60 percent K_2O minimum):				
Standard	40	43	[3] 37, 42	42
Coarse	44	47	[3] 40, 46	46
Sulfate (52 percent K_2O minimum):				
Standard	83	88	[4] 93, 98	98
Granular	91	96	[4] 103, 108	108

[1] Quoted by American Potash & Chemical Corp., carlots f.o.b. Trona, Calif. Muriate quotations from price schedules dated June 1, 1968, July 1, 1969, and Jan. 1, 1970. Sulfate quotations from price schedules dated June 1, 1969, July 1, 1969, and Dec. 1, 1969.
[2] Subject to revisions.
[3] Higher price began Dec. 15.
[4] Higher price began Dec. 1.

FOREIGN TRADE

Exports of potash materials were the second largest, and as usual, potassium chloride for fertilizer purposes was by far the principal material exported. Japan, Brazil, and Taiwan received 52 percent of the total potash materials exported for fertilizers; Canada and Japan received 52 percent of the potash materials exported for chemical purposes.

Imports for consumption of 3.98 million tons of potash materials established a new record for the ninth consecutive year; muriate continued to be the major material (96.3 percent). Of the muriate imported, Canada supplied 96.9 percent and thus became the largest individual supplier of muriate for the seventh consecutive year.

Table 9.—U.S. exports of potash materials

Materials	Approximate equivalent as potash (K_2O) (percent)	1968				1969			
		Short tons	Approximate equivalent as potash (K_2O)		Value (thousands)	Short tons	Approximate equivalent as potash (K_2O)		Value (thousands)
			Short tons	Percent of total			Short tons	Percent of total	
Used chiefly as fertilizers:									
Potassium chloride, all grades	60	1,071,181	642,708	85.9	$29,254	1,034,141	620,485	87.5	$25,258
Potassic chemical fertilizer, n.e.c	40	231,433	92,573	12.4	9,082	197,275	78,910	11.1	7,763
Natural potassic salt fertilizers, crude	20	361	72	----	17	1,220	244	----	40
Total	----	1,302,975	735,353	98.3	38,353	1,232,636	699,639	98.6	33,061
Used chiefly in chemical industries:									
Potassium hydroxide	80	4,627	3,702	0.5	634	2,878	2,302	0.1	455
Potassium peroxide	83	2	2	----	2	3	2	----	1
Potassium compounds, n.e.c	31	28,768	8,918	1.2	4,478	23,739	7,359	1.3	4,256
Total	----	33,397	12,622	1.7	5,114	26,620	9,663	1.4	4,712
Grand total	----	r 1,336,372	r 747,975	100.0	r 43,467	1,259,256	709,302	100.0	37,773

r Revised.

Table 10.—U.S. exports of potash materials, by countries

Destination	Fertilizer: Chloride (short tons)	Fertilizer: Chemical fertilizer, n.e.c. (short tons)	Fertilizer: Total: Short tons	Fertilizer: Total: Value (thousands)	Chemical: Hydroxide, caustic (short tons)	Chemical: Other, n.e.c. (short tons)	Chemical: Total: Short tons	Chemical: Total: Value (thousands)
1968:								
Australia	90,050	10,859	100,909	$2,816	174	459	633	$171
Belgium-Luxembourg	-----	27,841	[r] 27,841	[r] 987	3	58	61	24
Brazil	79,862	2,621	82,483	2,191	451	1,256	1,707	369
Canada	8,752	47,779	[r] 56,531	[r] 2,222	2,631	4,828	7,459	1,373
Chile	14,184	4,408	18,592	543	10	61	71	17
Colombia	13,290	10,513	23,803	784	26	24	50	17
Costa Rica	18,106	7,592	25,698	597	8	614	622	26
India	26,128	-----	26,128	1,165	236	247	483	113
Japan	382,635	37,609	[r] 420,244	[r] 12,646	32	825	857	75
Korea, Republic of	121,751	10,637	132,388	3,035	-----	10,582	10,582	366
Mexico	40,948	14,187	[r] 55,135	[r] 1,320	228	1,116	1,344	271
Netherlands	28,000	5,153	[r] 33,153	658	104	75	179	42
New Zealand	32,442	208	32,650	1,179	-----	59	59	22
Pakistan	27,269	11,333	38,602	1,552	14	369	383	77
Philippines	21,584	-----	21,584	511	6	73	79	38
Sweden	12,521	386	[r] 12,907	470	-----	45	45	16
Taiwan	71,094	2,204	73,298	1,649	-----	13	13	7
Venezuela	7,518	13,077	[r] 20,595	[r] 787	64	291	355	85
Other countries	75,047	25,026	[r] [1] 100,434	[r] [1] 3,241	640	7,773	[2] 8,415	[2] 2,005
Total	1,071,181	231,433	[r] 1,302,975	[r] 38,353	4,627	28,768	33,397	5,114
1969:								
Australia	88,570	5,262	93,832	2,630	217	455	672	160
Belgium-Luxembourg	72	111	183	14	-----	38	[2] 41	[2] 13
Brazil	134,966	11,889	146,855	3,218	386	925	1,311	253
Canada	800	59,660	[1] 61,169	[1] 2,556	1,437	7,093	8,530	1,480
Chile	19,683	3,750	23,433	615	5	105	110	36
China-Taiwan	102,906	18,575	121,481	2,946	-----	1	1	3
Colombia	19,021	17,669	36,690	980	41	25	66	22
Costa Rica	12,114	10,276	22,390	564	1	8	9	4
India	-----	-----	-----	-----	44	27	71	21
Japan	335,747	33,123	368,870	9,635	-----	5,406	5,406	237
Korea, Republic of	79,435	-----	79,435	1,721	-----	81	81	15
Mexico	39,704	21,146	[1] 60,880	[1] 1,614	48	1,812	1,860	428
Netherlands	12,322	-----	12,322	275	48	104	152	65
New Zealand	63,517	646	64,163	2,173	7	103	110	34
Pakistan	-----	-----	-----	-----	46	463	509	91
Philippines	39,522	-----	39,522	751	5	66	71	56
Sweden	10,255	281	10,536	341	-----	102	102	27
Venezuela	16,087	1,819	17,906	481	70	251	321	82
Other countries	59,420	13,068	[1] 72,969	[1] 2,547	523	6,674	7,197	1,685
Total	1,034,141	197,275	1,232,636	33,061	2,878	23,739	26,620	4,712

[r] Revised.

[1] Includes crude natural potassic salt fertilizer, 1968: Nicaragua 75 tons ($2,500), United Kingdom 221 tons ($12,108), Bahamas 65 tons ($2,875); 1969: Canada 709 tons ($23,764), Mexico 30 tons ($992), Bahamas 44 tons ($2,245), Argentina 437 tons ($13,195).

[2] Includes potassium peroxide, 1968: Jamaica 246 pounds ($200), United Kingdom 1,960 pounds ($1,000), West Germany 900 pounds ($800); 1969: Belgium-Luxembourg 5,280 pounds ($681).

Table 11.—U.S. imports for consumption of potash materials

Materials	Approximate equivalent as potash (K_2O) (percent)	1968				1969			
		Short tons	Approximate equivalent as potash (K_2O)		Value (thousands)	Short tons	Approximate equivalent as potash (K_2O)		Value (thousands)
			Short tons	Percent of total			Short tons	Percent of total	
Used chiefly as fertilizers:									
Muriate (chloride)	60	r 3,556,622	r 2,133,973	r 98.2	r $68,667	3,829,215	2,297,529	98.2	$57,085
Potassium nitrate, crude	40	16,001	6,400	.3	656	11,314	4,526	.2	449
Potassium sodium nitrate mixtures, crude	14	28,451	3,983	.2	1,009	36,585	5,122	.2	1,370
Potassium sulfate, crude	50	r 43,568	r 21,784	r 1.0	r 1,578	49,327	24,664	1.1	1,799
Other potash fertilizer materials	6	12	---------	----	(1)	38,834	2,330	.1	1,161
Total	----	r 3,644,654	r 2,166,140	99.7	r 71,910	3,965,275	2,334,171	99.8	61,864
Used chiefly in chemical industries:									
Bicarbonate	46	759	349		84	1,725	794		173
Bitartrate: Cream of tartar	25	1,296	324		647	1,338	335		703
Carbonate	61	440	269		68	(1)	(1)		1
Caustic	80	1,269	1,015		272	1,824	1,459		408
Chlorate and perchlorate	36	914	329		204	669	241		150
Cyanide	70	899	629	.3	406	1,035	725	.2	439
Ferricyanide	42	809	340		515	1,051	441		667
Ferrocyanide	44	2,197	967		944	730	321		272
Nitrate	50	1,145	573		138	604	302		78
Rochelle salts	22	293	64		118	498	110		203
All other	31	3,483	1,080		2,771	3,614	1,120		2,076
Total	----	13,504	5,939	.3	6,167	13,088	5,848	.2	5,170
Grand total	----	r 3,658,158	r 2,172,079	100.0	r 78,077	3,978,363	2,340,019	100.0	67,034

r Revised.
[1] Less than ½ unit.

Table 12.—U.S. imports for consumption of potash materials, by countries

(Short tons)

Year and country	Bitartrate cream of tartar	Caustic (hydroxide)	Chlorate and perchlorate	Cyanide	Muriate (chloride)	Potassium nitrate crude	Potassium sodium nitrate mixtures, crude	Potassium nitrate (saltpeter) refined	Potassium sulfate	All others	Total Quantity	Total Value (thousands)
1968:												
Belgium-Luxembourg	-----	141	-----	-----	18,372	-----	-----	-----	2,522	479	21,514	$1,243
Canada	-----	-----	-----	6	3,209,142	105	83	-----	150	331	3,209,817	61,675
Chile	-----	-----	-----	-----	-----	15,630	19,915	-----	-----	-----	35,545	1,383
France	5	321	-----	83	r 60,384	-----	8,440	-----	r 10,630	844	r 80,707	r 2,274
Germany, West	(1)	437	15	403	r 126,474	152	5	682	r 22,976	1,850	r 152,994	r 4,957
Italy	913	-----	-----	-----	-----	-----	-----	377	7,290	37	8,617	807
Japan	-----	5	-----	264	-----	-----	-----	-----	-----	-----	269	106
Netherlands	-----	18	-----	-----	-----	64	-----	-----	-----	2,688	2,770	1,082
Spain	344	-----	44	-----	73,566	-----	-----	73	-----	156	74,183	1,711
Sweden	-----	326	605	-----	-----	-----	-----	-----	-----	(1)	931	270
United Kingdom	-----	-----	1	93	(1)	-----	-----	13	-----	399	506	217
Other	34	21	249	50	68,684	50	8	-----	-----	1,209	70,305	2,352
Total	1,296	1,269	914	899	r 3,556,622	16,001	28,451	1,145	r 43,568	7,993	r 3,658,158	r 78,077
1969:												
Belgium-Luxembourg	-----	38	-----	-----	-----	-----	-----	11	-----	739	788	365
Canada	-----	-----	-----	-----	3,708,648	10	163	-----	236	38,499	3,747,556	56,256
Chile	-----	-----	-----	-----	-----	11,036	33,233	-----	1,500	-----	45,769	1,702
France	13	192	22	80	1,200	40	3,187	-----	14,451	1,402	20,587	940
Germany, West	-----	631	-----	477	69,496	228	2	384	20,732	2,030	93,980	3,290
Italy	871	-----	-----	-----	-----	-----	-----	209	12,408	52	13,540	1,040
Japan	-----	160	-----	265	-----	-----	-----	-----	-----	617	1,042	960
Netherlands	-----	16	-----	-----	-----	-----	-----	-----	-----	1,341	1,357	391
Spain	454	-----	85	-----	3,000	-----	-----	-----	-----	201	3,740	403
Sweden	-----	787	441	-----	-----	-----	-----	-----	-----	(1)	1,228	350
United Kingdom	-----	-----	-----	161	2	-----	-----	-----	-----	219	382	163
Other	-----	-----	121	52	46,869	-----	-----	-----	-----	1,352	48,394	1,174
Total	1,338	1,824	669	1,035	3,829,215	11,314	36,585	604	49,327	46,452	3,978,363	67,034

r Revised.
[1] Less than ½ unit.

WORLD REVIEW

Australia.—The Western Australia Government approved plans of Texada Mines Pty., Ltd., to develop the Lake McLeod potash deposits and the Cape Cuvier port facilities at a cost of over $13 million (Australian). Potash output reportedly will begin late in 1971. A proposal for at least 20 percent Australian equity will be submitted within 3 years.[4]

Table 13.—World production of marketable potash, by countries [1]

(Thousand short tons K_2O equivalent)

Country	1967	1968	1969 p
North America:			
Canada	2,383	2,918	3,146
United States	3,299	2,722	2,804
Europe:			
France	r 2,136	2,047	2,134
Germany:			
East	2,432	2,527	2,535
West	r 2,712	2,823	2,853
Italy	270	e 298	309
Spain	629	679	617
U.S.S.R.	3,161	3,439	3,505
Asia: Israel	331	403	408
Total [2]	r 17,353	17,856	18,311

e Estimate. p Preliminary. r Revised.
[1] Chile also produces potash-bearing materials as nitrate compounds; data on K_2O equivalent are not available, but quantity is relatively small.
[2] Totals are of listed figures.

Canada.—Seven potash mines were in production in Saskatchewan for all of 1969, two others were brought on stream during the year, and a 10th was planned for completion in 1970. The annual rated capacity of the nine operations was 6.92 million tons of equivalent K_2O. As a result of the U.S. Tariff Commission's investigation into dumping of Canadian potassium chloride in the United States and also because of oversupply, low prices, and uncertain marketing conditions, the Province of Saskatchewan proclaimed potash production and marketing would be controlled under the Mineral Resources Act of 1959. The regulations known as "The Potash Conservation Regulations, 1969", effective January 1, 1970, require producers to obtain licenses for potash production and disposal. The Minister of Mineral Resources, with guidance from a three-member Potash Conservation Board, may determine productive capacities, rates of production and disposal, prices, and other matters concerning potash. Specific regulations will be issued for each mine.[5] Reportedly, the price of muriate containing a minimum of 60 percent K_2O was determined at 31.25 cents per unit of equivalent K_2O.

Permission was temporarily denied by the Canadian Government for Hungarian and North American interests to exploit potash at Dundurn, Saskatchewan, at a cost of $60–$75 million. Hungary was to supply most of the labor and mining equipment to do the work.[6]

Texas Gulf Sulphur Co. acquired Homestake Mining Co.'s 40-percent ownership of Allan Potash Mines near Saskatoon, Saskatchewan. The remainder is owned by United States Borax & Chemical Corp. (40 percent) and Swift Canadian Co. (20 percent). The mine and related facilities were brought into operation in 1968 and have a designed capacity of 1.5 million tons of potassium chloride annually.

Congo (Brazzaville).—The new potash installation of Compagnie des Potasses du Congo at Holle, still in its break-in stage, was reported to be producing 2,000 metric tons of potash ore per day in October. The first 20,000 tons of potash was scheduled for shipment from the port of Pointe Noire, about 40 kilometers from Holle, in mid-October to either Bordeaux, France, or Antwerp, Belgium. Output is expected to reach 4,000 tons of ore per day by January 1970 and 5,600 tons per day by March. The plant uses flotation methods to separate the potash. The ore as mined contains 39 percent potash, the richest in the world; Canadian ore contains about 25 percent potash. Despite the favorable outlook, the mining operation reportedly has been slowed down because of unexpected irregularity of the potash beds and difficulty in operating the huge boring machines on gradients over 2 percent.[7]

Israel.—Eastern Europe was a major market for potash before the Arab-Israeli conflict of 1967, with 200,000 tons contracted annually to Poland alone. The loss

[4] Mining World (Australia). V. 5, No. 3, March 1969, p. 54.
[5] Koepke, W. E. Potash. The Canadian Mineral Industry in 1969, Preliminary. Mineral Resources Branch, Dept. of Energy, Mines, and Res. (Ottawa, Canada). Miner. Inf. Bull. MR 102, 1970, pp. 92–96.
[6] Fertilizer Feed and Pesticide Journal. Canadian Potash Veto. V. 66, No. 9, September 1969, p. 16.
[7] Bureau of Mines. Mineral Trade Notes. V. 66, No. 12, December 1969, p. 27.

of this market resulted in a surplus of 300,000 tons of fine-sized potash remaining from 1967 output which, reportedly, will have to be partially reprocessed before marketing. Currently, the output is the granulated variety which is readily marketable. Plant expansion underway at the Dead Sea Works will increase production to 1 million tons by 1970 and 1.2 million tons by 1971. The latter output, valued at U.S. $20 million, is expected to show a profit even at currently low prices.[8]

United Kingdom.—The United Kingdom may soon become an exporter of potash if current plans materialize. Three British groups will spend about $200 million to produce 3 million tons of potash annually by the mid-1970's, or four times the 1968 consumption. Cleveland Potash, jointly owned by Imperial Chemical Industries, Ltd., and Charter Consolidated, Ltd., hopes to produce potash in the Cleveland area (between Whitby and Teeside) by 1973 with a capacity up to 1.5 million tons annually. The potash deposit, discovered while drilling for oil before World War II, is 70 feet thick although 4,000 feet deep. Rio Tinto-Zinc Corp., Ltd., proposes a plant in the same area to produce 1 million tons of potash annually. Shellstar Ltd., wholly owned by Royal Dutch/Shell, also has a proposal for starting a 450,000-ton potash mine, the original proposal specifying solution mining; Armour Chemical Industries, Ltd., has retained an interest in this venture.[9]

U.S.S.R.—Output of marketable potash by Soviet Russia reportedly will be quadrupled between 1968 and 1972 as a result of a crash program. The U.S.S.R. and Canada are the only countries which have almost unlimited reserves of high-grade potash. The four principal potash deposits in the Soviet Union are Solikamsk-Berezniki, north Urals (north Kama Basin); Kalush and Stebnikov, western Ukraine; and Soligorsk, Belorussia. The north Urals deposit, discovered in 1926, currently extends over 1,800 square miles. The Ukraine deposits, exploited long before World War II, are near the Carpathian Mountains. The Belorussia deposit at Soligorsk, which came into production in 1963–64, is near the Baltic Sea. Potash exports in 1967, totaling 1.37 million tons, were shipped to almost 20 countries, the largest quantities going to Japan, Yugoslavia, Italy, and Belgium.[10]

TECHNOLOGY

Solution mining experiments were conducted using a 2-foot-thick layer of sylvinite, 1,150 feet below surface and deposited between layers of halite, in the Carlsbad, N. Mex. area.[11] Three wells forming an equilateral triangle and a center well located 200 feet from the apex wells were drilled, and a hydraulic fracture, similar to those used in oilfields, was started in the center hole about 1 foot below the potash. The fracture connected all holes within a few minutes. It migrated downward, however, about 8 feet, forming a wedge-shaped body of halite between the center well and the apex well chosen for the two-well mining test. Solution mining was done from an injection well in three steps. The wedge-shaped body of halite beneath the potash ore was dissolved in the first step; the layer of potash was then mined; and some halite above the potash was removed in the third step to demonstrate that all of the potash was mined. A total of 8,100 tons of halite and 1,450 tons of KCl were produced in the first two operations, with an average of almost 80 pounds of ore per barrel of water injected. Production of 1,500 tons of halite and 150 tons of KCl occurred in the third step.

Crawler-mounted continuous boring machines, crawler-mounted gathering-arm loaders, shuttle cars, and a belt conveyor were used by International Minerals & Chemical Corp. (Canada), Ltd., for driving its underground multiple-tunnel connection between the K–1 production shaft and new K–2 shaft at Esterhazy, Sas-

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[8] Bureau of Mines. Mineral Trade Notes. V. 66, No. 9, September 1969, p. 18.

[9] Oil, Paint and Drug Reporter. Potash Turn-About for Britian: One of World's Big Importers Likely To Become Big Exporter. V. 196, No. 5, Aug. 4, 1969, pp. 5, 51.

[10] Turcotte, R. F. Soviet Potash Industry. Foreign Trade (Dept. of Trade and Commerce, Ottawa, Canada), v. 131, No. 4, Feb. 15, 1969, pp. 24–26.

[11] Davis, J. C., and D. A. Shock. Solution Mining of Thin Bedded Potash. AIME Soc. Min. Eng., Preprint 69–AS–15, February 1969, 12 pp.

katschewan in 1964–66.[12] The headings, starting in the mine workings of K–1 shaft more than 3,100 feet below the surface, were driven for a distance of 38,000 feet in sylvinite to intersect K–2 shaft, which was being sunk from surface. The continuous borer is capable of cutting openings 21 feet wide by 7.5 feet high, advancing 15 inches per minute on a full face, and mining 350 tons of ore per hour. Each loader can fill 15-ton-capacity shuttle cars at the rate of 15 tons per minute; the shuttle cars in turn haul the ore to a belt conveyor rated at 600 tons per hour for transportation to the shaft. Currently, the firm's Esterhazy mining operations are highly mechanized, and the output of ore through two shafts reaches 30,000 tons per day.

Completion of Sylvite of Canada's potash facilities, the ninth firm entering the Canadian potash mining industry, was being expedited in 1970.[13] By June 1969 sinking of the two vertical shafts, 515 feet apart, was beyond the hazardous Blairmore Formation which is the major source of high-pressure water and is located 1,214 to 1,490 feet below surface. The perimeter area around each shaft was frozen solidly to a depth of 1,500 feet by 24 freeze holes using refrigerant from a 330-ton refrigeration plant. Shaft sinking in the first 1,490 feet from the surface was done with paving breakers and a Cryderman mucker to prevent rupturing the freeze pipes by blasting. However, regular drilling and blasting techniques were employed below the Blairmore Formation. Sinking and lining techniques were used simultaneously in advancing the shafts. Single-sheet steel with concrete was used to line the shafts down to the Blairmore Formation; concrete with cast-iron tubing was used through the Blairmore high-pressure water formation, below which concrete alone and concrete with ductile cast-iron tubing were used where needed. A cathodic protection-system was installed in each shaft to reduce the corrosion of the metal linings. Ore will be mined by the room-and-pillar method, employing rotor borers for cutting the ore. Conveyors will be used for transporting the ore to a storage silo at the shaft. The ore will be hoisted to the surface in 24-ton-capacity skips which travel 1,800 feet per minute. Plant facilities on the surface are designed to handle 2 million tons of ore and produce 1 million tons of finished product annually.

Five different grouts for stopping some of the water flows encountered during potash-mine shaft-sinking operations in Saskatchewan together with grouting procedures and the theory of grouting were developed.[14]

A comprehensive report on Saskatchewan plant engineering was published.[15] The report discusses and comments on the selection of hoists and headframes, general plant layouts, material handling and storage, construction materials, and various phases of the ore processing operations such as sizing, removal of clay, conditioning and flotation, product purification, and waste products.

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[12] Sadler, J. F., and E. M. Berthelsen. The Tunnel Connection of Two Shafts Using Continuous Boring Machines. Canadian Min. and Met. Bull. (CIM), v. 62, No. 691, November 1969, pp. 1186–1192.

[13] Western Miner. Sylvite Prepares for Potash Production in 1970. V. 42, No. 11, November 1969, pp. 28, 30–31.

[14] Annett, S. R. The Chemical and Physical Aspects of Grouting Potash Mine Shafts. Canadian Min. and Met. Bull. (CIM), v. 62, No. 687, July 1969, pp. 715–721.

[15] Crocker, B. S., J. T. Dew, and R. J. Roach. Contemporary Potash Plant Engineering. Canadian Min. and Met. Bull. (CIM), v. 62, No. 687, July 1969, pp. 729–741.

Pumice

By John G. Parker [1]

Sales and consumption of pumice by domestic producers amounted to 3.6 million tons valued at $5.0 million in 1969. This represents an increase of 2 percent in quantity but a decrease of 9 percent in value compared with production in 1968.

DOMESTIC PRODUCTION

In 1969, production was from 172 mines operated by 143 firms, individuals, and Governmental agencies in 16 States and American Samoa. With 26 active mines and 23 percent of domestic output, Arizona was the leading producer for the ninth consecutive year. Arizona's output however, was down from that in 1968. California, Oregon, and Colorado reported increased output. California had the largest number of active mines—41—followed by Oregon with 37; each State had a 22-percent share of the national output. Production in American Samoa came from one mine operated by the Samoan Government. Volcanic cinder composed 83 percent of U.S. output. Only volcanic cinder was produced in Colorado, Montana, Oklahoma, and American Samoa.

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Table 1.—Pumice, pumicite, and volcanic cinder sold or used by producers in the United States [1]

(Thousand short tons and thousand dollars)

Year	Pumice and pumicite		Volcanic cinder		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1965	483	$2,442	2,888	$4,108	3,371	$6,550
1966	549	2,629	2,669	4,136	3,218	6,765
1967	776	1,446	2,670	3,685	3,446	5,131
1968	481	1,360	3,049	4,210	3,530	5,570
1969	598	1,349	3,011	3,701	3,609	5,050

[1] Values 1965–66 f.o.b. mine or grinding plant, values 1967–69 f.o.b. mine.

Table 2.—Pumice, pumicite, and volcanic cinder sold or used by producers in the United States, by States

(Thousand short tons and thousand dollars)

State	1968		1969	
	Quantity	Value	Quantity	Value
Arizona	1,033	$974	910	$814
California	776	1,312	866	1,229
Colorado	28	234	42	232
Hawaii	408	724	403	783
Idaho	135	259	21	62
Kansas	11	10	W	W
Montana	93	327	134	102
Nevada	62	144	83	188
New Mexico	243	527	226	415
Oregon	725	977	875	1,139
Utah	8	19	10	21
Other States [1]	8	62	39	66
Total [2]	3,530	5,570	3,609	5,050
American Samoa	21	51	2	5

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Kansas (1969), Nebraska, Oklahoma, Texas, Washington, and Wyoming (1969).
[2] Data may not add to totals shown because of independent rounding.

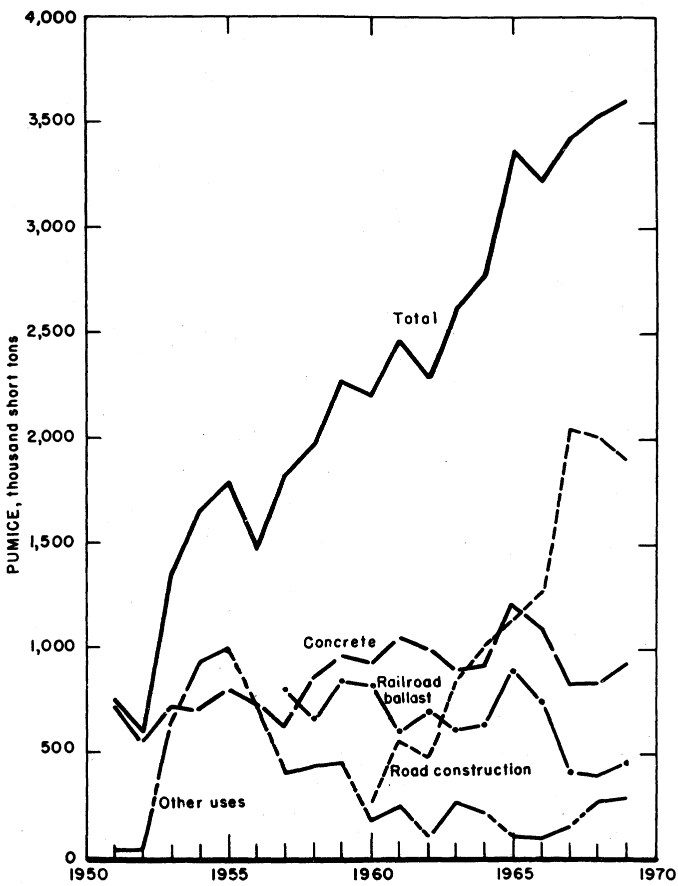

Figure 1.—Pumice sold or used by producers in the United States, by uses.

CONSUMPTION AND USES

Road construction accounted for 53 percent of the domestic pumice consumption of 3.6 million tons; concrete admixtures and aggregates, 26 percent; railroad ballast, 13 percent; and abrasive materials and miscellaneous uses, 8 percent. Compared with consumption the previous year, use in concrete increased 12 percent and that in railroad ballast, 17 percent.

Table 3.—Pumice, pumicite, and volcanic cinder sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1968		1969	
	Quantity	Value	Quantity	Value
Abrasive—Cleaning and scouring compounds	13	$55	14	$19
Concrete admixture and concrete aggregate	839	1,711	937	1,852
Railroad ballast	397	356	463	377
Road construction (includes ice control and maintenance)	2,007	2,417	1,912	1,910
Other uses [1]	275	1,032	283	892
Total [2]	3,530	5,570	3,609	5,050

[1] Includes miscellaneous abrasive uses, asphalt, heat- or cold-insulating medium, landscaping, roofing, and miscellaneous uses.

[2] Data may not add to totals shown because of independent rounding.

PRICES

The average value of crude pumice sold or used remained at $1.11 per ton in 1969; the price for prepared pumice decreased from $2.36 per ton to $1.85. The weighted average value of the two types of pumice decreased from $1.58 per ton in 1968 to $1.40. The average 1969 price per ton for pumice used in cleaning and scouring compounds was $1.41, a decrease of $2.85 from the 1968 price; for concrete admixtures and aggregates, $1.98, a $0.06 decrease; for railroad ballast, $0.81, a $0.09 decrease; for road construction, $1.00, a $0.20 decrease; and for other uses, including landscaping and roofing, $3.15, a $0.61 decrease.

Prices were quoted nominally in trade publications. Quotations in Oil, Paint and Drug Reporter were changed on August 4. Following are the current quotations per pound, bags, in ton lots: Domestic, fine, $0.0460 to $0.0487; domestic, medium, $0.0510; domestic, coarse, $0.0460; imported (Italian), silk-screened, coarse, $0.06 to $0.076; fine, imported, $0.05; and, bagged, imported (Italian), sun dried, fine and coarse, $91 per ton, unchanged from 1968.

Engineering and Mining Journal quoted the following prices for pumice stone per pound, in barrels, f.o.b. New York or Chicago: Powdered, $0.035 to $0.06, and lump, $0.06 to $0.08. These prices are the same as those in 1968.

FOREIGN TRADE

Exports of 533 short tons to 13 countries were 15 percent less than exports in 1968, but their total value increased.

Table 4.—U.S. exports of pumice

Year	Short tons	Value (thousands)
1966	298	$66
1967	343	64
1968	624	54
1969	533	NA

NA Not available.

Pumice imports of more than 384,000 tons were about 23 percent greater than those in 1968, due primarily to an increase of 75,000 tons (25 percent) in pumice used in the manufacture of concrete masonry. Most of the imports were from Greece and Italy. Imports classed as crude or unmanufactured declined 1,012 tons (11 percent) from 1968 to 8,424 tons, and pumice classed as wholly or partly manufactured decreased 61 percent to 1,255 tons.

Table 5.—U.S. imports for consumption of pumice, by class and countries

Country	Crude or unmanufactured		Wholly or partly manufactured		Used in the manufacture of concrete masonry products		Manufactured, n.s.p.f.
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Value (thousands)
1968:							
Austria	---	---	2	$5	---	---	---
Greece	---	---	---	---	184,080	$367	---
Italy	9,436	$69	3,189	116	114,969	248	$11
Other countries [1]	---	---	---	---	---	---	6
Total	9,436	69	3,191	121	299,049	615	17
1969:							
Austria	---	---	4	15	---	---	19
Greece	---	---	---	---	203,977	381	---
Italy	8,424	81	1,250	34	170,629	388	20
Other countries [2]	---	---	1	1	---	---	22
Total	8,424	81	1,255	50	374,606	769	61

[1] Canada, Hong Kong, United Kingdom, and West Germany.

[2] Canada, Hong Kong, Japan, Malagasy Republic, Mexico, and West Germany.

Pumice stone, TSUS No. 519.05, for use in concrete products, continued to be admitted into the United States duty-free. The duty on other pumice products was again reduced on January 1, 1970, in accordance with "Kennedy round" agreements. Duties were as follows: TSUS No. 519.11, crude or crushed pumice, value not over $15 per ton, 0.029 cents per pound; TSUS No. 519.14, crude or crushed pumice, value over $15 per ton, 0.055 cents per pound; TSUS No. 519.31, grains or ground, pulverized or refined, 0.24 cents per pound; and TSUS Nos. 519.93 and 523.61, millstones, abrasive wheels, and abrasive articles, n.s.p.f., and articles, n.s.p.f., 9.5 percent ad valorem.

WORLD PRODUCTION

Table 6.—World production of pumice and related volcanic materials by countries

(Short tons)

Country [1]	1967	1968	1969 [p]
Argentina [2]	4,891	10,906	12,125
Austria: Pozzolan	24,950	20,252	22,000
Cape Verde Islands: Pozzolan	8,807	9,000	9,920
Chile: Pozzolan	147,905	172,391	193,141
Dominica	NA	NA	61,270
France:			
Pumice	690	650	650
Pozzolan and lapilli	[r] 797,395	[e] 661,400	661,400
Germany, West (marketable)	[r] 4,559,154	3,924,224	3,278,300
Greece:			
Pumice	[r] 250,886	311,954	425,500
Pozzolan	[r] 496,976	523,597	617,300
Guadeloupe: Tuff (pozzolanic) [3]	26,455	35,274	38,580
Guatemala: Volcanic ash (for cement)	[r] 48,817	46,297	49,600
Italy:			
Pumice	[r] 546,028	701,731	[2] 661,400
Pumicite [e]	220,500	100,300	110,200
Pozzolan	[r] 4,716,564	4,661,346	4,629,700
Kenya	134	-----	-----
Martinique: Pumice [3,4]	[r] 16,535	16,502	19,841
New Zealand	18,081	18,273	18,200
Spain [5]	120,454	186,513	187,400
United Arab Republic [e,6]	4,630	5,200	5,500
United States (sold or used by producers):			
Pumice and pumicite	776,388	481,345	598,087
Volcanic cinder [7]	2,697,913	3,069,584	3,012,427
Total [8]	[r] 15,484,153	14,956,739	14,612,541

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.

[1] Pumice is also produced in Iceland, Iran, Japan, Mexico, Turkey, and the U.S.S.R. (sizable quantity), but data on production are not available. Japan's last available output figure was 110,000 tons in 1958.

[2] Unspecified volcanic materials produced mainly for use in construction products.

[3] Data converted from cubic meters on basis of estimated specific gravity of 1.0 for pumice and tuff.

[4] Output of material previously reported as tuff may actually represent calcareous tufa, and has been omitted pending clarification by source.

[5] Includes Canary Islands.

[6] Estimated on basis of 1 cubic meter = 1,300 pounds.

[7] Includes American Samoa.

[8] Total is of listed figures only.

Rare-Earth Minerals and Metals

By John G. Parker [1]

Output in 1969 of bastnaesite and monazite expressed as contained rare-earth oxides (REO) rose about 17 percent over that of 1968. Bastnaesite concentrate production in California increased nearly 20 percent. World production of bastnaesite and monazite mineral concentrate as REO rose over 25 percent. A 30-percent increase in apparent domestic industrial consumption during 1969, to over 8,800 tons REO equivalent valued at nearly $19 million, was due largely to increased use in petroleum cracking catalysts and in glass polishing powders. Applications in color television phosphors increased, after the recent low in 1968. Sales of yttrium oxide and europium oxide, although still relatively small in quantity, formed over one-third of the value of total shipments of REO from chemical processors.

Legislation and Government Programs.—The conventional war stockpile objective was raised on March 27 under Stockpile Objective Action 303 from 3,000 to 6,500 short dry tons (SDT) of contained rare-earth oxide. All the materials retained by the General Services Administration (GSA) in the strategic (national) and supplemental stockpiles were in the form of bastnaesite, monazite, rare-earth chloride, and rare-earth sodium sulfate. Of the total 13,521 SDT held at yearend, the supplemental stockpile contained 3,517 SDT, all as rare-earth sodium sulfate. GSA sold only rare-earth sodium sulfate during the year from the stockpile, as authorized in November 1967.

The depletion allowances for domestic and foreign mining of monazite (a rare-earth and thorium ore mineral) were lowered from 23 to 22 percent and from 15 to 14 percent, respectively. Those for mining other rare-earth minerals from domestic and foreign sites were lowered from 15 to 14 percent. The new rates were effective with taxable years beginning after October 9, 1969.

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DOMESTIC PRODUCTION

Concentrate.—Production (contained REO) as measured by output of bastnaesite and shipments of monazite increased about 17 percent in 1969. The Mountain Pass, Calif., mine and mill of Molybdenum Corporation of America (Molycorp), operating at about 55 percent of its 25,000 ton annual capacity, produced 13,650 tons of REO in bastnaesite concentrates from 259,000 tons of ore.[2] The concentrate output was an increase of nearly 20 percent over that in the previous year. Shipments of concentrate, however, were about 25 percent less than in the previous year. The company announced that proven reserves at Mountain Pass were 3.3 million tons, containing about 8.2 percent REO (about 271,000 tons REO), plus substantially larger quantities inferred by more widely spaced drilling.

The firm also contracted with Republic Steel Corp. for exclusive purchase rights to heavy rare-earth and yttrium concentrates which may be recovered from tailings at Republic's iron ore property at Mineville, N.Y.

Production of byproduct monazite from titaniferous-zirconiferous alluvial deposits owned by E. I. du Pont de Nemours & Co., Inc., at Folkston, Ga., and worked by Humphreys Mining Co. was almost 10 percent greater than in 1968. On the other

[2] Molybdenum Corporation of America. 1969 Annual Report. Mar. 26, 1970, 12 pp.

hand, the small output of a low-grade monazite byproduct resulting from operations of American Metal Climax, Inc., at its Climax, Colo., mine was only about one-fifth of that in 1968.

Michigan Chemical Corp., Chicago, Ill., retained on a standby basis the mining and concentrating operation in Bear Valley, Idaho, bought from Porter Bros. Corp. in 1966.

Compounds and Metals.—At Mountain Pass, the solvent extraction unit of Molycorp produced about 2-1/3 times as much purified europium oxide as in 1968. This reflected an increased need for the material and for yttrium oxide by color television phosphor manufacturers. Shipments of lanthanum and rare-earth chlorides, made by Molycorp at York, Pa., W. R. Grace, Davison Chemical Division, at Chattanooga, Tenn., and by American Potash & Chemical Corp., a division of Kerr-McGee Corp., at West Chicago, Ill., indicated a continued large use of these materials for petroleum cracking catalysts. Besides Molycorp, the larger chemical processors of rare-earth minerals, including bastnaesite and monazite, were American Potash & Chemical Corp. and W. R. Grace, Chattanooga, Tenn., and Pompton Plains, N.J.

High-purity rare-earth and yttrium oxides were produced in Molycorp's solvent extraction plant at Louviers, Colo., American Potash & Chemical Corp., Michigan Chemical Corp., St. Louis, Mich., and by Research Chemicals, Division of Nuclear Corporation of America, Phoenix, Ariz. Smaller producers of rare-earth compounds were as follows: Atomergic Chemetals Co., Division of Gallard-Schlesinger Chemical Manufacturing Corp., Carle Place, N.Y., and Transelco Inc., Penn Yan, N.Y. Rare-earth silicon compounds, used as metal additives, were made by Molycorp, Washington, Pa., and by Union Carbide Corp., Alloy, W. Va.

Ronson Metals Corp., Newark, N.J., and American Metallurgical Products Co. Inc., New Castle, Pa., were the only two domestic producers of misch metal, most of which was used to make lighter flints. Producers of higher purity rare-earth metals included American Potash, Lunex Co., Pleasant Valley, Iowa, Michigan Chemical, Nuclear Corp., and Ronson. Yttrium metal was made by Lunex, Michigan Chemical, and Nuclear Corp.

CONSUMPTION AND USES

Rare-earth chemical processors consumed about 23 percent more bastnaesite, but twice as much monazite concentrate as in 1968.

Shipments from chemical processors to domestic consumers indicated that apparent consumption of rare-earth chemicals and compounds was about 8,820 tons REO, an increase of 30 percent over the previous year. The value of shipments was nearly $19 million, over 50 percent greater than in 1968.

A breakdown of uses, based largely on information from processors and on actual data from certain consumers, showed that the largest use, quantitatively, as chlorides and hydrates, was in petroleum cracking catalysts. This usage increased 30 percent and formed almost 60 percent of the total. The second largest use, that of oxides in glass polishing, accounted for over 20 percent. The use of rare-earth compounds, such as hydrates and smaller quantities of misch metal, in steel and ductile iron was third, with about 8 percent of the total. The foregoing use of misch metal is about one-third of the total use of that alloy, which is made from rare-earth chloride; the other two-thirds, mixed with iron, goes into the manufacture of ferrocerium lighter flints. Misch metal production, glass additives employing cerium hydrate, and arc light carbons made from oxides and fluorides, account for smaller known uses of rare-earth compounds. Although the estimated use of higher purity rare-earth and yttrium compounds (usually the oxides) in phosphors and electronics accounted for less than 1 percent quantitatively, the value comprised over one-third of the total value of shipments. For example, the value of about 50 tons of yttrium oxide shipments was nearly $3.7 million, with the value of much smaller quantities of europium oxide not being significantly less. Research and development and other uses, such as magnesium alloys, superalloys, and ceramic tile colors, accounted for the remainder of total rare-earth usage.

Misch metal shipments were nearly 30 percent lower than they were in 1968; those of higher purity metals were over 50 percent lower.

The use of europium oxide in color television phosphors, based on shipments, was about three times that in 1968. The oxide is used as an activator in yttrium orthovanadate, yttrium oxide, and gadolinium oxide hosts. The latter phosphor, recently developed, was stated to be 20 to 70 percent brighter than other red television phosphors and was priced at $154.60 per pound.[3] The luminescent properties of rare-earth phosphors have led to their increasing use in lamps. Street lights with rare-earth filaments were said to produce four times as much illumination per money expended as ordinary incandescent lamps.

Rare-earth elements are used in crystalline, glass, and liquid lasing hosts. Neodymium is the most commonly used rare-earth element in lasers. A recently developed neodymium-doped phosphorous oxychloride is a nonorganic, hydrogen-free, liquid laser, priced at $500 per liter. Yttrium and gadolinium are components of synthetic iron garnets and aluminum garnets used increasingly for microwave filtration and control.

Rare-earth oxides are used to polish eyeglasses, mirrors, television tubes, and camera lenses but are losing ground in the finishing of flat glass. The Pilkington float glass process eliminates the need for final polishing. Also, certain rare-earth oxides are used as glass additives. For example, cerium oxide is added to glass as a decolorant, holmium exhibits strong blue absorption, and others, such as those of neodymium, praseodymium, and erbium act as colorants, contributing purple and wine red, green, and pink colors to glass. Yellow ceramic tiles composed of mixtures of praseodymium oxide and zirconium dioxide are receiving increased usage. Lanthanum oxide has long been used as an additive to camera lenses to increase the refractive indices and decrease the dispersion of the glass. Yttrium oxide is used as a structure stabilizer for zirconium dioxide in refractory applications.

Carbon-arc electrodes, to which have been added rare-earth oxides and fluorides, emit brilliant white light, making them indispensable in military searchlights and in color motion picture photography and projection.

Although the largest use of misch metal is still in the production of lighter flints, some is being employed along with other rare-earth material to prevent carbide formation and promote nodularity, and therefore ductility, in cast iron. Misch metal, rare-earth silicides, and master alloys containing rare-earth metals, can be beneficial when added to steels, although they can also have a deleterious effect. They do remove sulfur, by promoting globular sulfidization, and improve oxidation and mechanical properties. Careful process control is required, however, because excess quantities increase brittleness and lower the strengths of the steels.

A samarium-cobalt magnet, the strongest known permanent magnet material, was called one of the most significant new technical products of 1969. It is six times as strong as ferrite magnets, four times as strong as most alnico magnets, and twice as strong as those using platinum and cobalt. The components are cheaper than those of platinum-cobalt and can replace platinum, which is an expensive element obtained principally from the U.S.S.R. and the Republic of South Africa.

[3] American Metal Market. New Rare Earth Red Phosphor Developed for TV Picture Tube Manufacturers. V. 76, No. 35, Feb. 24, 1969, p. 22.

STOCKS

Monazite concentrates held by two chemical processing firms at yearend were 45 percent greater than at the end of 1968; bastnaesite held by the domestic miner of the mineral and by two other chemical processors was 30 percent lower. Stocks of rare-earth sodium sulfate, an intermediate product used by one chemical processor, were nearly four times higher at the end of 1969 than at yearend 1968. Yttrium oxide stocks held by seven firms were about 80 percent higher than at yearend 1968; europium oxide stocks in the hands of two companies were 5 percent lower. Misch metal stocks, mostly held by the two principal domestic producers, were 13 percent lower at yearend; higher purity metals held by five firms were 53 percent higher.

PRICES

Prices in the United States for large lots of monazite were quoted periodically in Metals Week at $180 to $200 per long ton, nominal. Unleached bastnaesite, with 55 to 60 percent REO, was quoted in ton and carload lots of 30 cents per pound of contained REO. Similarly, leached bastnaesite with 68 to 72 percent REO, remained at 35 cents per pound, and calcined bastnaesite, with 85 to 90 percent REO, at 40 cents per pound of contained REO. Concentrates recovered from bastnaesite were priced as follows: Rare-earth oxide, 88 to 92 percent REO, 45 cents per pound of contained REO; lanthanum-rare-earth hydrate, 65 to 70 percent REO, 50 cents per pound; and samarium-gadolinium, 60 to 65 percent REO, in 250 pound drums, $3.50 per pound of contained REO.

Australian monazite with a minimum of 55 percent REO quoted in Industrial Minerals for the London market, increased in October from £65 ($156)—£75 ($180) per long ton, C.I.F. to £70 ($168)—£80 ($192). Prices for monazite quoted in Metal Bulletin (London) rose from £70 ($168)—£75 ($180) per long ton early in 1969 to £75 ($180)—£85 ($204) in April. Also, Malaysian xenotime concentrate with a minimum of 25 percent yttrium oxide (Y_2O_3) content decreased early in the year on the London market from $3 to $5 per pound Y_2O_3 to $2 to $4 and then to $2 to $3 in October.

Prices from one firm on some low-grade (commercial chemicals) rare-earth compounds in lot sizes up to 100 pounds were as follows: Rare-earth and didymium chlorides, 36 cents to 55 cents per pound; rare-earth and didymium fluorides, $1 to $1.55 per pound; ceric oxide, $1.80 to $1.90 per pound; rare-earth oxide, $1.50 to $2.25 per pound; didymium oxide, $1.30 to $1.95 per pound; neodymium oxide, $2.60 to $4.50 per pound; and praseodymium oxide, $16 to $17 per pound.

Prices for optical-grade ceric oxide in lot sizes of 50 pounds or more, delivered in bags, remained at $1.85 to $1.90 per pound; for cerium hydrate in lots of 100 pounds or more, 74 percent CeO_2, $1.40 per pound, and 77 percent CeO_2, $1.74 per pound.[4] Molycorp lowered contract prices on some of its 15 pure rare-earth oxides by 10 to 20 percent. For example, buyers could order on an annual basis 600 pounds of europium oxide at $475 per pound, 7,500 pounds of praseodymium oxide at $14.75 per pound, or 12,000 pounds of gadolinium oxide at $50 per pound. Michigan Chemical Corp. reduced its price for phosphor-grade yttrium oxide. In lots of 12,000 pounds or more, the price was $35 per pound; 1,000 pounds to 11,999 pounds, $39 per pound; and in lesser quantities, $43 per pound. Prices on purified oxides are shown in table 1.

Table 1.—Prices of high-purity oxides in 1969

Oxide [1]	Price, per pound
Cerium	$1.25– $275.00
Europium [2]	475.00–1,900.00
Gadolinium	50.00– 500.00
Lanthanum	4.25– 200.00
Lutetium	3,000.00–4,500.00
Neodymium	3.50– 295.00
Praseodymium	14.75– 330.00
Samarium	35.00– 150.00
Yttrium [3]	30.00– 500.00

[1] In various size lots (usually minimum 1 pound) and purities from five domestic producers. A number of the higher prices are for 99.999 percent or purer oxides.
[2] Europium oxide, 99.99 percent pure, sold at $35 per ounce.
[3] With one company, yttrium oxide, refractory grade, was the lowest priced; crystal, the highest. The highest price shown was for 99.9999 percent pure yttrium oxide.

Quoted prices on 1 pound ingots in 50- to 100-pound lots of 97-percent-pure didymium metal, 99.9-percent-pure misch metal and cerium-free misch metal, remained at $15, $3, and $5, respectively.

High-purity rare-earth metals were available as ingot, powder, chips, or distilled. In general, the ingots were lower priced. Research Chemicals issued a new price list with some of the metals being shown in table 2.

Table 2.—Prices of high-purity metals in 1969

Metal ingot [1]	Price, per pound
Cerium and lanthanum	$50– $120
Neodymium	100– 160
Samarium	135– 195
Dysprosium	140– 340
Yttrium	145– 200
Praseodymium	170– 225
Gadolinium	220– 280
Europium	2,700–3,400
Lutetium	6,500–8,350

[1] Minimum 1 pound, produced from 99.9 percent grade oxide.

Cerium metal, 99-percent pure, delivered in the United Kingdom, remained at £7 ($16.80) per pound, nominal.

[4] Oil, Paint and Drug Reporter. Current Prices of Chemicals and Related Materials. V. 195, Nos. 1–26, Jan. 6–June 30, 1969; V. 196, Nos. 1–26, July 7–Dec. 29, 1969.

FOREIGN TRADE

Exports of ferrocerium and other pyrophoric alloys to the United Kingdom, Canada, Australia, Mexico, Hong Kong, and other countries totaled 103,169 pounds worth $350,586, a quantitative increase of 15 percent. The average unit value of $3.40 per pound was 3 cents more than that of 1968.

Imports of monazite sand concentrate were only slightly less than in the previous year and came mostly from Australia and Malaysia (table 3).

Cerium oxide imports, predominantly from Belgium-Luxembourg and also from Austria and Switzerland, more than doubled to 22,049 pounds valued at $7,312. Only the small quantity from Switzerland had a high unit value indicative of special high-purity oxides. Also, it was reported that Austria shipped to the United States 965 pounds of cerium chloride worth $1,356. Other cerium compounds, n.s.p.f., from West Germany and Austria totaled only 617 pounds valued at $3,488, a considerable decrease in quantity but an increase in unit value from those imports in 1968.

Imports of rare-earth metals are shown in table 4. Those imported from West Germany in 1967 and 1968 had low unit values, which led to the suspicion that they were low-value alloys. Reported imports of low-value alloys (including misch metal) totaling 22,377 pounds valued at $8,024 from West Germany also are suspect. The unit value is much lower than that of shipments from West Germany in previous years and lower than quoted misch metal prices. Ferrocerium and other pyrophoric alloys totaling 17,328 pounds worth $91,288 were received from Japan (over 80 percent of quantity and 86 percent of value), West Germany, the United Kingdom, Austria, France, and Switzerland. These imports quantitatively were only about 75 percent of those received from the six countries in 1968. The unit value, $5.27 per pound, was more than that for 1968 owing principally to the higher value of the Japanese material.

Table 3.—U.S. imports for consumption of monazite, by countries

Country	1965		1966		1967		1968		1969	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Australia	1,278	$111	1,542	$176	1,540	$195	2,810	$369	2,478	$300
Brazil	64	6	---	---	---	---	---	---	---	---
Ceylon	141	14	---	---	---	---	---	---	---	---
Germany, West	---	---	---	---	24	4	24	4	---	---
Hong Kong	---	---	---	---	---	---	---	---	167	20
Indonesia	---	---	---	---	72	13	---	---	---	---
Korea, Republic of	22	2	---	---	49	7	---	---	---	---
Malaysia	447	50	785	92	273	38	1,514	188	1,561	174
Nigeria	76	6	---	---	133	13	19	2	---	---
South Africa, Republic of	---	---	115	9	---	---	---	---	---	---
Total	2,028	189	2,442	277	2,091	270	4,367	563	4,206	494
ThO_2 content [e]	120	XX	145	XX	125	XX	262	XX	252	XX

[e] Estimate. XX Not applicable.

Table 4.—U.S. imports for consumption of rare-earth metals

(Including scandium and yttrium)

Country	1967		1968		1969	
	Pounds	Value	Pounds	Value	Pounds	Value
Germany, West	11,023	$13,396	3,355	$13,516	---	---
Japan	---	---	5	1,070	254	$22,916
U.S.S.R.	34	11,012	7	5,952	33	10,585
United Kingdom	9	5,744	7	5,131	6	6,312
Total	11,066	30,152	3,374	25,669	293	39,813

WORLD REVIEW

Australia.—Production of monazite concentrate during the first 6 months of 1969 was 2,154 short tons, with an average grade of 90 percent monazite.[5] Ilmenite mines in Western Australia accounted for 82 percent of this production; the rest was byproduct of rutile and zircon production along the east coast in Queensland and in New South Wales. Although most of the monazite concentrate was exported, some was processed locally and offered as a rare-earth hydrate.

Brazil.—Besides being a producer of monazite, Brazil also processed monazite to rare-earth chloride (2,175 tons), carbonate (21 tons), and oxide (21 tons). An undisclosed quantity of misch metal also was produced.

Burundi.—Production for the 3 years 1967 through 1969 of bastnaesite concentrate containing 68 to 70 percent rare-earth oxide was 331, 579, and 661 short tons, respectively. The one mine at Karonge in Bujumbura Province is operated by Société Minerale de Karonge (SOMIKA). This is believed to be the only free-world production of bastnaesite outside of the United States. Although several hundred tons of bastnaesite were shipped from deposits in Malawi and Malagasy Republic, these mines were reportedly inactive at yearend.[6]

Table 5.—World production of monazite concentrates, by country

(Short tons)

Country[1]	1967	1968	1969 p
Australia	r 2,590	2,287	4,250
Brazil	1,189	1,202	2,203
Ceylon	22	46	62
India	e 2,900	e 2,900	3,850
Korea, South	14	NA	NA
Malagasy Republic	28	2	NA
Malaysia	[2] 1,060	[2] 2,356	2,400
Nigeria [3]	126	7	14
Thailand	---	44	72
Total [4]	7,929	8,844	12,851

e Estimate. p Preliminary. r Revised.
NA Not available.
[1] United States production data withheld to avoid disclosing individual company confidential data. Monazite is produced in Indonesia, North Korea, and the Congo (Kinshasa), but quantities are insignificant or not available.
[2] Exports.
[3] Year ended March 31 of year following that stated.
[4] Totals are of listed figures only.

Canada.—Production of yttrium oxide from uranium milling continued to decline, dropping in 1969 to 86,127 pounds valued at $625,000, compared with 1968 production of 111,326 pounds valued at $865,000.

Finland.—Reports indicate that light rare-earth oxides will be recovered by Typpi Oy, Oulu, from Kola apatite residues at a potential rate of 400 tons of rare-earth oxide per year.[7]

India.—Construction during 1969 advanced on the new Chavara sand treatment plant in Kerala State, which will have an annual output of 645 short tons of monazite, along with 110,000 short tons of ilmenite, 6,450 short tons of rutile, and 7,700 short tons of zircon.[8]

A modern production record of 3,850 short tons of monazite was reported for 1969. The concentrate was processed at the Alwaye plant, Kerala State, of Indian Rare Earths Ltd. to produce rare-earth chlorides, oxides, fluorides, and nitrates. Europium and yttrium compounds were produced on a small scale. Most of the rare-earth production was exported to European, Japanese and United States markets.

Japan.—Output of high-purity cerium was 255,700 pounds. Shin-Etsu Chemical Industry Co. Ltd. entered into an agreement with Molycorp to produce the heavy rare-earth subgroup, from terbium through lutetium, partly from raw materials supplied by Molycorp. Most of the output will be marketed in the United States through Molycorp.[9]

Malaysia.—In addition to producing monazite, this country produced and sold about 170 tons of xenotime, an yttrium phosphate mineral, recovered as a byproduct in the mining of tin minerals.

South-West Africa.—The Ondurakorume carbonatite intrusion near Kalkfeld between Tsumeb and Walvis Bay was investigated and found to contain substan-

[5] The Australian Minerals Industry. Part 2—Quarterly Statistics. V. 22, No. 2, December 1969, p. 12.
[6] Cannon, Joseph G. Rare Earths. Eng. and Min. J., v. 171, No. 3, March 1970, pp. 90–92.
[7] Mining Annual Review, Mining Journal (London). Rare Earths. June 1969, p. 86.
[8] Journal of Mines, Metals & Fuels (Calcutta). V. 17, No. 12, December 1969, p. 445.
[9] Industrial Minerals (London). Molycorp Marketing All the Rare Earths. No. 19, April 1969, p. 28.

tial quantities of rare-earth elements that might be recovered as byproducts of apatite together with strontium- and columbium-bearing minerals. The cerium oxide content of some samples was about 1 percent.[10]

United Kingdom.—Rare Earth Products, Ltd., owned jointly by Thorium Ltd., and Johnson Matthey Chemicals Ltd., commissioned a new plant at Widnes in Lancashire for the production of high-purity rare-earth metals and compounds.[11] The plant, which is managed by Thorium Ltd., purified rare-earth oxides produced in an adjacent solvent extraction plant. The annual capacity includes up to 110,000 pounds of praseodymium oxide. The extraction process used by Thorium Ltd. has been licensed to Molycorp and to Nippon Yttrium Corp.

TECHNOLOGY

Promethium is a fission product of the operation of nuclear reactors, being recovered from wastes generated in reprocessing the spent nuclear fuel. The radioactive heat of promethium as it decays has led to the consideration of the metal as a specialized heat or power source. Multigram quantities of metallic promethium were made by scientists at Battelle-Northwest by reducing a mixture of promethium chloride, calcium, and iodine at 700° to 800° C. in a magnesia-lined steel container. The 97-percent-pure reaction product was refined by melting in an inert atmosphere and evaporating the impurities from the surface of the molten metal. This resulted in a 99.9-percent-pure metal.

The potential of certain rare-earth cobalt compounds as permanent magnets has led to research on production methods. Instead of using high-cost, high-purity rare-earth metals, scientists at the Bureau of Mines used oxides as a feed material. The electrolysis was performed in a cell with an inert atmosphere, using the individual rare-earth oxide, a cobalt cathode, and an electrolyte composed of lithium fluoride and that of the particular rare-earth metal.[12] Other investigations on rare-earth materials by Bureau personnel included the electrodeposition of rare earth-ferrous alloys and the separation of purified rare-earth metals by vacuum distillation, and differential thermal analysis measurements of the potassium fluoride-yttrium trifluoride system.[13]

Europium continued to be used as an activator in red color television phosphors. It has been found that europium-activated yttrium oxide provides a better host material than yttrium orthovanadate because it is 52 percent brighter. A gadolinium oxide host, activated by europium, was introduced and claimed to improve television tube brightness by 20 to 70 percent. Other host materials having distinctive fluorescent properties included rare-earth tellurates and phosphates. Uranium-activated yttrium, lanthanum, gadolinium, and lutetium tellurates emitted green radiation under stimulation from ultraviolet or cathode-ray excitation. The red-emitting europium-activated rare-earth tellurates have only 40 percent the luminous efficiency of the europium activated yttrium orthovandate.[14] Phosphor research was carried out on cerium-activated yttrium phosphate and on rare-earth phosphates, excluding those of lanthanum, promethium, and lutetium. Sensitized by thorium ions, the ultraviolet-emitting YPO_4:Ce phosphor was said to be much more efficient than the commercially used $BaSi_2O_5$:Pb phosphor when excited by a low-pressure mercury discharge lamp.[15]

Cerium- and europium-activated phosphors were described in a number of technical articles. Ce^{3+}-activated yttrium silicates, Y_2SiO_5 and $Y_2Si_2O_7$, were said to have

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[10] South African Mining and Engineering Journal. The Rare Earths. V. 80, Pt. 2, No. 3988, July 11, 1969, p. 65.

[11] Industrial Minerals (London). Rare Earths Plant Commissioned at Widens. No. 21, June 1969, p. 43.

[12] Morrice, E., E. S. Shedd, M. M. Wong, and T. A. Henrie. Preparation of Cobalt-Rare-Earth Alloys by Electrolysis. J. Metals, v. 21, No. 1, January 1969, pp. 34–37.

[13] Morrice, E., J. E. Murphy, and M. M. Wong. Preparation of Rare-Earth and Yttrium Metals by Electrodeposition and Vacuum Distillation of Alloys. BuMines Rept. of Inv. 7308, 1969, 11 pp.
Porter, Bernard, R. E. Meaker, and P. R. Bremner. Phase Diagram for the KF-YF_3 System. BuMines Rept. of Inv. 7246, 1969, 8 pp.

[14] Natansohn, S. Luminescence Properties of Rare Earth Tellurates. J. Electrochem. Soc., v. 116, No. 9, September 1969, pp. 1250–1254.

[15] Awazu, Kenzo, and Katsutoshi Muto. YPO_4:Ce Phosphor Sensitized by Thorium Ions. J. Electrochem. Soc., v. 116, No. 2, February 1969, pp. 282–283.

better properties than others which have detrimental afterglows.[16] Europium luminescence in a number of phosphor systems was studied.[17] In the paper on europium in the alumina-silica system, the author discussed the blue and green emissions of the divalent europium ion. The red color of a $LiYO_2$:Eu phosphor is about 1.5 times brighter than the commercial YVO_4:Eu phosphor, but is unstable in the presence of organic materials now used in tube fabrication processes. Rare-earth red-emitting phosphors, their relative brightness, and those in commercial use were discussed. In testing the milling, acid, and temperature stabilities, it was found that currently the most practical red components for color television tubes are YVO_4:Eu; YVO_4:Eu, Bi; and Y_2O_2S:Eu.

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Salt

By Mark H. Hibpshman [1]

Expanded industrial requirements resulted in a continued increase in domestic salt production. Most of the additional output was consumed by the chemical industry in the manufacture of chlorine, soda ash, and other chemicals. Total production increased to a record high of 44.2 million short tons, which represented a 7-percent increase in quantity and a 6-percent increase in value over those of 1968. Minor decreases were registered for imports and exports.

Table 1.—Salient salt statistics

(Thousand short tons and thousand dollars)

	1965	1966	1967	1968	1969
United States:					
Sold or used by producers	34,687	36,463	38,946	41,274	44,245
Value	$215,699	$229,985	$251,210	$272,275	$287,680
Exports	688	662	678	728	716
Value	$4,285	$4,472	$4,583	$4,650	$4,486
Imports for consumption	2,410	2,479	2,843	3,456	3,302
Value	$6,505	$6,464	$8,541	$11,487	$11,990
Consumption, apparent	36,409	38,280	41,111	44,002	46,831
World: Production	119,730	122,274	131,092	139,248	147,571

DOMESTIC PRODUCTION

Seventeen States recorded salt production in 1969. Eighty-six percent of the output from Louisiana, Texas, Ohio, New York, and Michigan.

Salt was produced by 52 companies at 99 plants in the United States and Puerto Rico. Twelve companies, each producing more than 1 million tons, operated 44 plants, which combined, accounted for 88 percent of the total U.S. output; fifteen companies, whose production was less than 1 million tons but greater than 100,000 tons, operated 26 plants and accounted for 10 percent of total production; and 25 other companies, whose individual production was less than 100,000 tons per year, operated 29 plants to supply the remaining material.

Twelve plants, each with an annual production of over 1 million tons, accounted for 57 percent of total domestic production; 15 plants producing 500,000 to 1 million tons yearly accounted for 23 percent. The remaining 20 percent was supplied by 72 plants.

The year 1969 was one of unusual growth in the salt industry, both domestically and worldwide. In February, Morton Salt Company announced a $30 million expansion of its salt facilities in the United States. The expansion included a $20 million rock salt mine in western New York. Contracts for development were awarded, and shaft construction started. The mine was slated to produce 2.5 million tons of rock salt per year. Other production facilities included in the expansion were a $2 million enlargement of the company's mine at Fairport Harbor, Ohio; a $900,000 shaft at Grand Saline, Tex., primarily for mine safety; and a $1 million mine expansion at Weeks, La. In addition to mine expansion, evaporating plants at Silver Spring, N.Y., Port Huron and Manistee, Mich., Hutchinson, Kans., Newark, Calif., and the solar evaporation plant at Great Salt Lake, Utah, were to undergo expansion. A collective total of about $6 million was slated for improvements at these plants. The company

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installed an air pollution control device that began operation in early 1969 at the Rittman, Ohio, plant.[2]

The Carey Salt Co. (Canada) Ltd. reported plans for conversion of the old Bestwall Gypsum Co. facilities at the Port of New Orleans, La., into a salt-processing plant by 1970. Raw material for the new facility is to come from Carey's Cote Blanche rock salt mine in St. Mary Parish. The operation will process salt for industrial, agricultural, and municipal markets.

Cargill, Inc. has indicated it will spend up to $2.5 million to expand salt production capacity at its Pawnee Rock, Kans., plant. The plant now produces industrial salt and water-softening pellets; the new facilities are to increase production of both those products and add agricultural livestock blocks.[3] The expansion is to be completed by 1972.

Cargill has also indicated that it will adopt all 12 safety recommendations made by the U.S. Bureau of Mines subsequent to the mine disaster that killed 21 men on March 5, 1968. The two principal recommendations were the installation of adequate fire-fighting facilities in the mine and construction of a separate shaft for use as an escapeway.[4]

International Salt Co. has announced plans to double the capacity of its Retsof mine at Retsof, N.Y. The mine presently has a production capacity of 3.5 million tons per year, exceeding that of any other rock salt mine in the nation. The project includes plans for a new shaft to develop a new 317-acre tract recently acquired by the company.[5]

Wyandotte Chemicals Corp.'s new 10,000-foot brine well, reportedly the deepest in the world, has been completed and shut in. The well will be used as needed to feed the company's new $20 million chlorine-caustic soda plant that went on stream in March of 1969.

The Dow Chemical Co. began a $1.5 million pollution control program at its chlorine-caustic soda, Midland, Mich., plant to remove organics and recycle brine to control water pollutants entering the Tittabawassee River.[6]

Western Salt Company started construction of a 240-acre solar evaporation salt facility in western Oklahoma. Initial investment was reported at about $600,000. The company will use the entire output from flowing artesian brine wells. The salt, to be processed into 26 different products ranging from table salt to rock salt, will be marketed in Oklahoma, New Mexico, Colorado, and Kansas. An added benefit of the new plant will be the reduction of salt now entering Lake Texoma located on the Red River on the Oklahoma-Texas line.[7]

[2] Morton Salt Co. News Release. Mar. 20, 1969, 4 pp.

[3] Kansas Economic Development Report. September 1969, p. 4.

[4] Department of the Interior News Release. Bureau of Mines Reports on Investigation of Louisiana Mine Fire. Feb. 14, 1969.

[5] Skillings' Mining Review. V. 58, No. 24, June 14, 1969, p. 8.

[6] Shannon, E. S. Statement to the Michigan Water Resources Commission by The Dow Chemical Company. Jan. 16, 1970.

[7] PEP Oklahoma Industrial Development and Park Department. New Salt Plant To Double as Lake Pollution Control. V. 5, No. 8, August 1969, p. 1.

Table 2.—Salt sold or used by producers in the United States, by methods of recovery

(Thousand short tons and thousand dollars)

Recovery method	1968		1969	
	Quantity	Value	Quantity	Value
Evaporated:				
Bulk:				
Open pans or grainers	322	$8,518	332	$8,827
Vacuum pans	2,943	69,253	3,055	73,100
Solar	1,900	12,805	1,907	13,004
Pressed blocks	357	9,246	369	9,622
Total	5,522	99,822	5,663	104,553
Rock:				
Bulk	12,376	77,546	13,314	84,100
Pressed blocks	85	2,321	83	2,352
Total	12,461	79,867	13,397	86,452
Salt in brine (sold or used as such)	23,291	92,586	25,185	96,675
Grand total	41,274	272,275	44,245	287,680

Table 3.—Salt sold or used by producers in the United States

(Thousand short tons and thousand dollars)

State	1968		1969	
	Quantity	Value	Quantity	Value
California	1,901	W	1,895	W
Kansas [1]	1,128	$15,520	1,270	$17,090
Louisiana	10,908	53,854	12,435	61,102
Michigan	4,893	44,481	4,819	45,961
New York	5,218	42,488	5,582	45,561
Ohio	5,713	43,172	5,844	43,519
Oklahoma	7	44	9	51
Texas	8,534	42,663	9,261	43,012
Utah	405	3,756	481	4,439
West Virginia	1,308	4,971	1,309	4,978
Other States [2]	1,259	21,326	1,340	21,967
Total	41,274	272,275	44,245	287,680
Puerto Rico	32	395	32	395

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Quantity and value of brine included with "Other States."
[2] Includes Alabama, Colorado, Hawaii, Kansas (brine only), Nevada, New Mexico, North Dakota, Virginia and State indicated by symbol W.

Table 4.—Evaporated salt sold or used by producers in the United States

(Thousand short tons and thousand dollars)

State	1968		1969	
	Quantity	Value	Quantity	Value
Kansas	556	$12,875	623	$13,810
Louisiana	293	7,183	277	7,598
Michigan	1,068	25,497	1,137	27,552
New York	W	17,183	W	17,143
Ohio	763	W	774	W
Oklahoma	5	37	5	42
Other States [1]	2,837	37,047	2,847	38,408
Total	5,522	99,822	5,663	104,553
Puerto Rico	32	395	32	395

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes California, Hawaii, Nevada, North Dakota, Texas, Utah, and States indicated by symbol W.

Table 5.—Rock salt sold by producers in the United States

(Thousand short tons and thousand dollars)

Year	Quantity	Value
1965	9,810	$57,710
1966	10,080	61,118
1967	11,661	71,953
1968	12,461	79,867
1969	13,397	86,452

Table 6.—Pressed-salt blocks sold by original producers of salt in the United States

(Thousand short tons and thousand dollars)

Year	From evaporated salt		From rock salt		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1965	375	$8,701	68	$1,767	443	$10,468
1966	328	8,529	60	1,682	388	10,211
1967	344	8,367	63	1,853	407	10,220
1968	357	9,246	85	2,321	442	11,567
1969	369	9,622	83	2,352	452	11,974

CONSUMPTION AND USES

The chemical manufacturing industry continued to use over two-thirds of the domestic salt output. Forty-three percent of the domestically produced material was used to make chlorine and caustic soda; 15 percent was used to manufacture soda ash; and 6 percent was used for other chemicals.

The second largest consuming use was for snow and ice removal and roadbed stabilization, which required 16 percent of total output. Salt assumed to be for table use represented 2 percent of the total. The use of salt for regeneration of water softening systems was 799,000 tons, a 1.7-percent decrease from 1968 consumption. Fifty-seven percent of total consumption was sold or used in the form of brine.

Table 7.—Salt sold or used by producers in the United States, by classes and consumers or uses

(Thousand short tons)

Consumer or use	1968				1969			
	Evaporated	Rock	Brine	Total	Evaporated	Rock	Brine	Total
Chlorine	328	1,593	14,810	16,731	302	1,546	17,089	18,937
Soda ash	W	W	6,972	6,974	W	W	6,658	6,659
Soap (including detergents)	29	7	---	36	29	W	W	36
All other chemicals	W	1,775	W	2,391	W	1,815	W	2,641
Textile and dyeing	W	98	W	244	130	80	---	210
Meatpackers, tanners, and casing manufacturers	W	389	W	694	262	356	---	618
Fishing	15	5	---	20	14	4	---	18
Dairy	47	5	---	52	45	5	---	50
Canning	189	W	W	246	155	W	W	213
Baking	W	W	---	117	101	5	---	106
Flour processors (including cereal)	62	9	---	71	60	W	W	68
Other food processing	158	W	W	201	145	W	W	177
Ice manufacturers and cold storage companies	W	7	W	15	W	6	W	11
Feed dealers	764	466	---	1,230	765	415	---	1,180
Feed mixers	297	W	W	491	342	192	---	534
Metals	69	199	---	268	W	137	W	210
Ceramics (including glass)	5	11	---	16	5	11	---	16
Rubber	W	W	54	125	44	38	73	155
Oil	54	51	87	192	48	49	83	180
Paper and pulp	W	144	W	321	157	W	W	341
Water softener manufacturers and service companies	419	W	W	813	390	401	8	799
Grocery stores	669	397	---	1,066	634	447	---	1,081
Railroads	7	25	---	32	5	25	---	30
Bus and transit companies	2	13	---	15	1	12	---	13
States, counties, and other political subdivisions (except Federal)	230	5,518	3	5,751	344	6,561	4	6,909
U.S. Government	31	36	W	68	W	32	W	55
Miscellaneous	1,094	1,062	938	3,094	1,232	1,020	746	2,998
Undistributed [1]	1,053	651	427	---	453	240	524	---
Total	5,522	12,461	23,291	41,274	5,663	13,397	25,185	44,245

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] Includes some exports and consumption in overseas areas administered by the United States and items indicated by symbol W.

Table 8.—Distribution (shipments) of evaporated and rock salt in the United States, by destination

(Thousand short tons)

Destination	1968		1969	
	Evaporated	Rock	Evaporated	Rock
Alabama	44	350	54	444
Alaska	8	W	13	---
Arizona	W	5	W	7
Arkansas	18	96	19	83
California	852	W	955	W
Colorado	107	41	123	32
Connecticut	22	W	26	W
Delaware	8	W	7	W
District of Columbia	4	W	3	1
Florida	31	99	31	103
Georgia	57	222	53	W
Hawaii	W	---	W	---
Idaho	44	W	52	W
Illinois	295	635	296	875
Indiana	143	376	142	387
Iowa	176	225	178	311
Kansas	90	201	79	234
Kentucky	43	465	39	481
Louisiana	35	485	31	308
Maine	13	W	W	155
Maryland	76	41	W	W
Massachusetts	60	399	82	472
Michigan	163	W	172	685
Minnesota	146	269	130	499
Mississippi	25	72	26	73
Missouri	81	398	93	265
Montana	46	1	43	1
Nebraska	92	171	87	91
Nevada	27	W	W	W
New Hampshire	10	W	W	W
New Jersey	167	492	185	W
New Mexico	10	82	16	84
New York	332	1,742	353	2,003
North Carolina	112	190	111	143
North Dakota	47	4	35	6
Ohio	300	1,124	307	952
Oklahoma	41	60	43	51
Oregon	29	W	23	W
Pennsylvania	208	986	200	867
Rhode Island	12	71	10	W
South Carolina	38	23	34	22
South Dakota	42	19	62	27
Tennessee	122	366	116	W
Texas	111	518	115	441
Utah	121	W	122	W
Vermont	6	W	6	W
Virginia	95	110	100	95
Washington	W	W	W	W
West Virginia	23	119	21	113
Wisconsin	154	327	151	576
Wyoming	22	W	23	3
Other [1]	814	1,677	896	2,507
Total	5,522	12,461	5,663	13,397

W Withheld to avoid disclosing individual company confidential data; included with "Other."
[1] Includes shipments to overseas areas administered by the United States, Puerto Rico, exports, some shipments to unspecified destinations, and States indicated by symbol W.

PRICES

At yearend, Oil, Paint and Drug Reporter quoted the price of salt per 100 pounds bags, f.o.b. plant, as follows: Common evaporated salt in 100-pound bags in carlots or trucklots, $1.14; chemical grade on the same basis, $1.25; rock salt, medium or coarse, $0.82; rock salt, extra coarse, $0.87.

Based on reported production data, the average per-ton values of rock and evaporated salt were $6.45 and $18.46, respectively. Prices during 1969 remained essentially the same as those in 1968, but a canvass of the industry indicates that price increases will be introduced in 1970.

FOREIGN TRADE

Exports and imports of salt continued to be minor compared with domestic production. Salt was exported to 52 countries and imported for consumption from 14 countries.

Exports of salt decreased 1.7 percent to 716,000 short tons in 1969. Canada and Japan received the bulk of salt exports. Exports to Japan decreased over 10 percent in 1969 to 396,000 short tons because of increased salt imports into Japan from Australia.

Imports decreased about 4.5 percent with Canada, Mexico, Bahamas, and Chile supplying about 88 percent of the total. Other countries supplying significant quantities of salt were Tunisia, the United Arab Republic, and Venezuela.

Table 9.—Salt shipped to the Commonwealth of Puerto Rico and overseas areas administered by the United States

Area	1968 Short tons	1968 Value (thousands)	1969 Short tons	1969 Value (thousands)
American Samoa	218	$9	232	$10
Guam	254	13	112	14
Puerto Rico	17,909	1,730	13,857	1,154
Virgin Islands	212	20	168	22

Table 10.—U.S. exports of salt, by countries

(Thousand short tons and thousand dollars)

Destination	1968 Quantity	1968 Value	1969 Quantity	1969 Value
Australia	1	$48	1	$71
Canada	262	1,942	298	2,004
Costa Rica	4	54	(1)	31
Japan	441	1,954	396	1,795
Mexico	2	41	2	49
Saudi Arabia	1	112	(1)	31
South Africa, Republic of	2	15	3	16
Other	15	484	16	489
Total	728	4,650	716	4,486

[1] Less than ½ unit.

Table 11.—U.S. imports for consumption of salt, by countries [1]

(Thousand short tons and thousand dollars)

Country	1968 Quantity	1968 Value	1969 Quantity	1969 Value
Bahamas	665	$2,490	595	$2,372
Canada	r 1,438	r 5,445	1,008	4,587
Chile	169	553	557	2,112
Mexico	834	1,660	754	1,425
Spain	r 73	r 395	37	264
Tunisia	215	655	187	469
United Arab Republic	---	---	39	130
United Kingdom	21	153	16	66
Venezuela	23	62	91	449
Other	18	74	18	116
Total	r 3,456	r 11,487	3,302	11,990

r Revised.
[1] Includes salt brine from Canada through the Detroit customs district for 1968, 300,596 short tons ($89,187); 1969, from West Germany through New York City customs district, 601 short tons ($5,912).

Table 12.—U.S. imports for consumption of salt, by classes

(Thousand short tons and thousand dollars)

Year	In bags, sacks, barrels or other packages (dutiable) Quantity	In bags, sacks, barrels or other packages (dutiable) Value	Bulk (dutiable) [1] Quantity	Bulk (dutiable) [1] Value
1967	14	$282	2,829	$8,259
1968	27	467	3,429	11,020
1969	11	316	3,291	11,674

[1] Includes salt brine from Canada through the Detroit customs district for 1967, 443,457 short tons ($128,839); 1968, 300,596 short tons ($89,187); 1969, West Germany through the New York City customs district, 601 short tons ($5,912).

Table 13.—U.S. imports for consumption of salt, by customs district [1]

(Thousand short tons and thousand dollars)

Customs district	1968 Quantity	1968 Value	1969 Quantity	1969 Value
Baltimore, Md	248	$831	224	$717
Boston, Mass	149	674	128	401
Bridgeport, Conn	120	401	172	671
Buffalo, N.Y	25	109	17	72
Chicago, Ill	303	1,397	76	334
Cleveland, Ohio	138	584	143	617
Detroit, Mich	745	2,315	551	2,526
Duluth, Minn	34	128	35	155
Juneau, Alaska	(2)	10	2	70
Los Angeles, Calif	197	444	198	448
Milwaukee, Wis	138	595	158	691
New York City	136	464	174	761
Norfolk, Va	24	92	35	171
Ogdensburg, N.Y	1	5	9	43
Philadelphia, Pa	44	195	51	140
Portland, Maine	231	1,076	371	1,765
Portland, Oreg	181	227	133	166
Providence, R.I	(2)	1	138	400
St. Albans, Vt	45	190	16	66
San Juan, Puerto Rico	6	31	6	32
Savannah, Ga	195	723	224	830
Seattle, Wash	457	898	429	884
Wilmington, N.C	39	97	12	30
Other	(2)	(2)	(2)	(2)
Total	3,456	11,487	3,302	11,990

[1] Includes salt brine from Canada through the Detroit customs district 1968, 300,596 short tons ($89,187); 1969, West Germany, 601 short tons ($5,912).
[2] Less than ½ unit.

WORLD REVIEW

Australia.—Production of salt in Australia increased in 1969. Most of the increase will be used for export, primarily to Japan.

Table 14.—World production of salt by countries

(Thousand short tons)

Country [1]	1967	1968	1969 [p]
North America:			
Canada	5,362	4,864	4,247
Bahamas	1,102	[e] 882	750
Martinque	287	---	358
Honduras	25	25	31
Costa Rica	11	13	10
El Salvador	NA	26	30
Mexico [e]	3,671	3,307	3,307
United States (including Puerto Rico):			
Rock salt	11,661	12,461	13,397
Other salt:			
United States	27,285	28,813	30,848
Puerto Rico	12	32	32
South America:			
Argentina	[r] 946	816	[e] 827
Brazil	1,146	1,693	1,797
Chile	461	940	1,466
Colombia:			
Rock salt	342	349	379
Other salt	175	207	368
Peru	[r] 236	190	183
Venezuela	[r] 188	139	188
Europe:			
Austria	467	495	525
Bulgaria	126	130	132
Czechoslovakia	223	226	[e] 228
Denmark	110	165	[e] 165
France:			
Rock salt and salt from springs	[r] 3,823	3,385	[e] 4,244
Marine salt	1,698	1,102	[e] 1,102
Germany:			
East	2,021	2,172	[e] 2,205
West (marketable):			
Rock salt	5,693	6,752	9213
Marine salt and other	1,920	2,126	
Greece	105	109	83
Italy:			
Rock salt and brine salt	2,841	2,895	3,081
Marine salt	1,404	[e] 1,433	1,264
Netherlands	2,123	2,661	2,942
Poland:			
Rock salt	915	1,068	1,285
Other salt	1,828	1,835	1,820
Portugal:			
Rock salt	125	166	183
Marine salt	354	290	[e] 331
Rumania	2,270	2,610	2,646
Spain:			
Rock salt	934	1,004	[e] 1,020
Marine salt [2]	994	1,002	[e] 992
Switzerland	238	281	294
U.S.S.R.	11,684	12,125	[e] 12,677
United Kingdom:			
Rock salt	775	1,218	1,562
Other salt	7,066	7,330	7,922
Yugoslavia	185	197	234
Africa:			
Algeria	132	[e] 132	40
Angola	86	80	88
Ethiopia (including Eritrea)	287	289	290
Ghana	40	[e] 32	37
Kenya	54	67	46
Malagasy Republic	15	19	24
Mali	4	[e] 3	3
Mauritius	4	4	4
Morocco	22	45	74
Mozambique	42	20	[e] 8
Niger	6	4	4
Senegal (including Mauritania)	66	93	10
South Africa, Republic of	349	377	417
South-West Africa: Marine salt [e]	110	121	121
Sudan	63	55	56
Tanzania	40	33	37
Tunisia	[e] 266	397	[e] 386
Uganda	NA	---	6
United Arab Republic	[r] 644	686	424

See footnotes at end of table.

Table 14.—World production of salt by countries—Continued

(Thousand short tons)

Country [1]	1967	1968	1969 p
Asia:			
Afghanistan	e 34	e 44	44
Burma	148	151	194
Ceylon	r 84	108	126
China, mainland e	14,300	16,500	16,500
Cyprus	8	6	7
India (including Goa)	r 4,947	5,560	7,033
Indonesia e	r 331	88	198
Iran [3]	285	e 303	342
Iraq	r 45	e 44	e 44
Israel	63	72	e 63
Japan	1,073	1,066	1,081
Jordan	13	18	20
Korea:			
North e	606	606	606
South	675	618	319
Kuwait	4	4	4
Laos e	3	3	3
Lebanon e	33	33	31
Mongolia e	9	9	9
Pakistan:			
Rock salt	270	360	622
Other salt	492	629	631
Philippines	128	239	255
Ryukyu Islands	7	e 7	e 7
Southern Yemen	e 88	87	e 88
Syrian Arab Republic e	22	22	24
Taiwan	571	343	422
Thailand e	121	165	220
Turkey:			
Rock salt	e 39	42	e 44
Other salt	e 331	584	e 584
Vietnam:			
North e	165	165	165
South e	r 176	176	176
Yemen e	110	94	110
Oceania:			
Australia	787	1,049	e 1,102
New Zealand	62	62	54
Total [4]	r 131,092	139,248	147,571

e Estimate. p Preliminary. r Revised. NA Not available.

[1] Salt is produced in many other countries, including Libya, Somalia Republic, and Cape Verde Islands but quantities are relatively insignificant or reliable data are not available.

[2] Includes an average annual production in the Canary Islands of 15,000 metric tons of marine salt.

[3] Year ended March 20 of year following that stated.

[4] Totals are of listed figures only.

Six new salt producing companies in Australia were reported to be either producing salt or will be in production in the near future. Leslie Salt Co. began shipping salt from its solar plant at Port Hedland, Western Australia. Expected production during 1969 was 350,000 to 400,000 tons. Ultimate capacity of the plant is to be in excess of 1.25 million tons per year.[8]

Norseman Gold Mines, N.L., and Sumitomo Shoji Koisha, Ltd., expected to make their first shipment of salt near the end of the year. The joint venture will produce salt from Lake Lefroy, an inland salt lake near Kambalda, Western Australia. All output is for export mainly to Japan at a reported rate of 150,000 tons per year.[9] Texada Mines Pty. Ltd. made initial shipment of salt to Japan in April 1969. The salt was produced from a common source with potash, but production of potash is not expected until 1971.[10] Exmouth Salt Pty. Ltd., began construction of a 500,000-ton-per-year salt plant at Exmouth Gulf southwest of Onslow. Production is to begin in 1971.[11]

Australian Gypsum Industries Ltd. recently concluded a 5-year contract to supply an undisclosed amount of salt to Mitsui and Co., Japan. The salt will be produced at the company's facilities at Lake MacDonnell near Thevenard in South

[8] Leslie Salt Co. Annual Report. March 1970, p. 4.

[9] Skillings' Mining Review. V. 58, No. 20, May 17, 1969, pp. 8–10.

[10] Mining Journal (London). V. 272, No. 6975, Apr. 25, 1969, p. 355.

[11] Kalix, Z. Salt and Other Sodium Compounds. Australian Mineral Industry, 1968 Annual Review, p. 213.

Australia.[12] Dampier Salt Ltd., started construction of a 600,000-ton-per-year plant near Dampier, Western Australia. First shipments are planned for late 1971.[13]

Brazil.—A new salt terminal, Ilha de Terral, was scheduled for completion by early 1969. The facility, an artificial island 8 miles from shore, was to handle solar salt produced in the Areia Branca area of Rio Grande do Norte. The salt is for delivery to consumers in central and southern Brazil.

Another terminal, a project of Superintendencia de Desenvolvimento do Nordeste, is under construction. The terminal will use an 8-kilometer aerial tramway system to deliver salt to ships at a rate of up to 1,000 tons per hour.[14]

Canada.—Salt production in Canada in 1969 totaled 4.25 million tons compared with 4.86 million tons in 1968. The decrease was due primarily as a result of labor disputes.

Sifto Salt Division of Domtar Chemicals Ltd. constructed a 15,000-ton salt-storage building and increased the capacity of its Unity, Saskatchewan plant from 85,000 to 200,000 tons annually. In 1970, the firm plans to increase hoisting capacity at its Goderich mine.

The Canadian Salt Co. began operating its $3 million salt-processing plant at Belle Plaine, Saskatchewan. The plant processed raw material from Kalcium Chemicals Ltd.'s potash mill located nearby.[15]

Chile.—The Compañia Minera Santa Adriana S.A. announced plans to install new primary, secondary, and tertiary crushers at its salt plant. Further increases in the truck fleet and improvement of maintenance facilities at the mine are also planned. The primary destinations of the salt produced by the company are Japan and the United States.[16]

Germany, West.—Dow Chemical Europe S.A., has announced it will build a new chemical complex at Stade in the State of Neidersachsen. Total expenditures will be $250 million by 1975. An exploratory drilling program for salt carried out in 1968 proved large reserves of salt for the chlor-alkali division of the new complex.

India.—India agreed to supply 45,000 tons of salt to Japan between July 1969 and June 1970.[17]

Italy.—Montecantini Edison S.p.A. announced plans to invest $24 million in expansion of its salt facilities in Italy. Expansion plans included a rock salt refining plant at Ciro Morini near Catanzaro with an intial capacity of 1 million tons per year and an ultimate annual capacity of 1.5 million tons. A pipeline is planned to transport rock salt the 50 kilometers from its mine at Timipa del Salto in Calabria.[18]

New Zealand.—Dominion Salt Co. Ltd., the sole New Zealand producer of salt, began extending the range of production at its solar salt works. The company will upgrade refining capabilities and begin adding various anticaking agents.

U.S.S.R.—Russian geologists were reportedly exploring salt domes north of the Caspian Sea. The domes are said to contain large reserves of mineral salts, including potassium and magnesium salts, and sulfur.[19]

United Kingdom.—A new salt refinery was opened at Middlewich in Cheshire, England, in June. The plant, built at a cost of about $9.1 million, has a capacity of 60,000 tons per year and will produce vacuum pan salt primarily for chemical and industrial purposes; quantities of table and agricultural salt also will be produced.[20] Cerebos Foods Ltd. has announced plans to close its salt plant at Greatham near Hartlepool in 1970. The plant, producing salt from brine, has operated since near the turn of the century.[21]

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[12] Chemical Age (London). V. 99, No. 2618, Sept. 19, 1969, p. 19.

[13] Mining Journal (London). V. 273, No. 6986, July 11, 1969, p. 33.

[14] Bureau of Mines. Mineral Trade Notes. V. 66, No. 1, January 1969, pp. 27–28.

[15] Canadian Mining and Metallurgical Bulletin. V. 62, No. 688, August 1969, p. 900.
Jeffery W. G. Industrial Minerals. Canadian Min. J., v. 91, No. 2, February 1970, pp. 141–142.
Koepke, W. E. Salt. Ch. in Canadian Minerals Yearbook, 1968, p. 3.

[16] Bureau of Mines. Mineral Trade Notes. V. 67, No. 2, February 1970, p. 25.

[17] Bureau of Mines. Mineral Trade Notes. V. 66, No. 12, December 1969, p. 28.

[18] Engineering and Mining Journal. V. 170, No. 11, November 1969, p. 166.

[19] Mining Journal (London). V. 273, No. 6987, July 18, 1969, p. 51.

[20] Industrial Minerals (London). No. 22, July 1969, p. 27.

[21] Chemical Age (London). V. 99, No. 2628, Nov. 28, 1969, p. 23.

TECHNOLOGY

An improved method for solvent extraction of salt values and producing storage caverns for light petroleum gas has been developed by Continental Oil Co. The method improves contact between unsaturated solvent water and the cavern wall by introducing carbon dioxide and other soluble gases into the solvent under pressure. Then the pressure is reduced and the gas produces bubbles.

A method to transport particulate salt, sylvite, other mineral salts, and finely divided iron oxide ore in a petroleum liquid via pipeline has been developed. The solids are mixed with an alkali metal or alkaline earth metal organic sulfonate to give the material a density approaching that of liquid petroleum. The process was designed to minimize the loss of material through settling-out in transit.

Sand and Gravel

By S. O. Wood, Jr. [1]

Sand and gravel production increased about 2 percent to 937 million short tons, a new high. The value of production increased almost 5 percent and established a new record of $1,070 million. Output from commercial operations increased about 3 percent, while Government-and-contractor production declined slightly (0.3 percent). Construction operations, users of 96 percent of the sand and gravel produced, were undergoing substantial reductions at yearend. Contributing to decreased construction activity was a decision by President Nixon in September to cut 75 percent of the funds allocated to Federal projects not underway as an anti-inflationary measure.

Legislation and Government Programs.—The Tax Reform Act of 1969 authorized changes in certain mineral and metal depletion rates effective with taxable years beginning after October 9, 1969. The depletion rate for industrial sand and gravel was lowered from 15 to 14 percent of gross income. The 5-percent depletion rate for sand and gravel used for construction purposes was unchanged.

Pursuant to the Federal Metal and Nonmetallic Mine Safety Act of 1966 (Public Law 89–577), the first Federal health and safety standards to be established for all domestic metal and nonmetal mines were published in August 1969 in the Federal Register.[2] The standards were promulgated to provide better on-the-job protection for nearly 200,000 workers in noncoal mines. Some included items were fire prevention and control; air quality; storage and handling of explosives; drilling, loading, hauling, and dumping operations; electrical equipment use and installation; radiation exposure; and maintenance and use of mining equipment.

DOMESTIC PRODUCTION

California, with 125 million tons, ranked first in sand and gravel output and produced more than twice as much as second-ranked Michigan. Other States producing substantial quantities of sand and gravel in descending order of production were Ohio, Minnesota, Illinois, Wisconsin, and New York. Combined production from the seven leading States was 407 million tons, about 43 percent of the U.S. total output. Value of sand and gravel produced in these seven States was $453 million, 42 percent of the Nation's total.

Nationwide, commercial operations continued to dominate production with 78 percent of the output, while Government-and-contractor operations accounted for 22 percent. There was only a small increase in the number of commercial sand and gravel processing plants (from 6,296 in 1968 to 6,308 in 1969); the largest increase was in the number of plants processing between 700,000 and 800,000 tons. Plants that processed more than 1 million tons increased from 66 to 73 during the year.

The industry continued to construct larger and more fully integrated sand and gravel complexes. Kaiser Sand and Gravel Co. completed its 2,000-ton-per-hour diversified plant that replaced its old one at Radum, Calif. Blue Diamond Division of the Flintkote Co. built a new plant at Irwindale, Calif., that included an automated 3,500-ton-per-hour loading and reclaiming system.[3] In balancing the practical advantages of automation against cost, the designers concentrated the auto-

[1] Petroleum engineer, Bureau of Mines, Washington, D.C.

[2] Federal Register. V. 34, No. 145, July 31, 1969, pp. 12503–12527.

[3] Bergstrom, John H. Automated Loadout Highlights Huge California Gravel Plant. Rock Prod., v. 72, No. 9, September 1969, pp. 68–73, 132.

Table 1.—Sand and gravel sold or used by producers in the United States, by classes of operations and uses

(Thousand short tons and thousand dollars)

Class of operation and use	1968 Quantity	1968 Value	1969 Quantity	1969 Value
Construction:				
Building:				
Sand	r 160,778	r $177,680	170,467	$193,016
Gravel	r 134,160	r 182,676	135,637	191,950
Paving:				
Sand	r 134,287	r 130,894	131,456	135,780
Gravel	r 336,843	r 338,809	350,090	354,840
Fill:				
Sand	r 38,629	r 23,194	41,630	27,862
Gravel	59,730	44,890	55,318	38,736
Railroad ballast:				
Sand	631	631	663	556
Gravel	2,417	1,988	2,189	1,971
Other:				
Sand	7,921	7,307	7,599	6,827
Gravel	9,895	11,507	6,672	7,288
Total construction [1]	r 885,291	r 919,576	901,711	958,836
Industrial sand:				
Underground:				
Glass	9,627	31,863	10,547	36,398
Molding	10,332	29,126	10,989	30,741
Grinding and polishing	551	1,411	354	995
Blast sand	1,179	6,679	1,219	6,743
Fire or furnace	470	1,115	473	1,005
Engine	832	1,907	920	2,062
Filtration	212	709	194	745
Oil hydrafrac	258	2,030	274	2,046
Other	2,166	6,809	2,150	6,822
Total [1]	25,627	81,649	27,123	87,567
Ground sand [2]	1,348	11,733	1,900	14,460
Total industrial [1]	26,975	93,382	29,021	102,026
Miscellaneous gravel	5,202	7,149	6,173	9,441
Grand total [1]	r 917,468	r 1,020,107	936,906	1,070,302
Commercial:				
Sand	r 322,910	r 398,981	339,400	431,668
Gravel	r 387,753	r 449,724	391,314	464,565
Government-and-contractor: [3]				
Sand	46,311	34,107	41,422	34,401
Gravel	160,494	137,295	164,762	139,670

r Revised.
[1] Data may not add to totals shown because of independent rounding.
[2] See table 10 for use breakdown.
[3] Approximate figures for operations by States, counties, municipalities, and other Government agencies under lease.

mated features in the reclaiming and loadout sections and provided minimum automation in the processing sections. The operation reclaims and loads nine different materials consisting of five dry asphalt aggregates, including dry sand; three coarse washed concrete aggregates; and concrete sand. The truck loadout station has 12 steel storage bins, each with a 200-ton capacity. Cascade Construction Co. completed a sand and gravel plant rated at 1,000 tons per hour at Scappoose, Oreg.[4]

Important operational changes in some of the new plants were noted in the literature. To take advantage of the raw material and transporation potential of the Ohio River, Evansville Materials, Inc., placed a dredging plant in operation near Evansville, Ind.[5] The complete processing system was mounted on a 46- by 120-foot hull and had a deliverability from 400 to 450 tons per hour. Virtually complete flexibility was provided for the blending of

[4] Pit and Quarry. Oregon Construction Firm To Operate Sand/Gravel Plant. V. 62, No. 1, July 1969, p. 27.

[5] Herod, Buren C. New Dredge, Modernized Shore Facilities Aid Evansville Materials' Growth. Pit and Quarry, v. 61, No. 12, June 1969, pp. 94–100, 139.

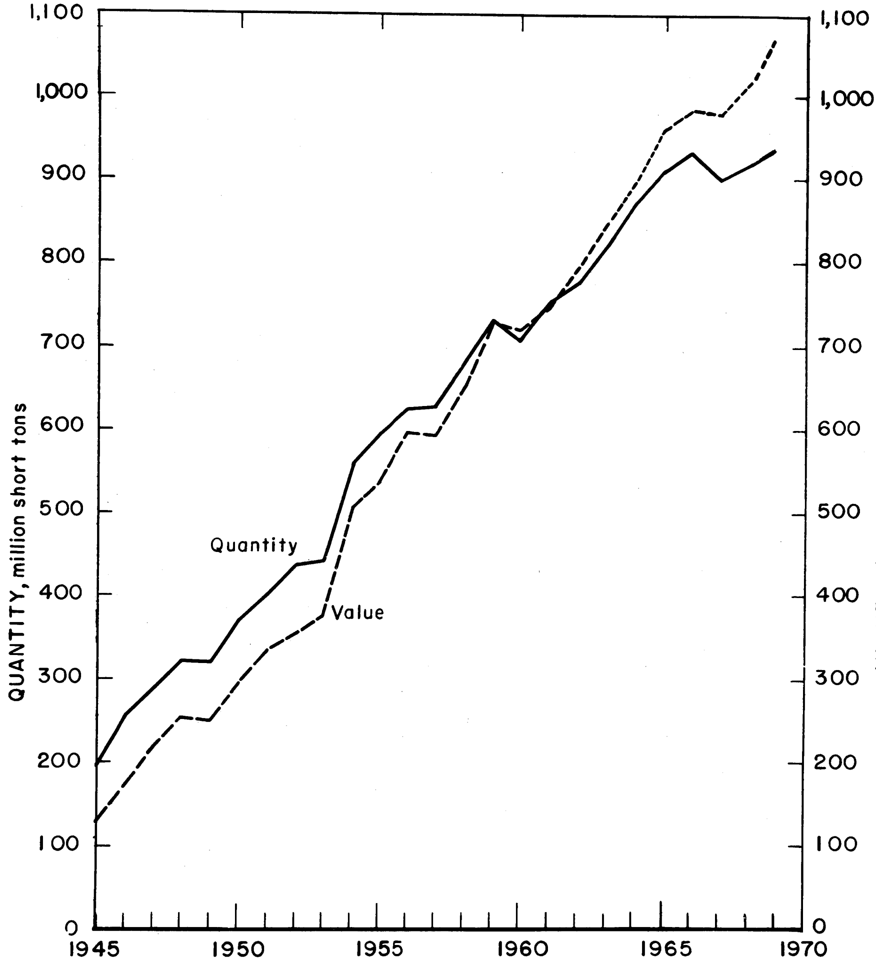

Figure 1.—Production and value of sand and gravel in the United States.

gradations of sand and gravel. A new 400-ton-per-hour sand plant was completed in central Florida near Loughman by E. R. Jahna Industries, Inc.[6] Sand is furnished to the plant by hydraulic dredge. Truck shipments are weighed, and a special hydraulic clamshell crane with a 1,700-pound bucket is used to adjust axle loads on tractor-trailers to within 10 pounds of the maximum legal axle loading.

Guaranteed Gravel and Sand Co. placed in operation a 350-ton-per-hour plant at a LeSueur River site, south of Mankato, Minn.[7] Raw material is excavated from the riverbed by a 100-foot tower excavator equipped with a 5-yard scraper. The tower structure was mounted on four sets of rail trucks that travel on standard-gage rails that can be relaid to accomodate movement paralleling the river.

Other new plants included Standard Slag Co.'s 200-ton-per-hour dredge assembled in an old flood plain about 1 mile from the

[6] Trauffer, Walter E. New 400-TPH Sand Plant in Central Florida Built To Serve Growing Area. Pit and Quarry, v. 62, No. 1, July 1969, pp. 163–165.

[7] Herod, Buren C. Guaranteed Not Just a Name to Progressive Sand-Gravel Producer. Pit and Quarry, v. 62, No. 2, August 1969, pp. 74–78.

Scioto River in southern Ohio.[8] The Warner Co. of Philadelphia, Pa., built a 450-ton-per-hour plant on land as a first step in a long-range plan to revise its sand production operation near Morrisville, Pa.[9] Fisher Concrete Co. started operations at a new plant at Memphis, Tenn.[10] This plant was the first in the area to transfer materials from the pit by field conveyors. Production facilities were installed at a new sand and gravel operation near Cleveland, Tex., by Southwest Towing & Shell Co.[11]

Portable plants, providing more flexibility in operations, continued to be widely used. Bigger equipment, better construction, and improved procedures were basic contributing factors in the increasing use of mobile plants. A direct loading operation, from crusher to truck, helped Madison Stone Co. avoid stockpiling costs at a Sheboygan, Mich., job.[12] A secondary crushing-screening plant, one of the largest of today's single-chassis portable units, operated at a rate of 540 tons per hour. Twenty 19-ton-capacity trucks were kept rolling on the 13-mile haul. In an 8-week period, 168,000 tons of minus 1-inch road gravel was processed and delivered. Frederick Parker Ltd. built three new types of mobile plants for use in the quarry and sand and gravel industries.[13] The units can crush and screen aggregate into four sizes and feed direct to trucks or stockpiles as required. The largest model has an output capacity in excess of 200 tons per hour, and the other two produce in excess of 150 tons per hour.

Bristol Silica Co. opened a new silica mine in Lucky Boy Pass, western Lyon County, Nev.[14] A company official stated that the deposit was 99.8-percent-pure silica and that there was no overburden.

Modernization and expansion programs by several companies resulted in increased plant capacity for the industry. Azusa-Western, Inc., increased pit production from 500 tons per hour to 1,000 tons per hour at Azusa, Calif., a northeast suburb of Los Angeles.[15] The company installed a new portable crusher and pit conveyor system to achieve the production increase. Illinois Minerals Co. increased the processing capacity of its amorphous silica operations at Elco, Ill.[16] High-purity amorphous silica was mined by the room-and-pillar method at nearby fee-owned and mineral-deeded property. New Jersey Silica Sand Co. modernized its southern New Jersey plant at Milville.[17] In addtiion to having twice the capacity of its predecessor, seven splits to finished gradations from the feed to its primary system can be made in the new plant.

The sand and gravel industries have joined others in reclamation of mined-out areas. The Brannan Sand & Gravel Co., Denver, Colo., rehabilitated one of its worked-out and water-filled pits by neatly landscaping the shores.[18] The water-filled pit is called Lake Sangraco, an acronym describing the company's operation.

CONSUMPTION AND USES

The construction industry continued as the principal user of sand and gravel by consuming 96 percent of the 1969 output valued at $959 million. The value of new construction projects, $67.4 billion in 1969, was 9 percent higher than the 1968 value, according to F. W. Dodge Division of McGraw-Hill Information Systems Co.[19] Most

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[8] Trauffer, Walter E. Standard Slag's Newest Plant. Pit and Quarry, v. 62, No. 6, December 1969, pp. 102, 105, 142.

[9] Trauffer, Walter E. Warner's New 450-TPH Plant. Pit and Quarry, v. 62, No. 5, November 1969, pp. 92–99.

[10] Pit and Quarry. New Sand and Gravel Plant Set for Memphis, Tenn., Area. V. 61, No. 11, May 1969, p. 32.

[11] Pit and Quarry. New Sand and Gravel Operation Developing in Cleveland, Tex. V. 62, No. 2, August 1969, p. 26.

[12] Levine, Sidney. Direct Crusher-to-Truck Load-out Eliminates Gravel Stockpiling. Rock Prod. v. 72, No. 2, February 1969, pp. 66–67.

[13] Mining & Minerals Engineering. Mobile Quarry Plant. V. 5, No. 1, January 1969, p. 16.

[14] Engineering and Mining Journal. Nevada. V. 170, No. 10, October 1969, p. 140.

[15] Bergstrom, John H. California Gravel Producer Doubles Production, Slashes Costs With Pit Crushing System. Rock Prod., v. 72, No. 6, June 1969, pp. 46–49.

[16] Herod, Buren C. Illinois Mineral Expands. Pit and Quarry, v. 61, No. 10, April 1969, pp. 142–148.

[17] Herod, Buren C. Holly Brand's Lustre Increases. Pit and Quarry, v. 2, No. 6, December 1969, pp. 98–101.

[18] Pit and Quarry. Refurbished Riverboat Cruises Water of Rehabilitated Colorado Gravel Pit. V. 62, No. 1, July 1969, p. 188.

[19] Pit and Quarry. F. W. Dodge Reports New Construction Contracts for December at 218 on Index. V. 62, No. 9, March 1970, p. 35.

of the increase in value was attributed to inflation. Construction costs were up more than 7 percent compared with 1968 costs.

Gravel was used to assist in environmental control to prevent erosion in Alaska. Atlantic Richfield Co. contracted Spruce Equipment Co., Fairbanks, Alaska, to construct roads and other facilities in order to permit transportation and year-round drilling operations in the Prudhoe Bay area.[20] The contracted projects include drilling-site pads, staging areas, and a network of roads having a gravel thickness ranging from 5 to 7 feet. The thick layer of gravel insulates the frozen tundra and thereby protects it from thaw and damage from heavy equipment.

Sand-producing companies in the Duluth, Minn., area profited from a price differential that resulted from a record boost in handling costs on the Gulf of Mexico and increased transoceanic shippers' charges.[21] A load of silica sand was shipped to Manchester, England, from Duluth at $8.02 per gross ton less than rates from Gulf ports.

Sand and gravel was not immune to substitution for reasons of environmental or economics. British Steel Corp's Scunthorpe, Division, Midland Group, Appleby Abrasives, manufactured grit from blast furnace molten slag at Appleby-Frodingham as a substitute for sand.[22] The product was used extensively for grit-blasting of surfaces to provide a clean base for anticorrosive-protective coatings and replaced sand which was banned on health grounds. In South Africa a study of sand versus diato-

[20] Skillings' Mining Review. Gravel Roads in Alaska for Year-Around Work. V. 58, No. 10, Mar. 8, 1969, p. 11.
[21] Rock Products. Smooth Sailing for Sand From Duluth. V. 72, No. 12, December 1969, p. 90.
[22] Steel Times. Appleby Abrasives Sells Substitute for Sand. V. 197, No. 7, July 1969, p. 488.

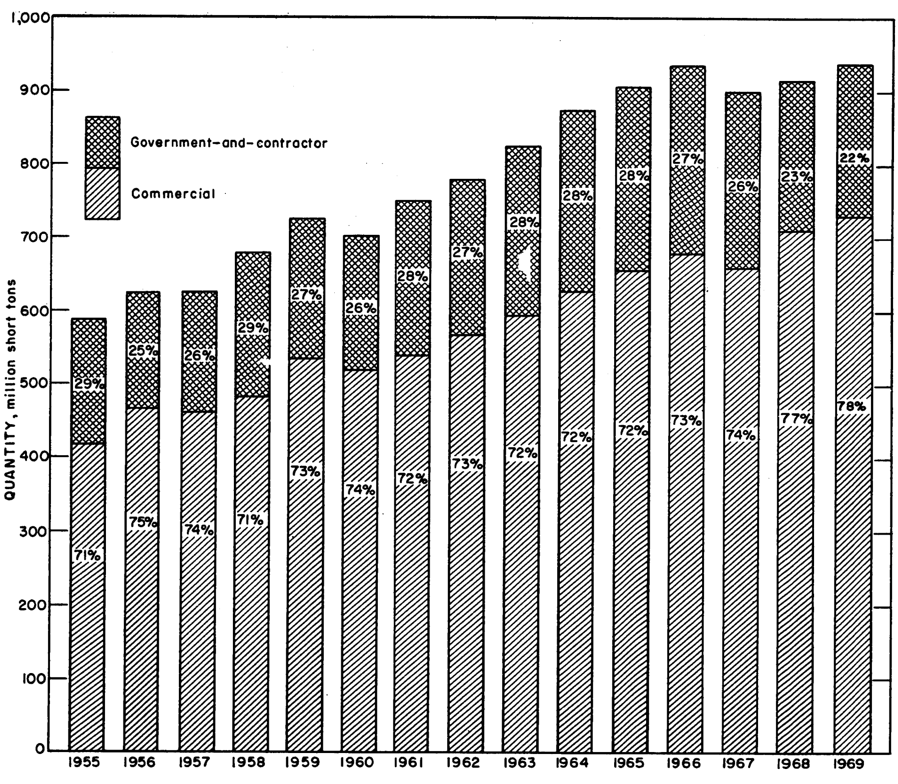

Figure 2.—Sand and gravel sold or used in the United States.

maceous-earth filter systems to remove soil from large swimming pools was conducted by the Penguin-Poolquip Group in Johannesburg.[23] The study group concluded that diatomaceous filters were preferable because of lower initial and maintenance costs and easier replacement of filters. In addition, water filtered by a diatomaceous-earth plant was more "polished." Fly ash from Duquesne Light Co.'s 500,000-kilowatt power station at Elrama, Pa., was processed into a lightweight aggregate for use as a substitute for sand and gravel in concrete.[24] Spokesmen stated that savings of 10 to 30 percent in the cost of steel and concrete building shells could be realized from reductions in the weight of finished concrete.

PRICES

On December 4, 1969, representative carload-lot prices for sand in 20 cities ranged from $1.55 per ton in Cincinnati to $5.75 per ton in Atlanta, according to the Engineering News-Record. The average of the sand prices reported was $2.76 per ton. Prices for either 3/4-inch or 1 1/2-inch gravel ranged from $1.70 per ton in Cincinnati to $4.40 per ton in Pittsburgh. The average of the 3/4-inch-gravel prices reported for 19 cities was $3.04, and for 1 1/2-inch gravel the average of the prices reported for 16 cities was $2.94 per ton. The average value of sand and gravel sold or used by producers, f.o.b. plant, was $1.14 per ton, a 3-percent increase over the 1968 average.

FOREIGN TRADE

Canada received 82 percent of U.S. exports of sand in 1969. The Bahamas received 9 percent, and Mexico received 7 percent. Canada also received the largest amount of U.S. exports of gravel—77 percent. Other large recipients of U.S. gravel were the Bahamas, 17 percent, and Bermuda, 5 percent. Total exports of sand were 1,797,044 short tons; gravel exports were 308,609 short tons. Virtually all of the crude sand and gravel imported was from Canada. About 95 percent of the U.S. imports of sand suitable for glassmaking came from Australia.

WORLD REVIEW

Belgium.—Societe d'Agregats Legers, a Belgium firm, was formed by three principals to manufacture a lightweight cement aggregate from expanded shale to replace gravel in cement manufacture.[25] The utilization of lightweight aggregate is becoming more prevalent for prefabricated structures in Europe.

Canada.—Indusmin Ltd. commenced expansion of their silica operations at Midland and Killarney, Ontario.[26] At Midland, $3.6 million was being expended to increase the capacity of the grinding plant and related facilities to about 500,000 tons of processed silica annually. Improvements underway at the Killarney operation, acquired from Union Carbide Canada Ltd. in 1968, were expected to cost about $2.4 million. Completion of both projects was scheduled for March 1970.

Newfoundland's Department of Mines and Resources indicated that substantial deposits of commercial silica were discovered in the Bonne Bay area of the Province's west coast.[27] Although the area has been defined as a national park, the Provincial Government was to consider the development potential of the area before setting the park boundaries. In Nova Scotia the Provincial Department of Mines expected that pilot-plant testing would determine the feasibility of commercial exploitation of silica deposits in the Musquodoboit Valley area about 40 miles north of Halifax.

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[23] South Africa Mining and Engineering Journal. Sand Versus Diatomaceous-Earth Filter Systems. V. 80, Pt. 1, No. 3963, Jan. 17, 1969, pp. 132–134.

[24] Mining Congress Journal. Environmental Quality Roundup. V. 55, No. 10, October 1969, p. 88.

[25] Rock Products. Belgium Firms To Manufacture Lightweight Cement Aggregate. V. 72, No. 12, December 1969, p. 17.

[26] Skillings' Mining Review. Indusmin Ltd. Program at Silica Operations in Ontario. V. 58, No. 25, June 21, 1969, p. 4.

[27] European Chemical News (London). Fluorspar, Silica Are Found in Canada. V. 15, No. 376, Apr. 18, 1969, p. 8.

France.—Societe Francaise des Sables et Graviers S.A., a wholly owned subsidiary of British Dredging Co. Ltd., recently built the largest marine aggregate plant in Europe at Dunkirk, France.[28] The highly automated 350-ton-per-hour plant features extra-large raw storage facilities so that processing can continue when bad weather prevents dredging at sea.

India.—Installation of the largest system of industrial ropeway in the world was recently completed.[29] Three high-speed ropeways, each designed to carry 450 tons of sand per hour, and having a total length of 40 miles, were accepted by the Chairman of the Coal Board for commercial use. Sand reclaimed from the Damodar and Ajoy Rivers is transported to the Jambad area and used as backfill in coal mines.

Sweden.—A new company, A/S Silversand,[30] was formed in Stockholm to dredge and process an extra-fine sand from the Baltic Sea near the Danish island of Bornholm. Estimated plant cost was $1.4 million.

United Kingdom.—The Sandsfield Gravel Co.'s Brandesburton plant in England, designed to grade sand into both concrete and building sand specifications while removing the impurities,[31] began operations during 1969.

There was a marked increase in the demand for portable or semiportable plants by sand and gravel producers in Britain.[32] Alexander Russell and Co. was one operator that accepted delivery of a portable plant.

A 35-acre area at Meering gravel pit, Newark Quarry, Nottinghamshire, England, was reclaimed and returned to agricultural use.[33] This area is about half of the total land area reclaimed by backfilling with fly ash pumped in suspension from high Marnham power station, 4 miles north of the quarry. The power station produces about 400,000 tons of fly ash annually. Backfilling operations have been conducted for about 10 years.

TECHNOLOGY

Numerous articles pertaining to mining and processing of sand and gravel were published. These articles covered such items as equipment, flexibility, research, management planning, and operational control.

From company records, Nugent Sand Co., Muskegon, Mich., documented the superiority of natural gas over oil as a fuel for rotary dryers.[34] Factors cited for gas superiority included the clean-burning characteristics whereby combustion residues did not form on dried sand and lower energy costs per unit of production. In addition, the life of refractory materials almost doubled, and nonproductive time for preheating the dryer was virtually eliminated. Company records indicated that purity, cleanliness, and granular uniformity, qualities so important for foundry sand and fused-glass ceramic products, were noticeably easier to achieve with the use of gas-fired dryers.

A 3-year study of heavy media plant separation of gravel aggregate production was concluded. The objective was to develop and demonstrate a process control that could supplant sample inspection. From this study, which was sponsored by the Michigan Department of State Highways in cooperation with the U.S. Bureau of Public Roads, the authors concluded that efficient plant control could be maintained by continuous monitoring of the specific gravity and consistency of the medium. They also concluded that product yield could be maximized for a designated quality of product.[35]

W. D. Jeffery, a Fort Smith, Ark., contractor, furnished sand and coarse material from the Arkansas River to markets in Ar-

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[28] Pit and Quarry. New 350-TPH Plant Supplies Aggregates for Expansion of Port of Dunkirk. V. 61, No. 9, March 1969, pp. 146–150.

[29] Mining & Minerals Engineering. World's Largest Industrial Ropeway System. V. 5, No. 2, February 1969, p. 11.

[30] Pit and Quarry. New Swedish Sand Plant. V. 62, No. 2, August 1969, p. 28.

[31] Pit and Quarry. New Coal-Sand Separation Plant Incorporates Classification and Dewatering in One Operation. V. 62, No. 5, November 1969, pp. 121–123.

[32] Mining & Minerals Engineering. New Pattern in Mobile Sand and Gravel Plant Design. V. 5, No. 6, June 1969, p. 16.

[33] Pit and Quarry. English Gravel Company Reclaims Land with Fly Ash Backfill. V. 61, No. 12, June 1969, p. 32.

[34] Rock Products. Gas Does the Big Job for Nugent Sand. V. 72, No. 8, August 1969, pp. 66–67.

[35] Volin, M. E., and L. Valentik. Control of Heavy Media Plants. Pit and Quarry, v. 62, No. 6, December 1969, pp. 111–120, 142.

kansas and Oklahoma. A 300-ton-per-hour waterborne plant, designed to produce two specifications of sand products and two gradations of coarse material, traveled the Arkansas River to stockpile needed materials on shore near Clarksville, Ark., and Gore, Okla. The contractor also operated a typical floating plant near Little Rock, Ark.; a bank plant at Conway, Ark.; and a small plant at Sallisaw, Okla.[36]

Caterpiller Tractor Co. reported that elevating scrapers resulted in more economical earthmoving in many situations.[37] The self-loading scrapers have less production capacity than comparably rated conventional scrapers but have the advantage of not requiring the help of a pusher. The capability of loading materials including sand, sandy clay, creek-run gravel, sandy silt, and top soil to payload capacity in less than 1 minute was demonstrated with a 32-cubic-yard elevating scraper.

Development of a dense-slurry separator that operates with water or with a heavy media slurry made up of magnetite and/or ferrosilicon was announced by Arthur G. McKee & Co.[38] Separation is controlled by the velocity of the uprising current through an orifice in the washing chamber and variations of slurry density. Oster Sand & Gravel Co. stated that its profits have been boosted as a result of using this equipment.[39] Low capital and operating costs, excellent separation with negligible loss of salable material, and minimum maintenance contributed toward the increased profits.

An alternate method of solving the common foundry problem of sand-sticking in chutes, hoppers, and oscillating conveyors was used by Wooster Products, Inc., Wooster, Ohio.[40] Rather than beating the sides of the containers with hammers and bars or installing vibrators, heat was applied to areas in which sand-sticking occurred. By increasing the temperature in the areas of sand-sticking above the dew point (the temperature at which condensation occurs), the problem was virtually eliminated.

The clay content of moldings and mixes was determined at the Two Harbors, Minn., foundry of Amsco Division, Abex Corp., through use of the methylene blue test.[41] The test was introduced to the foundry industry by Baroid Division, National Lead Co. Use of the test to obtain total active clay content and collodial clay content in sand mixtures made it possible to detect promptly changes in sand-bonding properties and make necessary changes before defects resulted. A faster methylene blue-test method for active clay was described by W. K. Bock.[42]

Personnel of the University of Missouri's Industrial Research Center worked under a grant from the U.S. Public Health Service's Bureau of Solid Waste Management to determine how ground glass might best be blended with asphalt to produce a wearing course comparable to, or better than, conventional limestone-asphalt combinations.[43] The glass-asphalt mixture was tested in a 2-inch-thick strip (18 feet wide by 58 feet long) used by more than 400 vehicles a day. Preliminary results indicated better-than-normal wear of the test surface. Additional tests scheduled include durability, skid resistance, and tire wear. The problem of grinding glass to a fineness adequate to eliminate the cutting of tires was overcome by using commercially available hammer mills.

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[36] Mattson, Ivar T. The Sarah Ann Navigates to Success. Rock Prod., v. 72, No. 4, April 1969, pp. 58–60.

[37] Road and Streets. Elevating Scrapers Prove Value in High-Production Jobs. V. 112, No. 4, April 1969, pp. 68–70, 75.

[38] World Mining. Lightweight Material Removed From Sand and Gravel Using Wemco Dense Slurry Separation. V. 5, No. 4, April 1969, p. 68.

[39] Rock Products. New HMS Plant Boosts Profits at Oster Sand & Gravel. V. 72, No. 3, March 1969, pp. 67–69.

[40] Brownell, Thomas A. Heat Moves Sticky Sand. Foundry, v. 97, No. 5, May 1969, pp. 251–252.

[41] Tarquinio, Tito, and Don Bolding. Sand Control With the Methylene Blue Test. Foundry, v. 97, No. 2, February 1969, pp. 119–124.

[42] Bock, W. K. Sand Control by Analysis. Foundry, v. 97, No. 11, November 1969, pp. 66–69.

[43] Engineering News-Record. Driving on Glass. V. 183, No. 25, Dec. 18, 1969, p. 60.

Table 2.—Sand and gravel sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Sand		Gravel		Total [1]	
	Quantity	Value	Quantity	Value	Quantity	Value
1965	352,735	$388,051	555,314	$569,365	908,049	$957,416
1966	368,321	408,757	566,160	576,225	934,481	984,982
1967 [r]	358,812	409,481	547,087	571,138	905,899	980,619
1968 [r]	369,221	433,088	548,247	587,019	917,468	1,020,107
1969	380,836	466,067	556,079	604,226	936,906	1,070,302

[r] Revised.
[1] Data may not add to totals shown because of independent rounding.

Table 3.—Sand and gravel sold or used by producers in the United States, by States and classes of operations

(Thousand short tons and thousand dollars)

State	1968						1969					
	Commercial		Government-and-contractor		Total		Commercial		Government-and-contractor		Total[1]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	8,052	$9,024	88	$106	8,140	$9,130	8,323	$9,427	--------	--------	8,323	$9,427
Alaska	1,564	1,723	16,449	18,643	18,013	20,366	943	1,123	15,261	$17,492	16,205	18,615
Arizona	9,267	9,890	4,714	4,527	13,981	14,423	10,351	12,751	6,129	5,315	16,481	18,066
Arkansas	10,682	12,795	2,315	1,848	12,997	14,643	10,067	12,919	2,608	2,030	12,674	14,949
California	100,495	129,841	24,160	23,517	124,655	153,360	102,013	134,532	22,705	21,351	124,718	155,883
Colorado	11,967	15,810	11,154	10,794	23,121	26,608	10,682	14,098	9,195	13,168	19,877	27,266
Connecticut	7,579	8,838	1,173	483	8,752	9,321	7,793	9,940	1,064	419	8,857	10,359
Delaware	1,596	1,483	--------	--------	1,596	1,483	2,257	2,074	--------	--------	2,257	2,074
Florida	7,640	7,890	125	77	7,765	7,967	13,737	13,457	672	531	14,409	13,988
Georgia	3,803	4,314	--------	--------	3,803	4,314	3,824	4,709	--------	--------	3,824	4,709
Hawaii	546	1,653	--------	--------	546	1,653	552	1,816	--------	--------	552	1,816
Idaho	2,162	2,839	6,062	6,294	8,224	9,133	2,119	2,698	6,435	4,885	8,555	7,583
Illinois	44,132	52,106	1,477	835	45,609	52,943	43,278	56,144	860	544	44,138	56,688
Indiana	24,856	25,636	918	524	25,774	26,160	25,352	26,950	866	488	26,218	27,438
Iowa	14,018	13,746	2,314	1,445	16,332	15,192	16,730	16,753	1,662	1,114	18,391	17,867
Kansas	10,267	8,953	2,160	1,608	12,427	10,559	9,734	8,576	2,295	1,485	12,029	10,061
Kentucky	7,349	7,944	129	137	7,478	8,081	8,124	9,509	240	119	8,364	9,628
Louisiana	20,208	26,354	203	150	20,411	26,504	17,715	21,278	416	616	18,131	21,895
Maine	2,764	2,270	9,102	3,711	11,866	5,978	3,047	2,603	8,228	3,423	11,275	6,026
Maryland	11,355	16,959	364	198	11,719	17,157	13,986	21,141	244	86	14,230	21,226
Massachusetts	14,386	16,934	3,413	3,171	17,799	20,106	16,489	20,178	2,967	2,772	19,456	22,950
Michigan	48,850	50,862	7,813	4,111	56,663	54,979	50,661	54,636	7,431	4,332	58,092	58,968
Minnesota	37,859	32,121	6,815	4,291	44,674	36,414	41,803	36,125	6,318	4,066	48,121	40,191
Mississippi	11,660	12,522	320	147	11,980	12,669	11,140	11,811	344	451	11,484	12,263
Missouri	10,597	14,153	52	51	10,649	14,204	10,886	14,524	53	50	10,940	14,574
Montana	2,432	2,886	6,330	4,867	8,762	7,754	2,140	2,855	14,455	11,529	16,595	14,383
Nebraska	r 11,784	r 12,103	958	842	r 12,742	r 12,946	11,962	12,940	796	652	12,758	13,592
Nevada	3,945	6,576	3,867	3,865	7,812	10,442	4,918	7,521	3,529	3,313	8,447	10,834
New Hampshire	4,449	4,350	3,293	1,350	7,742	5,698	4,330	4,285	1,980	865	6,310	5,149
New Jersey	20,306	33,570	--------	--------	20,306	33,570	20,325	33,977	--------	--------	20,325	33,977
New Mexico	3,523	4,832	8,739	7,563	12,262	12,396	3,246	4,402	5,328	6,020	8,574	10,422
New York	27,427	33,342	16,012	12,469	43,439	45,812	26,620	33,610	13,186	8,908	39,806	42,518
North Carolina	6,931	8,734	3,840	2,443	10,771	11,178	7,553	9,589	3,009	1,848	10,562	11,437
North Dakota	3,661	4,291	7,178	5,823	10,839	10,159	4,100	4,488	2,939	2,786	7,039	7,274
Ohio	46,162	57,404	572	267	46,734	57,671	49,133	63,340	27	21	49,160	63,361
Oklahoma	4,283	5,691	758	595	5,041	6,288	4,060	5,874	1,202	1,282	5,262	7,156
Oregon	12,485	14,546	5,775	6,910	18,260	21,457	11,946	14,765	3,795	5,726	15,740	20,491
Pennsylvania	18,011	30,839	90	237	18,101	31,076	18,105	31,451	--------	--------	18,105	31,451
Rhode Island	2,291	2,546	--------	--------	2,291	2,546	2,409	2,900	71	116	2,480	3,015
South Carolina	5,662	8,074	--------	--------	5,662	8,074	5,692	8,229	--------	--------	5,692	8,229
South Dakota	2,824	2,988	8,734	8,591	11,558	11,578	3,252	3,338	7,906	7,469	11,158	10,807
Tennessee	6,653	10,567	691	573	7,344	11,140	5,555	9,194	619	515	6,175	9,709

Texas	27,919	38,183	3,924	3,356	31,843	41,546	24,226	33,123	5,746	6,633	29,972	39,756
Utah	5,004	4,856	5,289	4,510	10,293	9,364	5,649	6,704	13,503	10,131	19,151	16,835
Vermont	2,314	2,294	1,273	510	3,587	2,806	2,643	2,781	694	247	3,336	3,028
Virginia	10,774	13,613	85	31	10,859	13,644	12,062	15,922	78	32	12,140	15,954
Washington	18,711	18,822	12,721	9,018	31,432	27,839	18,032	20,744	16,213	10,302	34,245	31,046
West Virginia	5,657	11,900	--------	--------	5,657	11,900	5,890	12,666	--------	--------	5,890	12,666
Wisconsin	29,220	24,849	10,587	6,053	39,807	30,903	31,771	28,521	11,044	6,893	42,815	35,414
Wyoming	4,581	4,189	4,769	4,789	9,350	8,973	3,492	3,243	4,076	4,045	7,568	7,288
Total [1]	r 710,663	r 848,705	206,805	171,327	r 917,468	r 1,020,107	730,717	896,234	206,189	174,070	936,906	1,070,302
American Samoa	--------	--------	20	19	20	19	--------	--------	7	7	7	7
Panama Canal Zone	55	77	--------	--------	55	77	60	97	--------	--------	60	97
Puerto Rico	14,250	22,655	1,896	2,066	16,146	24,723	9,265	22,774	167	522	9,432	23,296

r Revised.

[1] Due to independent rounding data may not add to total shown.

Table 4.—Sand and gravel sold or used by producers in the United States in 1969, by States, uses, and classes of operations

(Thousand short tons and thousand dollars)

State	Sand, construction							
	Building				Paving			
	Commercial		Government-and-contractor		Commercial		Government-and-contractor	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	2,330	$2,471	-----	-----	1,208	$1,228	-----	-----
Alaska	27	70	8	$19	7	38	1,135	$2,059
Arizona	2,076	2,978	-----	-----	917	1,069	1,139	990
Arkansas	1,444	1,807	4	2	2,187	2,343	561	325
California	22,916	28,988	209	221	13,706	15,893	5,773	6,127
Colorado	2,184	2,620	5	16	874	877	434	650
Connecticut	2,001	2,459	-----	-----	1,663	2,426	153	62
Delaware	365	495	-----	-----	252	331	-----	-----
Florida	8,024	7,311	-----	-----	W	W	-----	-----
Georgia	3,016	2,997	-----	-----	384	305	-----	-----
Hawaii	476	1,618	-----	-----	8	8	-----	-----
Idaho	299	421	-----	-----	74	114	76	94
Illinois	6,363	6,611	-----	-----	8,821	8,910	113	68
Indiana	4,809	4,520	-----	-----	4,587	4,243	11	5
Iowa	3,396	3,487	-----	-----	3,106	3,339	37	21
Kansas	3,661	3,374	75	75	2,888	2,630	965	613
Kentucky	3,800	4,456	-----	-----	1,512	1,754	-----	-----
Louisiana	5,988	6,183	79	166	2,232	2,272	-----	-----
Maine	334	326	-----	-----	574	530	465	198
Maryland	5,705	8,014	-----	-----	1,403	2,285	91	32
Massachusetts	3,150	3,813	-----	-----	2,534	2,842	90	85
Michigan	8,179	7,172	13	6	5,366	4,886	1,715	903
Minnesota	5,008	4,503	-----	-----	3,231	2,136	1,285	759
Mississippi	2,432	2,111	-----	-----	1,636	1,446	73	99
Missouri	4,500	4,429	-----	-----	1,450	1,487	-----	-----
Montana	249	463	5	12	79	149	3,165	2,536
Nebraska	2,387	2,315	2	3	1,211	1,219	35	35
Nevada	973	1,543	23	23	428	559	1,043	1,084
New Hampshire	697	743	-----	-----	543	554	664	287
New Jersey	6,344	6,501	-----	-----	4,189	4,426	-----	-----
New Mexico	729	1,005	227	294	429	464	280	364
New York	9,786	12,637	43	65	3,143	4,279	290	202
North Carolina	3,521	3,343	-----	-----	837	882	1,759	1,172
North Dakota	473	589	-----	-----	161	162	1,183	1,160
Ohio	7,905	9,585	-----	-----	8,837	9,982	3	2
Oklahoma	1,862	1,943	288	359	939	1,012	781	749
Oregon	1,415	1,875	21	43	270	380	103	90
Pennsylvania	5,094	7,811	-----	-----	3,443	5,473	-----	-----
Rhode Island	643	789	-----	-----	195	229	23	29
South Carolina	2,908	1,967	-----	-----	W	W	-----	-----
South Dakota	485	529	5	4	148	207	1,015	982
Tennessee	1,703	2,527	-----	-----	787	1,381	-----	-----
Texas	6,102	6,151	8	9	4,141	4,742	1,205	1,435
Utah	859	1,192	1	2	681	627	2,279	1,975
Vermont	430	465	-----	-----	443	328	156	55
Virginia	3,852	4,762	-----	-----	2,999	2,516	26	9
Washington	2,681	3,332	(1)	1	905	951	229	246
West Virginia	1,764	2,393	-----	-----	415	667	-----	-----
Wisconsin	3,944	3,751	-----	-----	2,443	2,023	2,072	1,127
Wyoming	162	251	-----	-----	130	165	1,696	1,688
Undistributed	-----	-----	-----	-----	917	694	-----	-----
Total	169,451	191,696	1,016	1,320	99,333	107,463	32,123	28,317
American Samoa	-----	-----	7	7	-----	-----	-----	-----
Panama Canal Zone	60	97	-----	-----	-----	-----	-----	-----
Puerto Rico	2,726	6,730	137	425	1,945	4,445	30	98

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Less than ½ unit.

Table 4.—Sand and gravel sold or used by producers in the United States in 1969, by States, uses, and classes of operations—Continued

(Thousand short tons and thousand dollars)

State	Sand, construction—Continued									
	Railroad ballast (commercial)		Fill				Other [2]			
			Commercial		Government-and-contractor		Commercial		Government-and-contractor	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	-----	-----	79	$31	-----	-----	W	W	-----	-----
Alaska	-----	-----	13	19	134	$154	-----	-----	-----	-----
Arizona	-----	-----	629	199	35	36	W	W	-----	-----
Arkansas	-----	-----	222	105	-----	-----	W	W	-----	-----
California	W	W	3,991	3,854	628	605	498	$527	4	$4
Colorado	-----	-----	202	143	30	37	57	33	2	1
Connecticut	-----	-----	313	180	15	10	274	292	25	16
Delaware	-----	-----	W	W	-----	-----	W	W	-----	-----
Florida	-----	-----	W	W	671	531	W	W	-----	-----
Georgia	-----	-----	22	18	-----	-----	-----	-----	-----	-----
Hawaii	-----	-----	9	10	-----	-----	3	17	-----	-----
Idaho	1	W	24	16	3	2	18	14	1	(1)
Illinois	-----	-----	W	W	230	138	W	W	-----	-----
Indiana	W	W	1,528	976	-----	-----	W	W	14	9
Iowa	W	W	1,472	1,026	2	1	W	W	3	1
Kansas	W	W	1,306	659	59	30	131	168	-----	-----
Kentucky	W	W	875	768	-----	-----	W	W	-----	-----
Louisiana	-----	-----	W	W	-----	-----	-----	-----	-----	-----
Maine	-----	-----	327	148	-----	-----	W	W	29	10
Maryland	-----	-----	W	W	-----	-----	W	W	-----	-----
Massachusetts	-----	-----	561	280	-----	-----	785	907	5	7
Michigan	-----	-----	4,189	2,076	356	148	W	W	135	63
Minnesota	13	W	622	328	42	19	W	W	31	14
Mississippi	W	W	W	W	-----	-----	W	W	-----	-----
Missouri	W	W	325	299	-----	-----	85	102	-----	-----
Montana	W	W	3	3	21	11	34	43	243	121
Nebraska	-----	-----	635	680	14	7	2	2	-----	-----
Nevada	-----	-----	125	122	6	4	8	16	16	16
New Hampshire	-----	-----	714	322	18	6	43	32	-----	-----
New Jersey	-----	-----	1,363	636	-----	-----	86	120	-----	-----
New Mexico	13	$13	76	42	25	12	-----	-----	2	2
New York	-----	-----	1,522	1,059	3,171	1,589	806	877	721	332
North Carolina	W	W	189	187	341	256	W	W	501	161
North Dakota	-----	-----	162	120	-----	-----	5	6	-----	-----
Ohio	-----	-----	1,670	1,066	-----	-----	304	349	-----	-----
Oklahoma	W	W	280	192	5	4	214	188	-----	-----
Oregon	W	W	417	396	6	3	58	70	12	12
Pennsylvania	-----	-----	89	138	-----	-----	235	443	-----	-----
Rhode Island	-----	-----	W	W	-----	-----	W	W	-----	-----
South Carolina	W	W	W	W	-----	-----	-----	-----	-----	-----
South Dakota	-----	-----	68	54	1	1	-----	-----	21	12
Tennessee	-----	-----	W	W	-----	-----	W	W	-----	-----
Texas	-----	-----	927	624	-----	-----	301	293	-----	-----
Utah	-----	-----	119	66	80	40	W	W	24	24
Vermont	-----	-----	65	29	-----	-----	W	W	16	9
Virginia	W	W	571	320	42	15	W	W	-----	-----
Washington	W	W	718	416	31	15	86	84	125	81
West Virginia	-----	-----	W	W	-----	-----	W	W	-----	-----
Wisconsin	-----	-----	2,030	1,043	156	70	W	W	238	119
Wyoming	-----	-----	74	80	1	1	-----	-----	-----	-----
Undistributed	636	543	6,981	5,387	-----	-----	1,398	1,230	-----	-----
Total	663	556	35,507	24,117	6,123	3,745	5,431	5,813	2,168	1,014
American Samoa	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Panama Canal Zone	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Puerto Rico	-----	-----	1,012	1,205	-----	-----	-----	-----	-----	-----

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Less than ½ unit.
[2] Includes unspecified.

Table 4.—Sand and gravel sold or used by producers in the United States in 1969, by States, uses, and classes of operations—Continued

(Thousand short tons and thousand dollars)

State	Sand, industrial (commercial)									
	Glass		Molding		Grinding and polishing		Blast		Fire or furnace	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	-----	-----	W	W	-----	-----	-----	-----	W	W
Alaska	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Arizona	-----	-----	-----	-----	-----	-----	W	W	-----	-----
Arkansas	147	W	208	W	-----	-----	8	W	-----	-----
California	1,366	$6,533	W	W	-----	-----	263	$1,288	W	W
Colorado	-----	-----	-----	-----	-----	-----	W	W	W	W
Connecticut	-----	-----	W	W	-----	-----	-----	-----	-----	-----
Delaware	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Florida	W	W	W	W	-----	-----	W	W	-----	-----
Georgia	W	W	W	W	-----	-----	W	W	-----	-----
Hawaii	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Idaho	W	W	-----	-----	-----	-----	W	W	-----	-----
Illinois	2,137	5,102	1,159	$4,305	W	W	150	795	-----	-----
Indiana	W	W	W	W	-----	-----	-----	-----	W	W
Iowa	-----	-----	W	W	-----	-----	W	W	-----	-----
Kansas	-----	-----	-----	-----	-----	-----	W	W	-----	-----
Kentucky	-----	-----	-----	-----	-----	-----	W	W	-----	-----
Louisiana	-----	-----	-----	-----	-----	-----	W	W	-----	-----
Maine	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Maryland	W	W	-----	-----	W	W	W	W	-----	-----
Massachusetts	-----	-----	W	W	-----	-----	W	W	-----	-----
Michigan	W	W	4,468	8,734	-----	-----	(1)	W	-----	-----
Minnesota	W	W	W	W	-----	-----	W	W	-----	-----
Mississippi	-----	-----	W	W	-----	-----	-----	-----	-----	-----
Missouri	588	1,744	W	W	W	W	W	W	-----	-----
Montana	-----	-----	-----	-----	-----	-----	W	W	-----	-----
Nebraska	-----	-----	-----	-----	-----	-----	(1)	(1)	-----	-----
Nevada	W	W	W	W	-----	-----	-----	-----	W	W
New Hampshire	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
New Jersey	1,337	5,669	1,431	5,216	-----	-----	129	647	73	$115
New Mexico	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
New York	-----	-----	166	764	-----	-----	-----	-----	-----	-----
North Carolina	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
North Dakota	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Ohio	W	W	525	2,282	-----	-----	W	W	W	W
Oklahoma	W	W	W	W	-----	-----	W	W	-----	-----
Oregon	-----	-----	-----	-----	-----	-----	9	4	-----	-----
Pennsylvania	W	W	542	869	W	W	W	W	38	132
Rhode Island	-----	-----	W	W	-----	-----	-----	-----	-----	-----
South Carolina	W	W	W	W	-----	-----	17	90	W	W
South Dakota	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Tennessee	W	W	W	W	-----	-----	W	W	13	31
Texas	W	W	W	W	-----	-----	W	W	W	W
Utah	-----	-----	-----	-----	-----	-----	2	5	-----	-----
Vermont	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Virginia	W	W	-----	-----	-----	-----	-----	-----	W	W
Washington	-----	-----	-----	-----	-----	-----	W	W	-----	-----
West Virginia	W	W	W	W	W	W	W	W	W	W
Wisconsin	W	W	916	2,516	-----	-----	68	236	-----	-----
Wyoming	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Undistributed	4,972	17,350	1,574	6,055	354	$995	573	3,678	349	727
Total	10,547	36,398	10,989	30,741	354	995	1,219	6,743	473	1,005
American Samoa	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Panama Canal Zone	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Puerto Rico	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Less than ½ unit.

Table 4.—Sand and gravel sold or used by producers in the United States in 1969, by States, uses, and classes of operations—Continued

(Thousand short tons and thousand dollars)

State	Sand, industrial (commercial)—Continued									
	Engine		Filtration		Oil (hydrafrac)		Other		Ground sand	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	W	W	-----	-----	-----	-----	W	W	-----	-----
Alaska	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Arizona	10	$12	(1)	W	W	W	-----	-----	-----	-----
Arkansas	1	W	-----	-----	-----	-----	45	W	12	W
California	71	184	W	W	W	W	52	$195	87	$813
Colorado	W	W	W	W	W	W	W	W	-----	-----
Connecticut	-----	-----	W	W	-----	-----	-----	-----	-----	-----
Delaware	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Florida	W	W	W	W	-----	-----	W	W	W	W
Georgia	W	W	W	W	-----	-----	W	W	W	W
Hawaii	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Idaho	-----	-----	(1)	W	-----	-----	W	W	-----	-----
Illinois	W	W	W	W	W	W	W	W	W	W
Indiana	W	W	-----	-----	-----	-----	W	W	W	W
Iowa	-----	-----	W	W	-----	-----	-----	-----	-----	-----
Kansas	46	42	-----	-----	-----	-----	W	W	-----	-----
Kentucky	W	W	-----	-----	-----	-----	-----	-----	W	W
Louisiana	-----	-----	-----	-----	-----	-----	-----	-----	W	W
Maine	W	W	-----	-----	-----	-----	W	W	-----	-----
Maryland	-----	-----	-----	-----	-----	-----	W	W	W	W
Massachusetts	-----	-----	W	W	-----	-----	-----	-----	-----	-----
Michigan	W	W	-----	-----	-----	-----	W	W	W	W
Minnesota	W	W	-----	-----	W	W	-----	-----	W	W
Mississippi	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Missouri	-----	-----	W	W	-----	-----	W	W	W	W
Montana	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Nebraska	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Nevada	-----	-----	-----	-----	-----	-----	W	W	-----	-----
New Hampshire	W	W	W	W	-----	-----	W	(1)	-----	-----
New Jersey	W	W	W	W	W	W	162	775	131	1,270
New Mexico	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
New York	W	W	W	W	-----	-----	W	W	W	W
North Carolina	-----	-----	W	W	-----	-----	-----	-----	-----	-----
North Dakota	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Ohio	W	W	W	W	-----	-----	W	W	W	W
Oklahoma	-----	-----	-----	-----	(1)	W	W	W	W	W
Oregon	W	W	-----	-----	-----	-----	W	W	-----	-----
Pennsylvania	W	W	-----	-----	(1)	W	170	510	51	711
Rhode Island	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
South Carolina	W	W	W	W	-----	-----	W	W	104	834
South Dakota	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Tennessee	W	W	-----	-----	-----	-----	W	W	W	W
Texas	W	W	W	W	W	W	57	153	107	744
Utah	10	24	-----	-----	-----	-----	-----	-----	11	30
Vermont	W	W	-----	-----	-----	-----	-----	-----	-----	-----
Virginia	W	W	-----	-----	-----	-----	W	W	W	W
Washington	-----	-----	-----	-----	-----	-----	-----	-----	54	483
West Virginia	W	W	W	W	(1)	W	W	W	W	W
Wisconsin	W	W	W	W	W	W	-----	-----	-----	-----
Wyoming	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Undistributed	782	1,800	194	$745	274	$2,046	1,664	5,189	1,343	9,575
Total	920	2,062	194	745	274	2,046	2,150	6,822	1,900	14,460
American Samoa	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Panama Canal Zone	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Puerto Rico	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Less than ½ unit.

Table 4.—Sand and gravel sold or used by producers in the United States in 1969, by States, uses, and classes of operations—Continued

(Thousand short tons and thousand dollars)

State	Gravel, construction									
	Building				Paving				Railroad ballast (commercial)	
	Commercial		Government-and-contractor		Commercial		Government-and-contractor			
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	2,240	$3,049	-----	-----	1,034	$1,274	-----	-----	-----	-----
Alaska	36	89	93	$206	175	414	3,756	$5,798	-----	-----
Arizona	3,420	4,437	-----	-----	2,098	2,469	4,739	4,038	-----	-----
Arkansas	1,675	2,821	5	5	3,722	4,175	2,038	1,697	W	W
California	24,984	33,190	508	522	30,086	38,139	15,123	13,425	70	$92
Colorado	2,942	4,819	28	75	3,645	4,619	7,883	11,742	W	W
Connecticut	1,438	2,403	-----	-----	1,003	1,354	827	299	W	W
Delaware	75	154	-----	-----	1,057	759	-----	-----	-----	-----
Florida	W	W	-----	-----	W	W	1	(1)	-----	-----
Georgia	W	W	-----	-----	(1)	W	-----	-----	-----	-----
Hawaii	2	6	-----	-----	54	158	-----	-----	-----	-----
Idaho	345	511	1	5	1,078	1,157	5,801	4,496	17	W
Illinois	8,384	8,409	4	2	11,321	13,307	514	337	W	W
Indiana	3,493	4,528	-----	-----	7,793	8,934	833	469	W	W
Iowa	1,362	2,419	-----	-----	6,939	5,871	1,611	1,086	W	W
Kansas	253	287	-----	-----	1,224	1,079	1,196	766	-----	-----
Kentucky	980	1,244	-----	-----	655	903	238	118	30	51
Louisiana	6,269	8,275	151	314	3,024	4,059	186	136	-----	-----
Maine	198	224	-----	-----	1,008	988	7,702	3,204	W	W
Maryland	3,588	6,170	-----	-----	1,240	2,295	150	53	-----	-----
Massachusetts	3,149	5,115	-----	-----	3,539	4,252	2,868	2,676	12	19
Michigan	7,291	11,087	11	7	19,647	17,637	4,956	3,094	173	260
Minnesota	3,680	6,623	-----	-----	27,039	20,269	4,772	3,198	198	139
Mississippi	2,423	2,797	-----	-----	4,277	4,898	271	352	-----	-----
Missouri	2,369	3,098	-----	-----	1,019	973	53	50	-----	-----
Montana	377	547	4	12	1,049	1,245	9,618	8,119	98	140
Nebraska	1,519	1,843	10	37	5,972	6,676	732	567	16	21
Nevada	1,307	2,392	19	19	1,465	1,506	1,991	1,728	-----	-----
New Hampshire	748	1,120	-----	-----	793	936	1,298	571	-----	-----
New Jersey	2,595	5,092	-----	-----	1,832	2,489	-----	-----	-----	-----
New Mexico	860	1,429	197	248	1,076	1,376	4,374	4,943	-----	-----
New York	4,787	7,238	-----	-----	3,832	4,599	5,530	4,837	W	W
North Carolina	1,223	2,221	-----	-----	1,133	1,379	409	260	W	W
North Dakota	411	821	3	2	2,613	2,630	1,746	1,619	133	58
Ohio	8,699	11,299	-----	-----	15,292	20,213	22	19	W	W
Oklahoma	19	31	33	72	51	70	96	99	-----	-----
Oregon	2,942	3,705	280	360	5,191	6,646	3,220	5,049	W	W
Pennsylvania	3,630	5,900	-----	-----	3,476	5,714	-----	-----	W	W
Rhode Island	721	1,074	-----	-----	375	390	48	87	-----	-----
South Carolina	W	W	-----	-----	W	W	-----	-----	-----	-----
South Dakota	217	313	624	629	2,282	2,188	6,222	5,822	-----	-----
Tennessee	692	956	-----	-----	1,405	1,503	579	475	W	W
Texas	5,488	7,981	3	4	5,728	8,056	4,515	5,179	-----	-----
Utah	1,204	1,844	2	3	2,417	2,686	10,264	7,484	1	1
Vermont	593	988	-----	-----	701	697	521	183	-----	-----
Virginia	2,501	4,569	-----	-----	1,271	1,940	3	1	-----	-----
Washington	4,705	5,993	-----	-----	6,504	7,672	6,013	5,028	W	W
West Virginia	1,420	1,892	-----	-----	923	1,373	-----	-----	W	W
Wisconsin	4,236	4,145	-----	-----	16,123	13,355	8,035	5,319	157	107
Wyoming	220	354	-----	-----	2,521	2,210	2,373	2,351	295	110
Undistributed	1,935	3,920	-----	-----	277	540	-----	-----	989	973
Total	133,645	189,422	1,976	2,522	216,979	238,072	133,127	116,774	2,189	1,971
American Samoa	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Panama Canal Zone	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Puerto Rico	1,760	5,839	-----	-----	1,147	3,779	-----	-----	-----	-----

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Less than ½ unit.

Table 4.—Sand and gravel sold or used by producers in the United States in 1969, by States, uses, and classes of operations—Continued

(Thousand short tons and thousand dollars)

State	Gravel, construction—Continued								Gravel, miscellaneous (commercial)	
	Fill				Other					
	Commercial		Government-and-contractor		Commercial		Government-and-contractor			
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	W	W	-----	-----	152	$190	-----	-----	W	W
Alaska	686	$492	10,136	$9,257	-----	-----	-----	-----	-----	-----
Arizona	1,140	1,379	216	250	3	1	-----	-----	12	$29
Arkansas	54	45	-----	-----	W	W	-----	-----	21	31
California	1,479	1,383	460	446	736	876	-----	-----	1,441	2,182
Colorado	377	365	813	647	W	W	-----	-----	215	303
Connecticut	790	383	44	33	146	225	-----	-----	147	192
Delaware	W	W	-----	-----	W	W	-----	-----	-----	-----
Florida	W	W	-----	-----	2	10	-----	-----	-----	-----
Georgia	W	W	-----	-----	-----	-----	-----	-----	-----	-----
Hawaii	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Idaho	167	114	544	279	62	50	9	$9	-----	-----
Illinois	1,503	1,273	-----	-----	W	W	-----	-----	-----	-----
Indiana	2,471	1,680	9	4	W	W	-----	-----	-----	-----
Iowa	W	W	-----	-----	(1)	W	9	4	-----	-----
Kansas	35	32	-----	-----	18	30	-----	-----	97	196
Kentucky	121	87	1	(1)	W	W	-----	-----	-----	-----
Louisiana	-----	-----	-----	-----	-----	-----	-----	-----	W	W
Maine	256	128	33	12	W	W	-----	-----	W	W
Maryland	W	W	3	1	W	W	-----	-----	W	W
Massachusetts	1,849	1,356	2	2	249	351	1	2	506	513
Michigan	325	247	246	111	80	90	-----	-----	-----	-----
Minnesota	1,428	617	159	64	62	60	28	13	-----	-----
Mississippi	W	W	-----	-----	W	W	-----	-----	W	W
Missouri	41	28	-----	-----	5	8	-----	-----	98	88
Montana	155	109	279	158	94	152	1,119	560	-----	-----
Nebraska	60	34	4	2	-----	-----	-----	-----	160	151
Nevada	350	294	371	365	(1)	W	59	73	84	227
New Hampshire	479	238	-----	-----	47	99	-----	-----	260	224
New Jersey	296	245	-----	-----	174	315	-----	-----	106	202
New Mexico	45	29	201	134	-----	-----	23	22	17	44
New York	1,845	1,163	3,364	1,820	W	W	68	63	380	461
North Carolina	W	W	-----	-----	-----	-----	-----	-----	W	W
North Dakota	109	70	9	4	-----	-----	-----	-----	32	32
Ohio	3,700	2,827	2	1	W	W	-----	-----	561	1,005
Oklahoma	W	W	-----	-----	7	8	-----	-----	9	24
Oregon	567	451	120	71	958	1,110	32	97	-----	-----
Pennsylvania	W	W	-----	-----	88	105	-----	-----	93	157
Rhode Island	W	W	-----	-----	-----	-----	-----	-----	W	W
South Carolina	W	W	-----	-----	-----	-----	-----	-----	W	W
South Dakota	43	38	19	18	-----	-----	-----	-----	9	8
Tennessee	W	W	40	40	W	W	-----	-----	W	W
Texas	280	162	12	6	438	639	-----	-----	1	1
Utah	287	148	853	604	34	40	-----	-----	24	39
Vermont	229	113	-----	-----	W	W	-----	-----	W	W
Virginia	W	W	7	7	W	W	-----	-----	72	123
Washington	1,248	942	9,749	4,888	628	527	68	42	-----	-----
West Virginia	W	W	-----	-----	-----	-----	-----	-----	-----	-----
Wisconsin	1,693	981	538	253	15	15	7	5	-----	-----
Wyoming	51	38	6	4	-----	-----	-----	-----	38	34
Undistributed	2,919	1,764	-----	-----	1,251	1,497	-----	-----	1,790	3,175
Total	27,078	19,255	28,240	19,481	5,249	6,398	1,423	890	6,173	9,441
American Samoa	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Panama Canal Zone	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Puerto Rico	675	776	-----	-----	-----	-----	-----	-----	-----	-----

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Less than ½ unit.

Table 5.—Sand and gravel sold or used by Government-and-contractor producers in the United States, by uses

(Thousand short tons and thousand dollars)

Year	Sand							
	Building		Paving		Fill		Other	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1965	316	$328	37,460	$29,695	14,824	$7,112	2,722	$2,038
1966	808	943	37,087	29,702	12,920	8,430	1,663	927
1967	660	800	r 38,497	r 31,512	11,747	8,737	2,738	1,836
1968	819	893	35,550	27,297	7,327	3,997	2,615	1,920
1969	1,016	1,320	32,123	28,317	6,123	3,745	2,168	1,014

Year	Gravel								Total Government-and-contractor sand and gravel [1]	
	Building		Paving		Fill		Other			
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1965	1,297	$1,028	149,111	$133,800	45,143	$35,410	1,292	$1,347	252,165	$210,758
1966	2,869	3,131	158,709	134,180	39,298	29,268	1,530	1,441	254,884	208,022
1967	863	1,074	r 153,274	r 132,734	26,145	21,500	4,374	4,062	r 238,298	r 202,233
1968	1,830	1,841	121,893	103,803	32,837	27,679	3,934	3,972	206,805	171,327
1969	1,976	2,522	133,127	116,774	28,240	19,481	1,423	890	206,189	174,070

r Revised.
[1] Data may not add to totals shown because of independent rounding.

Table 6.—Sand and gravel sold or used by Government-and-contractor producers in the United States, by types of producer

(Thousand short tons and thousand dollars)

Type of producer	1965		1966		1967		1968		1969	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Construction and maintenance crews	62,822	$39,611	67,163	$43,821	68,655	$44,903	62,939	$42,146	65,786	$45,691
Contractor	189,343	171,147	187,721	164,201	r 169,643	r 157,330	143,866	129,176	140,403	128,377
Total [1]	252,165	210,758	254,884	208,022	r 238,298	r 202,233	206,805	171,327	206,189	174,070
State	159,758	144,287	150,304	131,921	r 148,697	r 134,243	125,627	108,980	122,484	108,414
Counties	59,730	40,987	60,966	41,973	60,004	41,390	53,087	38,408	52,547	39,429
Municipalities	3,278	2,343	2,916	2,576	3,001	2,202	4,200	3,208	3,784	4,466
Federal agencies	29,399	23,141	40,698	31,552	26,596	24,398	23,891	20,731	27,374	21,761
Total	252,165	210,758	254,884	208,022	r 238,298	r 202,233	206,805	171,327	206,189	174,070

r Revised.
[1] Data may not add to totals shown because of independent rounding.

Table 7.—Sand and gravel sold or used by producers in the United States by classes of operation and degree of preparation

(Thousand short tons and thousand dollars)

	1968		1969	
	Quantity	Value	Quantity	Value
Commercial operations:				
Prepared	r 649,554	r $810,017	668,150	$854,470
Unprepared	61,109	38,688	62,569	41,766
Total [1]	r 710,663	r 848,705	730,717	896,234
Government-and-contractor operations:				
Prepared	160,663	137,922	156,394	142,967
Unprepared	46,142	33,407	49,793	31,103
Total [1]	206,805	171,327	206,189	174,070
Grand total [1]	r 917,468	r 1,020,107	936,906	1,070,302

r Revised.
[1] Data may not add to totals shown because of independent rounding.

Table 8.—Number and production of domestic commercial sand and gravel plants by size of operation

Annual production (short tons)	1968 Plants [1] Number	1968 Plants [1] Percent of total	1968 Production Thousand short tons	1968 Production Percent of total	1969 Plants [1] Number	1969 Plants [1] Percent of total	1969 Production Thousand short tons	1969 Production Percent of total
Less than 25,000	2,404	38.2	r 25,325	3.6	2,375	37.7	26,219	3.6
25,000 to 50,000	1,026	16.3	38,263	5.4	1,047	16.6	38,513	5.3
50,000 to 100,000	1,039	16.5	76,197	10.7	1,023	16.2	74,626	10.2
100,000 to 200,000	854	13.5	r 122,762	r 17.3	855	13.6	122,222	16.7
200,000 to 300,000	420	6.7	r 101,740	r 14.3	414	6.6	100,416	13.7
300,000 to 400,000	168	2.7	r 59,250	8.3	208	3.2	72,899	10.0
400,000 to 500,000	127	2.0	r 56,200	8.0	113	1.8	50,139	6.9
500,000 to 600,000	80	1.3	43,979	6.2	81	1.3	44,377	6.1
600,000 to 700,000	45	.7	29,441	4.1	40	.6	25,810	3.5
700,000 to 800,000	19	.3	14,483	2.0	41	.6	30,794	4.2
800,000 to 900,000	30	.5	25,479	3.6	20	.3	17,072	2.3
900,000 to 1,000,000	18	.3	17,063	2.4	18	.3	17,278	2.4
1,000,000 and over	66	1.0	100,481	14.1	73	1.2	110,352	15.1
Total	6,296	100.0	r 710,663	100.0	6,308	100.0	730,717	100.0

r Revised.
[1] Includes a few companies operating more than 1 plant but not submitting returns for individual plants.

Table 9.—Sand and gravel sold or used in the United States, by classes of operation and methods of transportation

	1968		1969	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Commercial:				
Truck	r 616,891	67	641,762	69
Rail	r 58,199	6	56,565	6
Waterway	34,294	4	31,912	3
Unspecified	1,279	(1)	477	(1)
Total commercial [2]	r 710,663	77	730,717	78
Government-and-contractor: Truck [3]	206,805	23	206,189	22
Grand total [2]	r 917,468	100	936,906	100

r Revised.
1 Less than 0.5 percent.
2 Data may not add to totals shown because of independent rounding.
3 Entire output of Government-and-contractor operations assumed to be moved by truck.

Table 10.—Ground sand sold or used by producers in the United States,[1] by uses

(Thousand short tons and thousand dollars)

Use	1968		1969	
	Quantity	Value	Quantity	Value
Abrasives	179	$1,733	253	$2,191
Chemicals	96	535	291	799
Enamel	13	143	52	493
Filler	117	988	123	1,253
Foundry uses	183	1,141	274	1,725
Glass	207	1,357	330	1,951
Pottery, porcelain, tile	258	2,708	269	2,913
Unspecified	295	3,128	309	3,132
Total [2]	1,348	11,733	1,900	14,460

1 Arkansas, California, Florida, Georgia, Idaho, Illinois, Indiana, Kansas (1968 only), Kentucky, Louisiana, Maryland (1969 only), Michigan, Minnesota, Missouri, New Jersey, New York, Ohio, Oklahoma, Pennsylvania, South Carolina, Tennessee, Texas, Utah, Virginia, Washington (1969 only), West Virginia, and Wisconsin (1968 only).
2 Data may not add to totals shown because of independent rounding.

Table 11.—U.S. imports for consumption of sand and gravel, by class

(Thousand short tons and thousand dollars)

Year	Glass sand [1]		Sand, n.s.p.f., crude or manufactured, and gravel		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1967	44	$159	588	$753	632	$912
1968	25	144	729	984	754	1,128
1969	43	194	854	1,253	897	1,447

1 Classification reads: "Sands containing 95 percent or more silica and not more than 0.6 percent oxide of iron and suitable for manufacturing glass."

Silicon

By Frank L. Fisher [1]

Production of silicon metal and ferrosilicon increased to meet sharply rising demands for a wide variety of products. A worldwide shortage of ferrosilicon, especially in Europe, was reflected in higher prices for the major silicon-bearing ferroalloys. High-purity metal continued to make impressive gains in electronic applications, especially in silicon carbide and nitride fibers and whiskers, and in numerous new uses for silicones.

DOMESTIC PRODUCTION

Production of silicon metal showed a slight increase over that of 1968. Consumer stocks remained relatively unchanged. The rise in production paralleled the worldwide increase in demand for the ferroalloys. In addition, a wider variety of ferrosilicon types and grades, plus closer quality control, were made necessary by a change in demand from a greater number of electric furnaces with larger individual capacities.

Demand for both monocrystal and polycrystal high-purity silicon rose sharply during the year. The increase was particularly significant in new uses for silicon carbide and silicon nitride fibers and whiskers. The production of both high-purity silicon and ferrosilicon continued to be adversely affected by the shortage of low-cost electric power required for their production. The Carborundum Co., world's largest manufacturer of silicon carbide, announced plans for a major expansion of its facilities with construction of a multimillion-dollar plant at Jacksboro, Tenn.

[1] Physical scientist, Bureau of Mines, Minneapolis, Minn.

Table 1.—Production, shipments, and stocks of silvery pig iron, ferrosilicon, and silicon metal in 1969 [1]

(Short tons, gross weight)

Alloy	Silicon content (percent)	Producers' stocks as of Dec. 31, 1968	Production	Shipments	Producers' stocks as of Dec. 31, 1969
Silvery pig iron	5–20	r 46,931	216,586	240,458	27,736
Ferrosilicon	21–55	31,944	396,032	392,167	36,942
Do	56–70	3,992	12,145	12,563	3,346
Do	71–80	12,783	98,499	97,197	14,613
Do	81–89	3,157	27,708	28,731	2,245
Do	90–95	121	873	924	214
Silicon metal	96–99	4,853	100,890	102,226	3,778
Ferrosilicon briquets	40–50	2,111	69,993	68,543	3,173
Miscellaneous silicon alloys	-----	5,411	36,823	36,794	5,259

r Revised.

[1] Excludes ferrosilicon used to make other silicon alloys.

Table 2.—Producers of silicon alloys and/or silicon metal in the United States in 1969

Producers	Plant location	Product
Air Reduction Co., Inc., Airco Alloys and Carbide Division.	Calvert City, Ky	FeSi.
Do	Niagara Falls, N.Y	FeSi, silvery iron.
Calumet & Hecla, Inc	Selma, Ala	FeSi.
Chromium Mining and Smelting Corp	Woodstock, Tenn	Do.
Foote Mineral Co	Graham, W. Va	Do.
Do	Keokuk, Iowa	FeSi, silvery iron.
Do	Vancoram, Ohio	FeSi.
Do	Wenatchee, Wash	Do.
The Hanna Furnace Corp	Buffalo, N.Y	Silvery iron.
Hanna Nickel Smelting Co	Riddle, Oreg	FeSi.
Interlake Steel Corp	Beverly, Ohio	FeSi, silvery iron, Si.
Jackson Iron & Steel Co	Jackson, Ohio	Silvery iron.
National Metallurgical Corp	Springfield, Oreg	Si.
Ohio Ferro-Alloys Corp	Brilliant, Ohio	FeSi, Si.
Do	Philo, Ohio	Do.
Do	Powhatan Point, Ohio	Do.
Do	Tacoma, Wash	Do.
Reynolds Metals Co	Sheffield, Ala	Si.
Union Carbide Corp., Ferro Alloys Division	Alloy, W. Va	FeSi, Si.
Do	Ashtabula, Ohio	FeSi.
Do	Marietta, Ohio	Do.
Do	Portland, Oreg	Do.
Do	Sheffield, Ala	Do.
Woodward Corp	Woodward, Ala	Do.

CONSUMPTION AND USES

The use of silicon and its compounds increased over that of 1968. Consumption of silicon in conventional uses such as silvery pig iron, ferrosilicon, and silicon metal showed slight gains. The major increase was realized in widespread applications as silicones, silicon carbides, and nitrides. Silcones, the name adopted for the silicon-oxygen polymer chains, were widely used during the year as fluids, resins, and elastomers for adhesives, sealants, lubricants, insulators, and special molds. Consumer stocks of ferrosilicon and high-purity silicon were unchanged at the end of the year.

The fastest growth in consumption of silicones during 1969 was reported for room-temperature vulcanizing (RTV). Other major uses were for resins and heat-curable rubber. Silicon nitrides and carbides were used in increased quantities in high tem-

Table 3.—Consumption by major end uses and stocks of silicon alloys and metal in the United States in 1969

(Short tons)

	Silvery pig iron	Ferrosilicon [1]				Silicon metal	Miscellaneous silicon alloys [2]
	Silicon content (percent)						
	5–24	25–55	56–70	71–80	81–95	96–99	
Steel:							
Carbon	11,228	117,387	4,861	26,016	223	1,721	16,148
Stainless and heat-resisting	------	19,152	347	6,979	189	198	251
Alloy (excludes stainless and heat-resisting)	6,224	42,556	4,849	31,895	1,693	1,402	7,164
Tool	------	2,321	50	537	W	W	72
Cast irons	141,016	185,432	1,936	19,743	7,596	W	59,644
Superalloys	W	364	------	W	W	53	17
Alloys (excludes alloy steels and superalloys)	65	3,331	W	207	3,801	42,016	4,648
Miscellaneous and unspecified	4,979	14,092	483	378	1,141	20,436	807
Total	163,512	384,635	12,526	85,755	14,643	65,826	88,751
Consumer stocks Dec. 31, 1969	13,598	28,378	943	7,371	1,632	5,465	7,251

W Withheld to avoid disclosing individual company confidential data; included in "Miscellaneous and unspecified."

[1] Includes briquets.

[2] Includes magnesium-ferrosilicon and other silicon alloys.

perature applications because of their exceptional insulation, hardness, and rigidity under elevated temperatures. Three companies comprised the 1969 silicone market. Dow Corning Corp. was reported to have 50 percent of the volume. The remainder was equally shared by Union Carbide Corp. and and the General Electric Co.

PRICES

Silicon metal prices vary with the percentage of iron contained. Silicon metal with a maximum of 0.35 percent iron was quoted at 21.55 cents per pound at year-end after four across-the-board increases. The metal with 1.00 to 1.50 percent iron content was 18.65 cents per pound. The price of 50-percent-grade ferrosilicon increased from 13.8 cents per pound of contained silicon at the beginning of the year to 14.1 cents per pound in December 1969. The price of electronic-grade, high-purity silicon remained high, but its use in electronic and other applications required only minute quantities per unit or device. At the end of 1969, solar-grade high-purity silicon was $70 per pound and the semiconductor or electronic grade was quoted at $130 to $355 per pound. As the prices for the many silicon-bearing ferroalloys are usually based on the amount of contained silicon in the alloy, these alloys generally followed a uniform price change after the announced changes in silicon metal prices.

FOREIGN TRADE

Exports of ferrosilicon dropped sharply during the year; 6,487 tons valued at nearly $1.7 million were exported. Canada and the United Kingdom were the major importers of United States metal and acquired 69 percent of the quantity shipped, valued at $1,095,056. Twenty countries received shipments varying in quantity from 1 to 670 short tons. Imports for consumption increased substantially in quantity and value for all grades. The major rise in imports was for 60 to 80 percent silicon grade. Norway, France, and Yugoslavia were the major sources of supply.

Imports for consumption of silicon metal with less than 99.7 percent silicon content were 58,880 pounds gross weight containing 55,913 pounds of silicon valued at $1,178,000. Italy supplied 52,947 pounds of the metal, with the remainder coming from the United Kingdom. Imports of silicon metal with more than 99.7 percent silicon content totaled 78,938 pounds valued at $2,742,743 and were from six countries, with 89 percent coming from West Germany.

Table 4.—U.S. exports of ferrosilicon

Year	Short tons	Value (thousands)
1967	11,774	$3,228
1968	18,372	4,481
1969	6,487	1,666

Table 5.—U.S. imports for consumption of ferrosilicon, by grades and countries

Grade and country	1967			1968			1969		
	Short tons		Value (thousands)	Short tons		Value (thousands)	Short tons		Value (thousands)
	Gross weight	Silicon content		Gross weight	Silicon content		Gross weight	Silicon content	
8 percent and less than 60 percent silicon:									
Canada	10,673	1,846	$621	12,419	2,608	$729	15,344	4,515	$1,074
France	215	116	67	354	171	97	568	270	166
Germany, West	502	242	144	281	130	74	77	39	22
Italy	------	------	------	------	------	------	31	15	11
Japan	2,621	1,265	698	3,459	1,705	884	3,534	1,683	850
Norway	552	247	180	1	(1)	(1)	3	1	(1)
South Africa, Republic of	------	------	------	------	------	------	64	32	3
Total	14,563	3,716	1,710	16,514	4,614	1,784	19,621	6,555	2,126
60 percent and not more than 80 percent silicon:									
Canada	------	------	------	------	------	------	1,379	1,067	261
France	5,493	3,922	1,093	1,849	1,127	550	2,509	1,648	691
Germany, West	887	545	306	462	277	137	404	248	120
India	110	87	14	------	------	------	1,925	1,444	269
Japan	------	------	------	------	------	------	661	529	130
Norway	6,601	5,018	941	1,037	794	141	3,471	2,645	453
Portugal	27	21	4	------	------	------			
Rhodesia, Southern	------	------	------	1,459	1,117	186	------	------	------
South Africa, n.e.c.	------	------	------	21	16	3	------	------	------
South Africa, Republic of	549	420	84	1,292	1,006	183	1,410	1,095	203
Sweden	1,918	1,450	263	------	------	------	------	------	------
Yugoslavia	------	------	------	r 1,920	r 1,373	r 150	2,101	1,599	295
Total	15,585	11,463	2,705	8,040	5,710	1,350	13,860	10,275	2,422
Over 80 percent and not over 90 percent silicon:									
Italy	185	158	41	178	153	38	20	17	4
South Africa, Republic of	------	------	------	158	135	35	113	97	25
Total	185	158	41	336	288	73	133	114	29
Grand total	30,333	15,337	4,456	24,890	10,612	3,207	33,614	16,944	4,577

r Revised.
1 Less than ½ unit.

WORLD REVIEW

Canada.—A quartzite ore body reported to be the largest and purest silica deposit in Canada was being developed at Badgeley Island on Georgian Bay in Lake Huron. Owner and operator of the property is Indusmin Ltd., of Toronto, a subsidiary of Falconbridge Nickel Mines, Ltd. Mill facilities were under construction at Midland, Ontario. Production of 500,000 tons of processed silica per year is planned.

India.—Mysore Iron & Steel, Ltd., announced it was planning to increase its annual ferrosilicon output from the Bhadravati plant from 20,000 to 35,000 metric tons per year. Markets for the ferrosilicon available for export were expected to be the United Kingdom and the Netherlands.

Japan.—Efforts were advanced to increase Japanese silicon-processing capacity by adding two new plants. The three leading producers were Shin-Etsu Chemical Industry, Tokyo Shibaura Electric Co., and Showa Denko. The new firms will be Nippon Unicar Co. at Kawasaki and Ichikara Toray Silicone Co.

Luxembourg.—Aciéries Réunies de Burbach-Eich-Dudelange, Société Anonime (ARBED), a Luxembourg-based company, and Continental Ore Corp., New York, have announced plans to build a ferroalloy plant in Dommeldarge, Luxembourg. The plant, on the outskirts of the city of Luxembourg, is located within a 60-mile radius of one-third of all Europe's steel capacity.

Norway.—A serious drought in Norway during 1969 sharply curtailed production of silicon and its alloys. Hydroelectric power was rationed for several months, and production of silicon ferroalloys was reduced as much as 50 percent of normal capacity. Total ferroalloy exports from Norway in 1969 amounted to 350,000 metric tons. A/S Hafslund completed construction of a plant with an annual rated capacity of 35,000 metric tons at its Skjeberg works in eastern Norway. Elektrokemish A/S has added facilities at its Salten Verk in northern Norway designed to raise the firm's annual capacity to 83,000 metric tons. Norway continued to dominate the European ferrosilicon market. The United Kingdom is its major customer.

Silver

By Charles D. Hoyt[1]

The domestic mine output of silver surged 28 percent above the 1968 level primarily because there were no strikes during the year. With the exception of 1966 when production reached 43.7 million ounces, the 1969 output was the highest since 1950. Silver prices varied widely, declining from a peak early in January of about $2.00 per ounce to $1.56 late in June to early in July, then rising steadily again to almost the $2.00 level early in November and closing the year at almost $1.80. The Treasury Department's mid-May lifting of the ban on the melting of silver coins and at the same time the reduction of the General Services Administration (GSA) silver sales from 2.0 million ounces to 1.5 million ounces per week were the most significant events in the silver market for 1969.

U.S. silver consumption for industrial uses declined modestly (2.6 percent) and silver coinage use was reduced almost in half. Treasury stocks continued their precipitous decline, dropping almost 60 percent. Industrial stocks rose about one-fifth and almost reached the 200-million-ounce level compared with somewhat over 57 million in 1966. Trading activity on the New York Commodity Exchange was up 6.6 percent over the previous year. The net export pattern in silver sales continued in 1969 but exports declined considerably and imports were down slightly from 1968.

[1] Physical scientist, Division of Nonferrous Metals.

Table 1.–Salient silver statistics

	1965	1966	1967	1968	1969
United States:					
Mine production______thousand troy ounces__	39,806	43,669	32,345	32,729	41,906
Value______thousands__	$51,469	$56,464	$50,135	$70,191	$75,040
Ore (dry and siliceous) produced:					
Gold ore______thousand short tons__	3,113	2,580	2,315	2,003	2,002
Gold-silver ore______do____	205	248	157	199	216
Silver ore______do____	902	1,069	904	701	755
Percentage derived from—					
Dry and siliceous ores______	35	33	39	39	36
Base-metal ores______	65	67	61	61	64
Refinery production [1]___thousand troy ounces__	[2] 39,000	[2] 48,358	30,268	42,052	62,676
Exports [3]______do____	39,665	85,538	70,769	125,761	88,909
Imports, general [3]______do____	54,709	63,032	55,520	70,709	71,876
Stocks Dec. 31:					
Treasury [4]______thousand troy ounces__	804	594	351	256	104
Industry [5]______do____	--------	57,244	83,358	166,356	198,490
Consumption: Industry and the arts thousand troy ounces__	137,000	183,696	171,031	145,293	141,546
Coinage______do____	320,321	53,852	43,851	36,833	19,408
Price [6]______per troy ounce__	$1.293+	$1.293+	$1.550+	$2.144+	$1.790+
World:					
Production______thousand troy ounces__	257,415	266,731	258,203	275,075	288,601
Consumption:[7] Industry and the arts thousand troy ounces__	336,600	355,100	348,600	347,300	362,400
Coinage [8]______do____	381,100	130,700	89,200	59,500	24,300

[1] From domestic ores.
[2] U. S. Bureau of the Mint.
[3] Excludes coinage.
[4] Excludes silver in silver dollars.
[5] Includes silver in COMEX warehouses.
[6] Average New York price.
[7] Free world only. Source: Handy & Harman, 1965; U. S. Bureau of Mines, 1966–69.
[8] Free world only. Source: Handy & Harman.

Legislation and Government Programs.—In mid-May, following recommendations made by the Joint Commission on the Coinage, the U.S. Treasury lifted its ban on the melting of silver coins and also revised its weekly silver sales program administered by GSA. Effective May 12, 1969, the melting ban was lifted and the GSA weekly silver sales volume was reduced from 2.0 million ounces to 1.5 million ounces as of May 27. The GSA sales were opened to all competitive bidders, foreign and domestic, and the administrative ban on the export of silver coins also ended. The actual executive order appeared in the Federal Register, volume 34, No. 93, May 15, 1969. Concurrently the Joint Commission on the Coinage also recommended that the Treasury also ask for authority to mint a nonsilver dollar and a half dollar. Legislation was introduced and eventually passed the House but at yearend could not get Senate approval because of support for minting of 150 million Eisenhower memorial silver dollars which would consume about 47.5 million ounces of silver.

In 1969 the Office of Minerals Exploration (OME) of the U.S. Geological Survey provided exploration assistance to six prospects that potentially might provide future silver output. OME negotiated six contracts involving silver totaling $423,190 of which the Government's share was 49.5 percent. Three of these prospects were in Colorado, two in Nevada, and one in Utah.

DOMESTIC PRODUCTION

Mine output of recoverable silver rose by more than one-fourth compared with 1968 because of the absence of strikes in the copper industry which had reduced byproduct silver production drastically in both 1967 and 1968. Base metal ores provided 64 percent of the total silver output, and silver ores provided 35 percent with the remainder coming from gold and gold-silver production.

Idaho's silver output increased almost 19 percent and amounted to 45 percent of U.S. production. Output of silver in Arizona, Montana, Utah, and Colorado also rebounded comparably and the combined production of these four States and Idaho was 88.4 percent of domestic production.

The 25 leading silver producers contributed 80 percent of the total output. Four of the leading producers (1st, 3d, 7th, and 9th) were mining silver ores alone and all the rest were base metal producers. Eight mines produced over 1 million ounces of silver each and their combined output equaled 55.5 percent of the total domestic production. Domestic mine output provided almost 30 percent of the silver consumption by industry and the arts.

In 1969 the Hecla Mining Co. provided almost 16 percent of domestic output and increased its silver output to 6.56 million ounces compared withh 4.97 million ounces for 1968. The average selling price for their silver in 1969 was $1.781 per ounce, down from $2.121 in 1968. Hecla's totally owned Lucky Friday mine, the Nation's fourth largest silver producer, returned to normal operation following an 8-month strike that ended in mid-June 1968. Lucky Friday, located in Idaho's Coeur d'Alene district, produced nearly 2.94 million ounces of silver, more than 19,000 tons of lead and lesser amounts of zinc, copper, and gold by processing almost 184,000 tons of ore averaging 16.35 ounces of silver per ton. Manpower shortages at the property limited development work, and ore reserves at the end of 1969 were down 4.5 percent to 598,000 tons. Hecla operates the Park City district, Mayflower mine (Nation's No. 14 silver producer) under a leasing arrangement with the New Park Mining Co. This operation produced almost 687,000 ounces of silver from milling almost 117,500 tons of ore. Ore reserves declined 17 percent to 257,000 tons.

Hecla also owns approximately one-third of the Nation's leading silver producer, the Sunshine mine which produced a record 8.33 million ounces in 1969 through mining and milling 271,600 tons of ore. Ore reserves at the Sunshine mine were estimated at 1.2 million tons at the end of 1969. At yearend the Sunshine Mining Co. announced plans to construct a $2 million silver refinery that would be in operation late in 1970.

In addition to the Sunshine mine, Hecla also owns part of the Star-Morning Unit Area and the Silver Summit mine. These two provided an additional 203,600 ounces of silver output. Output of silver provided almost 51 percent of Hecla's sales income in 1969.

The Galena mine in the Coeur d'Alene district, Idaho, is operated by the American Smelting and Refining Co. (ASARCO). Output in 1969 was 3.03 million ounces of silver recovered from milling almost 136,000 tons of silver-copper ore that averaged 22.3 ounces of silver per ton. Reserves of this type ore at yearend were more than 2 million tons. In addition the mine has substantial lead-silver ores that will require separate processing when mined and milled in the future.[2] In 1969 ASARCO continued extensive development work on the Coeur Project, from a new shaft west of the Galena mine. At yearend 80,000 tons of reserves averaging 25 ounces of silver per ton and 1 percent copper were developed by over 10,000 feet of drifting and nearly 17,000 feet of diamond drilling.[3] Another major Coeur d'Alene silver prospect known as the Caladay Project was initiated in 1968 by three mining companies: Callahan Mining Co., ASARCO, and Day Mines Inc. Callahan Mining Co. is the operator of this $8.5 million exploration project which will not be completed until late in 1974. In 1969 surface facilities were completed and a tunnel was driven to a point from which a 4,500 foot exploration shaft will be sunk.

Early in 1969 the Bureau of Mines published a comprehensive resource evaluation of the production potential of domestic silver mining districts, both active and inactive.[4] The purpose of this study was to determine the potential silver *resources* that could be made available at higher price levels. Using 1964 economic conditions and assuming silver prices ranging up to $3.00 per ounce, the study concluded that the United States has an estimated 4.9 billion ounces of unmined silver. About 1.35 billion ounces are in currently operating mines and 3.58 billion ounces in deposits requiring higher silver prices to be economically mined. Eighty-five percent of the Nation's silver resources are found in the States of Nevada, Idaho, Montana, Utah, and California.

The original manuscript presenting this evaluation contained 350 pages. The Information Circular 8427 is an abbreviated and condensed version of the original, which presents primarily the conclusions. The remainder of the report is available as an open-file report in the offices of the Bureau of Mines in Washington, D.C., Spokane, Wash., and Denver, Colo.[5]

Smelter and refiner reports show that 62.5 million ounces of silver were generated from old scrap and nearly 32 million ounces from new scrap. These were combined with output from foreign and domestic concentrates and ores for a total production of more than 199 million ounces in 1969.

CONSUMPTION AND USES

Consumption data, as measured by sales to the consuming industries, compiled by the Bureau of Mines, show a 12-percent decline compared with 1968. There were major reductions in sterling and electroplated ware, jewelry, dental and battery usage. Photographic consumption was essentially unchanged. Significant increases were registered by contact and conductor uses, catalytic use, and lesser increase in brazing alloys and solders. Excluding coinage from the totals, four industries consume 80 percent of the total silver use. They are photography (29.2 percent); electrical contacts and conductors (24.4 percent); sterling ware (14.3 percent); and brazing alloys and solders (11.7 percent).

Silver used in domestic coinage continued its steady decline from the 1965 peak when more than 320 million ounces was used. Silver coinage in 1969 dropped to 19.4 million ounces, 17.4 million ounces below the 1968 consumption.

Engelhard Minerals & Chemical Corp. reported development of a new superior, mirror bright silver electroplating process which uses a potassium-antimony-glycerol complex as the primary brightener.[6] The new brightener uses much less antimony

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[2] Day Mines, Inc. Annual Report. 1969, pp 4–5.
[3] Work cited in footnote 2.
[4] Banister, D'Arcy, and Richard W. Knostman. Silver in the United States. BuMines Inf. Circ. 8427, 1969, 34 pp.
[5] Bureau of Mines Staff. Silver in the United States. BuMines Open-File Rept., 1970, 300 pp.
[6] Greenspan, L. Bright Silver Plating. Engelhard Minerals & Chemical Corp. Tech. Bull., v. 10, No. 7, March 1970, pp. 138–140.

than previous processes and also has high ductility and much greater hardness than other techniques. Because the new brightener has a combination of superior characteristics, it is reportedly being used extensively in the electrical, electronics, and decorative fields.

GSA contracted the Charles River Associates to conduct an economic assessment of the silver industry. This lengthy study,[7] completed in 1969, observes that "it is hazardous to predict the course of price during the next few years" but nevertheless offers the opinion from its analysis that "it appears the present price (mid-1969) is high in relation to what might be profitable for long-term speculation."

[7] Charles River Associates. Economic Analysis of the Silver Industry. September 1969, 472 pp.; U.S. Department of Commerce, Clearinghouse for Federal Scientific and Technical Information, PB 191-464.

STOCKS

The Treasury bullion stock outflow in 1969 totaled 112.2 million ounces most of which (91.6 million ounces) was sold through GSA auction. Nearly all of the balance (19.4 million ounces) was consumed in U.S. coinage use for 50-cent pieces.

Total yearend stocks were estimated at 268.6 million ounces which consisted of 70.2 million ounces of Treasury bullion and the remainder primarily in the form of unmelted coins. Total stocks also included the Commodity Exchange (COMEX) stocks of 112.9 million ounces which was up 23.7 million ounces over 1968 stocks. Stocks of silver held by refiners, fabricators, and dealers increased almost 11 percent to 85.7 million ounces.

PRICES

Silver prices in New York in 1969 as quoted daily by Handy & Harman in cents per ounce varied widely, declining from a high in mid-January of 202.50 cents to a low on June 27, of 154.00 cents, which was the lowest silver price since July of 1967. The second half of the year showed a fairly steady rise to a second peak of nearly 200.00 cents early in November and then a decline with yearend prices closing at slightly more than 180.00 cents. The mid-May lifting of the melting and export ban plus the reduction of GSA auction sales from 2.0 million ounces to 1.5 million ounces were dominant factors in the market situation. The average price on the New York market for 1969 was 179.067 cents per ounce.

Sales of Treasury silver through GSA continued all through 1969. Total sales of coin silver 897–900 fine were 89.3 million ounces at prices, ranging from $1.525 in July to $1.999 per ounce in January. The trading volume on the New York Commodity Exchange (COMEX) increased to 6.6 billion ounces, up from 4.9 billion ounces in 1968. COMEX prices for 1969 reached a high on January 10 of 233.20 cents per ounce and a low on June 27 of 151.00 cents.

In the London market, prices for spot delivery of silver converted to U.S. funds ranged from a low of 155.90 cents per ounce in June to a high of 203.80 cents per ounce in January.

In November 1969 the Chicago Board of Trade started a new market for future silver trading in lots of 5,000 ounces of silver. Reported silver stocks at yearend were 290,000 ounces and trading for the year totaled 231.8 million ounces.

FOREIGN TRADE

Silver exports were down 29 percent to 88.9 million ounces compared with 1968 exports. Exports went primarily to the United Kingdom (41 percent); Canada (20 percent); Switzerland (14 percent); and Belgium-Luxembourg (11 percent).

Silver imports increased slightly in 1969 compared with 71.9 million ounces in 1968. The main sources of imports were Canada (66.1 percent) and Peru (15.8 percent) with 22 other countries providing the remaining 18.1 percent.

Net exports were 17.0 million ounces in 1969 compared with 55.0 million ounces for 1968.

WORLD REVIEW

World output of silver increased more than 10 million ounces to an alltime high of more than 285 million ounces. The major increase in the world was the U.S. gain of 9.2 million ounces. Production increases were also reported in Australia, Mexico, the U.S.S.R., and Bolivia which more than compensated for declines in output from Canada and Peru. Western Hemisphere output of silver provided slightly more than 61 percent of total world output.

World silver consumption for the arts and industry was up 15.1 million ounces compared with 1968 consumption to 362.4 million ounces. But coinage requirements for the world declined from 59.5 million ounces in 1968 to 24.3 million ounces. Total free-world silver consumption exceeded production by 101.4 million ounces. This production-consumption gap continued to be met mainly by sales of U.S. Treasury silver distributed through GSA weekly auctions which are scheduled to end on November 10, 1970. At the end of 1969, there were about 63.8 million ounces available for sale by GSA in 1970. It was estimated by Handy & Harman that silver stocks in the hands of investors and speculators amounted to about 400 million ounces.[8] Estimates were also made that from 20 million to 30 million ounces of silver were smuggled from India and entered into world markets.

Australia—Silver production increased almost 16 percent over that of 1968 to 24.7 million ounces, which is an alltime high. The leading Australian silver producer is Mount Isa Mines Ltd. which had a 1969 output of almost 10.1 million ounces, an increase of 38.3 percent over the 1968 output. Nearly 5 million tons of ore were milled to achieve this output. Over 1.9 million tons of silver-lead-zinc ores and 3.0 million tons of copper ores were treated to recover the silver. Mount Isa is also a major lead-zinc-copper producer. Ore reserves were also significantly increased and as of June 30, 1969, there were 45 million tons of primary silver-lead-zinc ores averaging 5.2 ounces of silver per ton and 75 million tons of primary 3 percent copper ore. Tons of ore treated per day by this major producer increased from over 10,000 tons to almost 13,800.

Canada.—Silver output of Canadian mines declined from an alltime high of 45.4 million ounces in 1968 to 41.9 million ounces in 1969. Canada dropped behind Mexico to return to the number two world producer position with an output only 23,000 ounces in excess of U.S. production. Ore mined in base metal mines provided about 90 percent of Canadian silver output with silver-cobalt ores the source of nearly all the remainder.

The leading silver producer in Canada and probably in the world is the Kidd Creek mine and concentrator of Ecstall Mining Ltd., near Timmins, Ontario, which produced about 31 percent of Canada's total output. This operation, totally owned by Texas Gulf Sulfur Co., had an output of 13.1 million ounces of silver from mining and was processing more than 3.6 million tons of ore. This was down slightly from a 13.4 million-ounce output in 1968. The present mine is an open pit operation but development will be underway in 1970 for underground mining. A $50 million zinc plant is under construction and is scheduled for completion in 1972.[9]

Ontario was by far the leading province in silver output having provided over half of Canada's 1969 output. British Columbia, New Brunswick, and Quebec were responsible for an additional one-third of the total output.

The second largest silver producer in Canada was the Cominco, Ltd., Sullivan mine at Kimberley, British Columbia, which recovered 3.0 million ounces of silver from more than 2 million tons of ore. Total silver output from the Cominco refinery in 1969 was 5.7 million ounces.[10]

There was no silver consumption by the Royal Canadian Mint in 1969 since nickel coins have been used since August 1968. Estimates of silver consumption by industry for 1969 were 5.4 million ounces.

Another silver mine which had earlier (1953–67) been the largest silver mine in Canada is the lead-silver-zinc calumet mine of United Keno Hill Mines Ltd.

[8] Handy & Harman. The Silver Market in 1969. 54th Annual Review. P. 3.

[9] Texas Gulf Sulphur Co. Annual Report. 1969, pp. 8–9.

[10] George, J. G. Silver. Canadian Minerals Yearbook 1969. Mineral Resouces Branch. Department of Energy, Mines and Resources (Ottawa), Preprint p. 9.

which produced 2.4 million ounces of silver in 1969, up from 1.98 million the previous year. The United Keno mine is located near Elsa in the Yukon Territory.[11]

Japan.—Mine output of silver increased slightly in 1969 to 10.8 million ounces. This compared with 1969 industrial use of silver of 39.7 million ounces. No silver is used in coinage although about 700,000 ounces were used in manufacturing commemorative medallions for the 1970 World Exposition.

Mexico.—Silver output increased almost 2.9 million ounces to 42.9 million ounces which placed Mexico back in the lead as the world's largest silver producer. Industrial consumption in Mexico was 4.3 million ounces and no silver was used in coinage during 1969. The largest silver producer in Mexico is Asarco Mexicana, S.A., which treated 2.2 million tons of silver-bearing ores to recover 20.0 million ounces of silver.

Peru. —Silver output in Peru declined 6 percent to 34.2 million ounces. It ranked fifth in world output due to the U.S. resuming normal output in 1969. Silver production comes primarily as a coproduct or byproduct of base metal production. The largest silver producer and refining company in Peru is the Cerro Corporations group of mines. Its totally owned subsidiary, the Cerro de Pasco Corporation, operates six metal mines which produced over one-quarter of Peru's total silver output. The total silver production refined in 1969 by Cerro's Peruvian operations was 18.5 million ounces which was more than 53 percent of the total silver output. Due to several strikes the silver output was down from 20.4 million ounces in 1968.[12]

United Kingdom.—It was estimated that the United Kingdom's industrial consumption of silver was 25 million ounces in 1969, up 2 million over that of 1968. Imports of silver bullion in 1969 were 123.9 million ounces and exports of bullion were 26.7 million ounces. The Bank of England recovered 1.3 million ounces of silver from old British coins and sold 1.15 million ounces in the London bullion market. Estimates for other Western European countries which consumed large amounts of silver in 1969 were West German, 46.6 million ounces; France, 17.4 million ounces; Italy, 26 million ounces.[13]

TECHNOLOGY

In 1969 the Bureau of Mines continued a program of collection of case-history data on rock burst occurrences which are peculiar to the silver mines of the Idaho Coeur d'Alene districts. On-site examinations were made and seismic records were analyzed and correlated with U.S. Coast and Geodetic records. Descriptive reports on bursts are prepared and recommendations for their control are suggested. A paper by Galen G Waddell on the "progress on Techniques of Investigating and Controlling Rock Bursts," outlined a research approach concerning rock bursts and was presented in February 1970 to the 1970 Denver, Colo., annual meeting of the American Institute of Mining, Metallurgical and Petroleum Engineers.

Research continued in 1969 on further development and modest marketing efforts for several silverless processes for photographic uses. Despite occasional optimistic claims it is felt that such processes will have little impact on substantially reducing silver uses in photography in the near future.

Late in 1969 the Eastman Kodak Company issued several publications on the recovery of silver from photographic materials.[14] It was estimated that in 1970 from 80 to 90 million ounces of silver will be contained in photographic products, worldwide. The major source of silver recovery from photographic materials is from exhausted processing solutions. In many black and white film processes, 60 to 80 percent of the original silver in the emulsion goes into solution in the fixing bath. In color processing nearly all the silver is removed by the fixing bath.

There are three principal methods of recovery of silver from solutions: Metallic replacement, electrolytic plating and chemical precipitation.

[11] United Keno Hill Mines Ltd. Annual Report. 1969, pp. 3, 9.
[12] Cerro Corp. Annual Report. 1969, p. 4.
[13] Handy & Harman. The Silver Market in 1969. 54th Annual Review. p. 15.
[14] Eastman Kodak Company. Recovering Silver From Photographic Materials. J–10, December 1969, 42 pp. Eastman Kodak Company, Professional, Commercial, & Industrial Markets Division. Recovery of Silver From Discarded Photographic Films. J–32, December 1969, p. 9.

It is also possible to recover the remaining 20 to 30 percent of the silver that remains on the black and white photographic films. The most common recovery technique is burning. Another technique is to remove the silver by wet chemical treatment.

Silver reclamation from waste materials at Eastman Kodak Company's plants in Rochester, N.Y., amounts to more than $3 million annually.[15] A Bureau of Mines publication [16] describes in detail a metallic displacement process using steel wool or steel window screen and a smelting process to recover pure silver from sludges containing 27 to 80 percent silver.

[15] Secondary Raw Materials. V. 7, No. 8, August 1969, pp. 29–30.
[16] Dannenberg, R. O., and G. M. Potter. Silver Recovery From Waste Photographic Solutions by Metallic Displacement. BuMines Rept. of Inv. 7117, 1968, 22 pp.

Table 2.—Mine production of recoverable silver in the United States, by months

(Thousand troy ounces)

Month	1968	1969
January	1,564	3,233
February	1,523	3,019
March	1,432	3,226
April	2,460	3,375
May	3,130	3,386
June	3,126	3,444
July	3,133	3,421
August	3,299	3,655
September	3,059	3,591
October	3,347	3,811
November	3,399	3,832
December	3,257	3,914
Total [1]	32,729	41,906

[1] Data may not add to totals shown because of independent rounding.

Table 3.—Twenty-five leading silver-producing mines in the United States in 1969, in order of output

Rank	Mine	County and State	Operator	Source of silver
1	Sunshine	Shoshone, Idaho	Sunshine Mining Co	Silver ore.
2	Utah Copper	Salt Lake, Utah	Kennecott Copper Corp	Copper, gold-silver ores.
3	Galena	Shoshone, Idaho	American Smelting and Refining Co	Silver ore.
4	Lucky Friday	do	Hecla Mining Co	Lead ore.
5	Berkeley Pit	Silver Bow, Mont	The Anaconda Company	Copper ore.
6	Bunker Hill	Shoshone, Idaho	The Bunker Hill Co	Lead-zinc ore, silver tailings.
7	Crescent	do	do	Silver ore.
8	White Pine	Ontonagon, Mich	White Pine Copper Co	Copper ore.
9	Bulldog	Mineral, Colo	Homestake Mining Co	Silver ore.
10	U. S. and Lark	Salt Lake, Utah	United States Smelting Refining and Mining Co	Lead, lead-zinc ores.
11	Copper Queen-Lavender Pit	Cochise, Ariz	Phelps Dodge Corp	Copper ore.
12	Idarado	Ouray and San Miguel, Colo	Idarado Mining Co	Copper-lead-zinc ore.
13	Pima	Pima, Ariz	Pima Mining Co	Copper ore.
14	Mayflower	Wasatch, Utah	Hecla Mining Co	Copper-lead-zinc ore.
15	Mission	Pima, Ariz	American Smelting and Refining Co	Copper ore.
16	Butte Hill Copper Mines	Silver Bow, Mont	The Anaconda Company	Do.
17	Morenci	Greenlee, Ariz	Phelps Dodge Corp	Copper, gold-silver ores.
18	Mineral Park	Mohave, Ariz	Duval Corp	Copper ore.
19	Copper Canyon	Lander, Nev	do	Do.
20	Magma	Pinal, Ariz	Magma Copper Co	Do.
21	Burgin	Utah, Utah	Kennecott Copper Corp	Lead, lead-zinc ores.
22	New Cornelia	Pima, Ariz	Phelps Dodge Corp	Copper, gold-silver ores.
23	United Park City	Summit and Wasatch, Utah	United Park City Mines Co	Lead-zinc ore.
24	Darwin	Inyo ,Calif	West Hill Exploration, Co	Do.
25	Dayrock	Shoshone, Idaho	Day Mines, Inc	Lead ore.

Table 4.—Production of silver in the United States, by States, type of mine, and by class of ore, old tailings, etc., yielding silver, in terms of recoverable metal, 1969

State	Placer Troy ounces of silver	Lode: Gold ore Short tons	Lode: Gold ore Troy ounces of silver	Lode: Gold-silver ore Short tons	Lode: Gold-silver ore Troy ounces of silver	Lode: Silver ore Short tons	Lode: Silver ore Troy ounces of silver
Alaska	1,726	(1)	11	---------	---------	---------	---------
Arizona	---------	312	25	63,565	4,245	104,272	83,110
California	336	3,507	2,333	(2)	(2)	165	679
Colorado	130	100	129	515	693	69,887	954,195
Idaho	---------	(3)	(3)	[3] 58	[3] 572	531,323	13,164,043
Michigan	---------	---------	---------	---------	---------	---------	---------
Missouri	---------	---------	---------	---------	---------	---------	---------
Montana	---------	(3)	(3)	[3] 7,086	[3] 163,465	37,121	441,155
Nevada	---------	1,489	197	---------	---------	9,012	52,947
New Mexico	---------	---------	---------	1,287	26,322	52	796
New York	---------	---------	---------	---------	---------	---------	---------
Oregon	---------	(3)	(3)	[3] 854	[3] 4,161	12	588
South Dakota	---------	1,934,622	124,114	---------	---------	35	383
Tennessee	---------	---------	---------	---------	---------	---------	---------
Utah	---------	---------	---------	142,738	10,355	2,842	73,062
Other States [4]	---------	62,237	220,297	---------	---------	171	126
Total	2,192	2,002,267	347,106	216,103	209,813	754,892	14,771,084
Percent of total silver	(1)	---------	1	---------	(1)	---------	35

State	Lode—Continued: Copper ore Short tons	Copper ore Troy ounces of silver	Lead ore Short tons	Lead ore Troy ounces of silver	Zinc ore Short tons	Zinc ore Troy ounces of silver
Alaska	-----------	-----------	50	293	-----------	-----------
Arizona	117,744,767	5,899,843	571	5,224	-----------	-----------
California	(2)	(2)	3,349	34,006	-----------	-----------
Colorado	-----------	-----------	990	4,767	277,350	186,890
Idaho	682	834	246,472	3,586,803	(5)	(5)
Michigan	8,199,659	1,009,022	-----------	-----------	-----------	-----------
Missouri	-----------	-----------	7,774,969	1,442,090	-----------	-----------
Montana	16,016,931	2,555,970	2,691	22,803	(6)	(6)
Nevada	[7] 14,358,425	[7] 770,398	4,709	46,679	-----------	-----------
New Mexico	12,492,998	324,204	-----------	-----------	221,563	32,225
New York	-----------	-----------	-----------	-----------	-----------	-----------
Oregon	-----------	-----------	-----------	-----------	-----------	-----------
South Dakota	-----------	-----------	-----------	-----------	-----------	-----------
Tennessee	-----------	-----------	-----------	-----------	-----------	-----------
Utah	38,650,345	3,009,099	2,116	13,124	4	6
Other States [4]	143,392	18,993	-----------	-----------	444,991	54,260
Total	207,607,199	13,588,363	8,035,917	5,155,789	943,908	273,381
Percent of total silver	-----------	32	-----------	12	-----------	1

State	Lode—Continued: Copper-lead, lead-zinc copper-zinc, and copper-lead-zinc ores Short tons	Copper-lead, lead-zinc copper-zinc, and copper-lead-zinc ores Troy ounces of silver	Old tailings, etc. Short tons	Old tailings, etc. Troy ounces of silver	Total Short tons	Total Troy ounces of silver	Refinery Troy ounces of silver
Alaska	---------	---------	---------	---------	50	2,030	1,600
Arizona	106,783	40,134	91,692	[8] 108,441	118,111,962	6,141,022	6,250,000
California	[2] 103,674	[2] 405,599	605	[9] 48,974	111,300	491,927	450,000
Colorado	741,484	1,450,069	3	[10] 1,690	1,090,329	2,598,563	2,350,000
Idaho	716,290	1,921,993	[5] 306,422	[5] 255,452	1,801,247	18,929,697	18,250,000
Michigan	---------	---------	---------	---------	8,199,659	1,009,022	984,000
Missouri	---------	---------	---------	---------	7,774,969	1,442,090	793,000
Montana	[6] 12,446	[6] 147,485	55,111	98,436	16,131,386	3,429,314	3,000,000
Nevada	(7)	(7)	18,399	13,934	14,392,034	884,155	846,000
New Mexico	54,683	81,924	76	120	12,770,659	465,591	455,600

Table 4.—Production of silver in the United States, by States, type of mine, and by class of ore, old tailings, etc., yielding silver, in terms of recoverable metal, 1969—Continued

State	Lode—Continued: Copper-lead, lead-zinc copper-zinc, and copper-lead-zinc ores: Short tons	Troy ounces of silver	Old tailings, etc.: Short tons	Troy ounces of silver	Total: Short tons	Troy ounces of silver	Refinery: Troy ounces of silver
New York	572,013	31,755	--------	--------	572,013	31,755	31,500
Oregon	---------	---------	--------	--------	866	4,749	3,700
South Dakota	---------	---------	--------	--------	1,934,657	124,497	124,600
Tennessee	1,574,140	78,614	--------	--------	1,574,140	78,614	79,070
Utah	567,519	2,752,275	56,606	95,646	39,422,170	5,953,567	5,800,000
Other States [4]	215,703	16,991	33	[11] 9,051	866,527	319,718	[12] 255,430
Total	4,664,735	6,926,839	528,947	631,744	224,753,968	41,906,311	39,674,500
Percent of total silver	---------	17	--------	2	-----------	100	----------

[1] Less than ½ unit.
[2] Gold-silver, copper, lead-zinc ores combined to avoid disclosing individual company confidential data.
[3] Gold and gold-silver ores combined to avoid disclosing individual company confidential data.
[4] Includes Maine, Oklahoma, Pennsylvania, Washington, and Wyoming.
[5] Zinc ore and old tailings, etc., combined to avoid disclosing individual company confidential data.
[6] Zinc and lead-zinc ores combined to avoid disclosing individual company confidential data.
[7] Copper and lead-zinc ores combined to avoid disclosing individual company confidential data.
[8] Includes byproduct silver recovered from uranium ore.
[9] Includes byproduct silver recovered from tungsten ore.
[10] Includes byproduct silver recovered from fluorspar ore.
[11] Includes byproduct silver recovered from magnetite-pyrite ore.
[12] Includes Kentucky, Texas, Virginia, Washington, and Wisconsin.

Table 5.—Mine production of recoverable silver in the United States, by States

(Troy ounces)

State	1965	1966	1967	1968	1969
Alaska	7,673	7,193	5,787	3,900	2,030
Arizona	6,095,285	6,338,696	4,588,081	4,958,162	6,141,022
California	196,787	189,989	144,515	597,961	491,927
Colorado	2,051,105	2,085,534	1,817,699	1,646,283	2,598,563
Idaho	18,456,809	19,776,785	17,033,330	15,958,715	18,929,697
Kentucky	1,931	1,086	568	----------	----------
Maine	----------	----------	----------	[1] 371,745	[1] 319,718
Michigan	457,851	483,000	301,992	472,813	1,009,022
Missouri	299,522	----------	226,168	340,856	1,442,090
Montana	5,207,031	5,319,785	2,066,464	2,132,571	3,429,314
Nevada	507,113	867,567	565,755	645,192	884,155
New Mexico	287,472	242,620	157,495	224,866	465,591
New York	11,441	21,590	31,103	27,615	31,755
Oklahoma	[2] 358,477	[2] 368,788	[2] 279,898	(1)	(1)
Oregon	8,801	343	31	335	4,749
Pennsylvania	(2)	(2)	(2)	(1)	(1)
South Dakota	128,971	109,885	121,258	137,668	124,497
Tennessee	94,142	100,716	130,078	89,525	78,614
Utah	5,635,570	7,755,411	4,874,640	5,120,772	5,953,567
Washington	(2)	(2)	(2)	(1)	(1)
Wyoming	52	----------	----------	----------	(1)
Total	39,806,033	43,668,988	32,344,862	32,728,979	41,906,311

[1] Production of Maine, Oklahoma, Pennsylvania, Washington, and Wyoming (1969) combined to avoid disclosing individual company confidential data.
[2] Production of Oklahoma, Pennsylvania, and Washington combined to avoid disclosing individual company confidential data.

Table 6.—Silver produced in the United States from ore, old tailings, etc., in 1969 by States and methods of recovery, in terms of recoverable metal

State	Total ore, old tailings etc., treated[1 2] (thousand short tons)	Ore and old tailings to mills: Thousand short tons[1 2]	Recoverable in bullion: Amalgamation (troy ounces)	Recoverable in bullion: Cyanidation (troy ounces)	Concentrates smelted and recoverable metal: Concentrates (short tons)	Concentrates smelted and recoverable metal: Troy ounces	Crude ore, old tailings, etc., to smelters[1]: Thousand short tons	Crude ore, old tailings, etc., to smelters[1]: Troy ounces
Alaska	(3)	-------	11	-------	6	293	-------	----------
Arizona	118,492	117,907	-------	5,503	3,062,631	5,794,250	585	341,269
California	111	107	418	-------	12,198	449,779	4	41,394
Colorado	1,090	1,087	1,317	-------	156,777	2,567,910	3	29,206
Idaho	1,801	1,748	16	-------	196,208	18,822,856	54	106,825
Michigan	8,200	8,200	-------	-------	249,108	1,009,022	-------	----------
Missouri	7,874	7,874	-------	-------	610,094	1,442,090	-------	----------
Montana	16,131	16,032	3	-------	393,882	2,695,838	99	733,473
Nevada	15,864	15,778	191	1,500	372,443	780,839	87	101,625
New Mexico	12,835	12,769	-------	-------	484,867	437,878	66	27,713
New York	741	741	-------	-------	113,387	31,755	-------	----------
Oregon	1	1	14	-------	49	3,247	(3)	1,488
South Dakota	1,935	1,935	81,805	42,309	----------	----------	(3)	383
Tennessee	5,863	5,863	-------	-------	309,678	78,614	-------	----------
Utah	39,422	39,211	-------	-------	1,023,839	5,600,648	212	292,919
Other States	2,167	2,167	-------	-------	139,641	318,872	(3)	846
Total[4]	232,527	231,420	83,775	49,312	7,124,808	40,033,891	1,110	1,677,141

[1] Includes some nonsilver-bearing ore not separable.
[2] Excludes tonnage of magnetite-pyrite, tungsten, and uranium ores from which silver was recovered as a byproduct.
[3] Less than ½ unit.
[4] Data may not add to total shown because of independent rounding.

Table 7.—Silver produced at amalgamation and cyanidation mills in the United States and percentage of silver recoverable from all sources

Year	Bullion and precipitates recoverable (troy ounces): Amalgamation	Bullion and precipitates recoverable (troy ounces): Cyanidation	Silver recoverable from all sources (percent): Amalgamation	Cyanidation	Smelting[1]	Placers
1965	167,331	48,632	0.42	0.12	99.44	0.02
1966	80,033	41,098	.18	.09	99.71	.02
1967	84,290	47.054	.26	.15	99.57	.02
1968	92,021	53,666	.28	.16	99.55	.01
1969	83,775	49,312	.20	.11	99.68	.01

[1] Crude ores and concentrates.

Table 8.—Silver produced at refineries in the United States, by source

(Thousand troy ounces)

	1968	1969
From concentrates and ores:		
Domestic	42,052	62,676
Foreign	31,222	42,016
Total	73,274	104,692
From old scrap	57,466	62,499
From new scrap	34,602	31,972
Total production	165,342	199,163

Table 9.—U.S. consumption of silver, by end use

(Thousand troy ounces)

	1968	1969
Electroplated ware	15,279	12,706
Sterling ware	28,349	20,291
Jewelry	4,538	3,011
Photographic materials	41,607	41,380
Dental and medical supplies	3,094	1,591
Mirrors	1,744	1,510
Brazing alloys and solders	15,124	16,549
Electrical and electronic products:		
Batteries	5,764	3,799
Contacts and conductors	25,805	34,555
Catalysts	2,310	4,081
Bearings	451	481
Miscellaneous [1]	1,228	1,592
Total net industrial consumption	145,293	141,546
Coinage	36,833	19,408
Total consumption	182,126	160,954

[1] Includes silver-bearing copper, silver-bearing lead anodes, ceramic paints, etc.

Table 10.—Value of silver exported from and imported into the United States

(Thousand dollars)

Year	Exports	Imports
1967	$95,960	$77,087
1968	247,100	137,800
1969	156,720	119,362

Table 11.—U.S. exports of silver in 1969, by countries [1]

(Thousand troy ounces and thousand dollars)

Country	Ore, concentrates, and waste and sweepings		Refined bullion	
	Quantity	Value	Quantity	Value
Australia	-------	-------	5	$11
Belgium-Luxembourg	9,056	$16,530	597	954
Brazil	16	32	148	295
Canada	16,380	27,025	1,510	2,623
Colombia	-------	-------	36	60
Denmark	-------	-------	323	598
France	-------	-------	1,888	3,293
Germany, West	202	416	667	1,180
Italy	28	45	430	775
Japan	257	434	3,030	5,590
Mexico	1	2	-------	-------
Netherlands	-------	-------	4,600	7,830
Norway	288	568	-------	-------
Peru	-------	-------	215	390
Philippines	-------	-------	2	4
Spain	228	443	-------	-------
Sweden	249	552	-------	-------
Switzerland	2,262	3,983	10,086	17,428
United Kingdom	1,985	3,304	34,375	62,264
Venezuela	-------	-------	1	2
Yugoslavia	-------	-------	44	89
Total	30,952	53,334	57,957	103,386

[1] Does not include 95,651 troy ounces worth $185,400 of reexports to Switzerland.

Table 12.—U.S. imports of silver in 1969, by countries

(Thousand troy ounces and thousand dollars)

Country	Ore, base bullion, and sweepings		Refined bullion	
	Quantity	Value	Quantity	Value
Argentina	169	$145	-------	-------
Australia	1,790	2,624	-------	-------
Belgium-Luxembourg	-------	-------	536	$1,029
Bolivia	515	835	-------	-------
Canada	13,733	21,671	33,757	60,856
Chile	1,285	1,601	-------	-------
Colombia	46	26	-------	-------
Denmark	-------	-------	217	387
Ecuador	23	15	-------	-------
El Salvador	-------	-------	12	21
Germany, West	1	3	(1)	1
Guatemala	20	30	-------	-------
Honduras	3,560	4,286	77	135
Mexico	912	1,471	2,658	4,572
Nicaragua	148	242	3	6
Norway	29	37	-------	-------
Panama	2	4	8	18
Peru	9,172	13,713	2,180	3,988
Philippines	300	470	23	58
South Africa, Republic of	567	809	-------	-------
Switzerland	6	12	-------	-------
United Kingdom	(1)	(1)	73	176
Venezuela	8	12	-------	-------
Yugoslavia	46	109	-------	-------
Total	32,332	48,115	39,544	71,247

[1] Less than ½ unit.

Table 13.—World production of silver, by countries [1]

(Thousand troy ounces)

Country [2]	1967	1968	1969 p
North and Central America:			
Canada	r 37,206	45,389	41,929
Haiti e	34	17	17
Honduras	4,009	4,397	3,905
Mexico	r 38,273	40,031	42,904
Nicaragua	372	416	247
United States	32,119	32,729	41,906
South America:			
Argentina	r 2,575	2,422	e 2,820
Bolivia	4,515	5,180	6,013
Brazil	r 479	464	357
Chile	3,156	3,739	3,133
Colombia	110	100	77
Ecuador	80	136	82
Peru	r 32,107	36,362	34,147
Europe:			
Austria	126	161	129
Czechoslovakia e	r 1,100	1,100	1,100
Finland	623	677	625
France (mine output)	2,163	2,041	e 2,000
Germany:			
East e	4,800	4,800	4,800
West	2,042	1,769	e 2,000
Greece	232	261	258
Ireland (mine output)	2,067	1,913	e 1,866
Italy	1,382	1,156	1,832
Poland e	160	160	165
Portugal (mine output)	357	327	339
Rumania e	800	800	800
Spain [3]	2,218	1,736	e 1,700
Sweden (mine output)	3,455	3,524	3,683
U.S.S.R. e	35,000	35,000	37,000
Yugoslavia	3,075	2,577	3,456
Africa:			
Algeria e	100	100	100
Congo (Kinshasa)	1,840	2,139	e 1,896
Ghana	-----	-----	3
Kenya	3	3	2
Morocco	773	920	861
South Africa, Republic of	3,064	3,337	3,335
South-West Africa, Territory of [4]	1,450	1,350	1,273
Tanzania	2	2	2
Tunisia	45	e 46	e 47
Zambia e [5]	750	768	768
Asia:			
Burma e	1,000	900	1,000
China, mainland e	600	700	800
India	112	90	127
Indonesia	309	309	316
Japan	10,800	10,693	10,804
Korea:			
North e	700	700	700
South	588	611	906
Philippines	1,396	1,575	1,561
Taiwan	r 116	90	81
Oceania:			
Australia	19,842	21,281	24,667
Fiji	61	55	38
New Guinea and Papua	17	18	17
New Zealand	-----	4	7
Total [6]	r 258,203	275,075	288,601

e Estimate. p Preliminary. r Revised.
[1] Recoverable content of ores and concentrates produced unless otherwise noted.
[2] Silver is also produced in Bulgaria, Guatemala, Hungary, New Zealand, Thailand, Turkey, Southern Rhodesia, and several other African countries. Quantities are insignificant or not reported.
[3] Smelter and/or refinery production.
[4] Recoverable content of Tsumeb Corp. Ltd. concentrates, as reported for year ending June 30 of year stated.
[5] Includes recovery from copper refinery sludges.
[6] Totals are of listed figures only.

Slag—Iron and Steel

By Frank L. Fisher [1]

Consumption of iron-blast-furnace slag in 1969 equaled available supplies, and slightly more material was processed than in 1968. The value of iron-blast-furnace slag marketed in 1969 was higher for most categories; the sharpest price increases were reported for roofing granules and agriculture slag used for liming soil. The steel slag consumed in 1969 was below the production rate, although several significant new uses were developed. The tonnage of air-cooled slag used in bituminous concrete was approximately the same as in 1968. A significant change occurred, however, in the use made of slag in highway construction. The greatly expanded use of blast furnace slag as the required aggregate in the surface courses of highways, was due to its unusually fine skid-resistant characteristics. In many geographical areas, it is now customary that slag be used in the composite material for the surface (wearing) area of heavily traveled highways.

[1] Physical scientist, Bureau of Mines, Minneapolis, Minn.

Table 1.—Iron-blast-furnace slag processed in the United States, by types

(Thousand short tons and thousand dollars)

Year	Air-cooled				Granulated		Expanded		Total	
	Screened		Unscreened							
	Quantity	Value	Quantity	Value	Quantity	Value [1]	Quantity	Value	Quantity	Value
1965	22,531	$39,624	1,402	$1,270	3,550	$2,674	2,596	$7,879	30,079	$51,447
1966	19,925	35,348	551	588	3,749	3,026	2,525	7,860	26,750	46,822
1967	22,326	39,204	1,052	800	3,760	2,834	2,456	7,262	29,593	50,101
1968	21,757	39,034	1,826	1,493	2,944	2,631	2,215	6,251	28,742	49,408
1969	22,295	41,388	2,239	2,525	2,818	3,431	2,422	6,985	29,774	54,330

[1] Excludes value of slag used for manufacturing hydraulic cement 1965–69; and granulated aggregate for concrete-block manufacturing 1966–68.

Source: National Slag Association.

Table 2.—Iron-blast-furnace slag processed in the United States, by States

(Thousand short tons and thousand dollars)

Year and State	Screened air-cooled		All types	
	Quantity	Value	Quantity	Value
1968				
Ohio	4,175	$8,208	5,994	$11,571
Pennsylvania	5,728	11,251	7,398	13,751
Illinois, Indiana, Michigan	4,808	7,759	6,472	9,776
Other States [1]	7,046	11,817	8,878	14,309
Total	21,757	39,034	28,742	49,408
1969				
Ohio	4,576	9,024	6,806	13,291
Pennsylvania	5,579	11,346	7,268	14,548
Illinois, Indiana, Michigan	4,277	7,767	5,922	10,706
Other States [1]	7,863	13,252	9,778	15,784
Total	22,295	41,388	29,774	54,330

[1] Alabama, California, Colorado, Kentucky, Louisiana (1969), Maryland, Minnesota, New York, Texas, Utah, and West Virginia.

Source: National Slag Association.

Table 3.—Shipments of iron-blast-furnace slag in the United States, by methods of transportation

Method of transportation	1968		1969	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Rail	6,334	22	4,610	14
Truck	21,478	75	24,425	83
Waterway	718	3	738	3
Total	28,530	100	29,774	100

Source: National Slag Association.

DOMESTIC PRODUCTION

The production of iron-blast-furnace slag is dominated by the air-cooled, screened product, which totaled 22.3 million short tons valued at $41.4 million in 1969. Overall slag output increased 4 percent over 1968 figures, with granulated and expanded slag contributing to the total of 30 million short tons, valued at $54.3 million. Most of the production centered in 11 States, with Pennsylvania and Ohio the leading States in the quantity produced. A total of 1,667 plant and yard personnel worked 3,877,520 man-hours during 1969 in 56 air-cooled, 17 expanded, and 14 granulated slag plants. Their output was approximately the same as in 1968 with equal work force and facilities. The quantity of slag-encrusted magnetic iron produced in 1969 at these operations was 4,162,000 tons.

CONSUMPTION AND USES

Consumption of air-cooled, iron-blast-furnace slag increased in 1969, especially as an aggregate in portland cement concrete structures. Other uses showed moderate increases in consumption with the exception of the quantity of slag used in pavements (other than highway construction) and railroad ballast, which showed sharp declines in use. Consumption of steel slag increased 18 percent. The major gain in use was in the slag categorized as miscellaneous base or fill.

Table 4.—Air-cooled iron-blast-furnace slag sold or used by processors in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1968				1969			
	Screened		Unscreened		Screened		Unscreened	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Aggregate in—								
Portland cement concrete construction:								
Structures	1,284	$2,461	-----	-----	2,010	$4,205	-----	-----
Pavements	1,378	2,899	-----	-----	712	1,623	-----	-----
Bituminous construction (all types)	3,661	6,929	249	$109	3,796	7,418	127	$228
Highway and airport construction [1]	9,282	16,785	95	111	10,086	18,198	446	432
Manufacture of concrete block	264	464	-----	-----	430	792	-----	-----
Railroad ballast	4,223	6,149	-----	-----	3,403	5,047	-----	-----
Mineral wool	390	612	26	20	413	681	29	20
Roofing slag:								
Cover material	352	1,061	-----	-----	414	1,266	-----	-----
Granules	167	328	-----	-----	84	577	-----	-----
Sewage trickling filter medium	24	40	-----	-----	23	48	-----	-----
Agricultural slag, liming	2	3	-----	-----	8	20	-----	-----
Other uses	731	1,304	1,457	1,253	914	1,511	1,637	1,846
Total	21,757	39,034	1,826	1,493	22,295	41,388	2,239	2,525

[1] Other than in portland cement concrete and bituminous construction.
Source: National Slag Association.

Table 5.—Granulated and expanded iron-blast-furnace slag sold or used by processors in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1968				1969			
	Granulated		Expanded		Granulated		Expanded	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Highway construction and fill (road, etc.)	1,643	$2,309	-----	-----	1,707	$2,459	-----	-----
Agricultural slag, liming	59	107	-----	-----	59	115	-----	-----
Manufacture of cement (all types)	914	NA	-----	-----	680	NA	-----	-----
Lightweight concrete	-----	-----	718	$2,233	-----	-----	222	$908
Aggregate for concrete-block manufacture	131	NA	1,438	3,809	174	366	1,955	5,733
Other uses	197	215	59	209	197	234	245	345
Total	2,944	[1] 2,631	2,215	6,251	2,818	3,431	2,422	6,985

NA Not available.
[1] Excludes value of granulated slag used for hydraulic cement manufacture and concrete-block manufacture.

Source: National Slag Association.

Table 6.—Steel slag sold or used by processors in the United States, in 1969, by uses [1]

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Railroad ballast	922	$941
Highway base or shoulders	1,604	1,570
Paved-area base	1,063	889
Miscellaneous base or fill	2,381	2,723
Bituminous mixes	265	312
Agricultural	95	368
Other uses	969	882
Total	7,299	7,685

[1] Excludes tonnage returned to furnaces for charge material.

Source: National Slag Association.

Granulated blast-furnace slag has found increased use in agriculture where it is used for liming soils. The slag has been found to be as effective in increasing the soil pH as either dolomitic or calcitic limestone. Extensive tests in Ohio have shown that granulated blast-furnace slag can be effectively used for correcting soil acidity.[2]

[2] Jones, J. B., Jr. Granulated Slag for Liming Soils. Ohio Report on Research and Development, Ohio Research & Development Center, Wooster. July–August, 1968, pp. 62–63.

PRICES

The prices of iron-blast-furnace slag sold or used by processors in the United States showed a general upward trend during 1969. The diverse characteristics of the many types of commercial slag indicated a range from $0.68 per short ton for slag used in mineral wool to $6.84 per short ton for roofing granules. The higher price of slag for roofing granules is attributed in part to an increase in demand. The increase in the average value of expanded slag used in lightweight concrete reflects the higher demand for its use in this type of concrete.

Table 7.—Average value of iron-blast-furnace slag sold or used by processors in the United States, by uses

(Per short ton)

Use	Air-cooled				Granulated		Expanded	
	Screened		Unscreened					
	1968	1969	1968	1969	1968	1969	1968	1969
Aggregate in—								
Portland cement concrete construction	$2.01	$2.09	-----	$.45	-----	-----	-----	-----
Bituminous construction (all types)	1.89	1.95	-----	1.79	-----	-----	-----	-----
Highway and airport construction [1]	1.80	1.80	$1.16	1.26	$1.40	$1.44	-----	-----
Manufacture of concrete block	1.76	1.84	-----	-----	1.80	2.10	$2.65	$2.93
Lightweight concrete	-----	-----	-----	-----	-----	-----	3.11	4.08
Railroad ballast	1.45	1.48	-----	-----	-----	-----	-----	-----
Mineral wool	1.58	1.64	-----	.68	-----	-----	-----	-----
Roofing slag:								
Cover material	3.00	3.05	-----	-----	-----	-----	-----	-----
Granules	4.65	6.84	-----	-----	-----	-----	-----	-----
Sewage trickling filter medium	1.64	2.04	-----	-----	-----	-----	-----	-----
Agricultural slag, liming	1.58	2.46	-----	-----	1.80	1.96	-----	-----
Other uses	1.78	1.65	.86	1.12	1.69	1.18	3.52	1.40

[1] Other than in portland cement and bituminous construction.

Source: National Slag Association.

TECHNOLOGY

A technique was developed for producing lighter weight slag by air-cooling in thin layers. The production of lightweight pellets by another process results in an end product with greatly increased workability and strength in slag lightweight concrete.

Detailed information on electroslag refining (ESR) is now available.[3] The ESR process is presently firmly established on a commercial scale for the production of special alloy steels in East and West Europe, especially in the U.S.S.R. In this process, slag is effectively used as the purifier and impurity scavenger. In the resulting slag-metal reaction, the process is manipulated to give an ingot with desirable physical properties. The economics of the process reportedly compare favorably with those of the vacuum-arc-refining (VAR) process, which is also widely used in these countries. Other technical articles on slag utilization were published.[4]

[3] Duckworth, W. E., and G. Hoyle. Electroslag Refining. Chapman and Hall, (London), 1969, 178 pp.

[4] Pit and Quarry. Vulcan Materials Solves Slag Handling Problem at Fairfield, Ala., Plant. V. 62, No. 3, September 1969, pp. 123–124.

Sodium and Sodium Compounds

By Arnold M. Lansche [1]

Total domestic production of soda ash (sodium carbonate) and crude salt cake (sodium sulfate) from manufactured and natural sources increased approximately 13 percent in 1969, with the proportion of total output derived from natural occurrences showing a marked rise. The trona deposits near Green River, Wyo., continued to supply the major portion of soda ash from natural sources.

DOMESTIC PRODUCTION

Total production of soda ash increased about 6 percent in 1969. Production of manufactured soda ash declined 2 percent, while output from natural sources rose 23 percent. The contribution of trona and natural brines to the total production of soda ash has trended upward during the past 5 years, increasing in 1965 by 23 percent; 1966, 26 percent; 1967, 26 percent; 1968, 31 percent; 1969, 36 percent.

Soda ash derived from natural sources was produced in California from dry lake brines and in Wyoming from underground bedded trona deposits. California producers were American Potash and Chemical Corp. and Stauffer Chemical Co. Wyoming producers were Allied Chemical Corp., FMC Corp., and Stauffer Chemical Co. of Wyoming.

Allied Chemical Corp. developed a new trona mine and began operating a 550,000-ton-per-year trona (natural soda ash) refinery in the Green River area of Wyoming

[1] Physical scientist, Bureau of Mines, Bartlesville, Okla.

Table 1.—Manufactured and natural sodium carbonates produced in the United States

(Thousand short tons and thousand dollars)

Year	Manufactured soda ash (ammonia-soda process) [1] [2]	Natural sodium carbonates [3]	
	Quantity	Quantity	Value
1965	4,926	1,494	$34,717
1966	5,071	1,738	40,674
1967	4,849	1,726	40,589
1968	r 4,596	2,043	42,104
1969	p 4,503	2,513	50,922

p Preliminary. r Revised.
[1] Bureau of the Census.
[2] Includes quantities used to manufacture caustic soda, sodium bicarbonate, and finished light and dense soda ash.
[3] Soda ash and trona (sesquicarbonate).

Table 2.—Sodium sulfate produced and sold or used by producers in the United States [1]

(Thousand short tons and thousand dollars)

Year	Production (manufactured and natural) [2]		Sold or used by producers (natural only)	
	Lower purity [3] (99 percent or less)	High purity	Quantity	Value
1965	976	428	620	$11,024
1966	1,009	436	640	11,271
1967	r 696	r 668	637	10,710
1968	r 758	r 725	700	12,729
1969	p 1,042	p 429	672	12,427

p Preliminary. r Revised.
[1] All quantities converted to 100 percent Na_2SO_4 basis.
[2] Bureau of the Census.
[3] Includes glauber's salt.

in 1969.[2] FMC Corp. reportedly planned its fourth mine shaft into Wyoming trona deposits to supply the increasing demand. Texas Gulf Sulphur Co. sank a 16-foot-diameter shaft at its trona property at Black's Fork, Wyo., during the year. The shaft was sunk to a depth of 1,500 feet and perforated the upper and lower trona beds.

Total production of manufactured and natural sodium sulfate declined less than 1 percent from that of 1968. Salt cake was produced from dry lake brines in California by American Potash and Chemical Corp. at Trona, by Stauffer Chemical Co. at Westend, and by United States Borax and Chemical Co. at Wilmington and San Francisco. Ozark-Mahoning Co. recovered salt cake from subterranean brines at its Brownfield, Monahans, and Seagraves plants in Texas. William E. Pratt Co. harvested sodium sulfate from dry lake beds near Casper, Wyo.

During the past 3 years, Gulf Resources and Chemical Corp. developed a fully integrated operation in Utah to produce sodium sulfate and other important salts from Great Salt Lake brines.[3] The Utah State Land Board gave the company rights to 84,000 acres of the lake to produce the salts with the stipulation that operations could not begin until after March 1969. Initial production is scheduled for late 1970.

Sodium metal production increased from 156,859 tons in 1968 to about 165,000 tons in 1969.

Sodium and its coproduct chlorine were produced by electrolysis of molten salt by three companies at five plants: E. I. du Pont de Nemours & Co., Inc., at Niagara Falls, N.Y., and Memphis, Tenn.; Ethyl Corp., at Baton Rouge, La., and Houston, Tex.; and Reactive Metals, Inc., at Ashtabula, Ohio.

CONSUMPTION AND USES

According to the most recent statistics (1967) published by the Bureau of the Census, glass consumed approximately 50 percent of the manufactured soda ash, chemicals about 40 percent, and pulp and paper production about 8 percent; the remainder was used in water treatment and making soap and detergent. Natural soda ash also was consumed in those uses. Caustic soda has replaced most of the soda ash used to convert bauxite to alumina.

Kraft paper production utilized about 74 percent of sodium sulfate output. Manufacture of glass, ceramic glazers, detergents, stockfeeds, dyes, textiles, medicines, and miscellaneous chemicals also consumed sodium sulfate.

A new process, Holopulping (from holocellulose pulps), may revolutionize the papermaking industry and cause salt cake to lose its major consuming market.[4] Holopulping is a selective process for removing lignin from wood used in papermaking. If successful, the new process could reduce chemical costs about 60 percent and increase pulp yield from about 50 percent by the Kraft process to almost 80 percent.

Manufacture of tetraethyl lead and tetramethyl lead consumed most of the metallic sodium output in 1969. Future marketing of metallic sodium for use in making tetraethyl and tetramethyl lead compounds was threatened by plans to stop adding these lead compounds to gasoline. Sodium-cored electrical conduction cable received greater acceptance as a substitute for more expensive copper cable. Titanium producers used sodium in reducing titanium tetrachloride to elemental titanium.

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[2] Industrial Minerals (London). No. 22, July 1969, p. 31.

[3] Industrial Minerals. The Mineral Wealth of Utah's Great Salt Lake. No. 21, June 1969, pp. 45–46.

[4] Chemical and Engineering News. Holopulping Paper Process to Cost Chemicals a Market. V. 47, No. 21, May 19, 1969, pp. 30–32.

PRICES

Price quotations for sodium carbonate, sodium sulfate, and sodium metal at the end of 1968 and 1969 as reported in the Oil, Paint and Drug Reporter were as follows:

		1968	*1969*
Sodium carbonate (soda ash, 58 percent Na_2O):			
Light, paper bags, carlots, works	per 100 pounds	$2.05	$2.15
Light, bulk, carlots, works	do	1.55	1.65
Dense paper bags, carlots, works	do	2.15	2.15–2.25
Dense, bulk, carlots, works	do	1.60	1.65
Sodium sulfate (100 percent Na_2SO_4):			
Technical detergent, rayon-grade, bags, carlots, works	per ton	40.00	40.00
Technical detergent, rayon-grade, bulk, works	do	38.00	34.00
Domestic salt cake, bulk, works[1]	do	28.00	28.00
National Formulary (N.F.VII), drums	per pound	.23	.25½
Metallic sodium:			
Bricks, carlots, works	do	.24	.24
Fused, lots of 18,000 pounds and more, works	do	.23	.22½
Bulk, tank, works	do	.18	.17¾

[1] Delivered east of the Mississippi River.

FOREIGN TRADE

Exports of sodium sulfate in 1969 increased 63 percent over those in 1968. About 74 percent of the total exports went to Australia (22,882 tons) Canada (22,124 tons) and the Netherlands (22,104 tons). Almost 6 percent of total sodium sulfate production was exported, compared with about 4 percent in 1968.

Exports of sodium carbonate increased 12 percent compared with those of 1968. About 55 percent of the exports, 179,537 tons, went to Canada. Exports represented approximately 7 percent of manufactured output in 1969.

Imports of sodium sulfate declined about 6 percent, compared with those of 1968. Belgium-Luxembourg supplied 46 percent or 131,552 short tons of the total imports; imports were also received from Canada, Chile, Jamaica, Japan, the United Kingdom, and West Germany.

Table 3.—U.S. exports of sodium carbonate and sodium sulfate

(Thousand short tons and thousand dollars)

Year	Sodium carbonate		Sodium sulfate	
	Quantity	Value	Quantity	Value
1967	304	$9,914	28	$856
1968	288	9,131	56	1,844
1969	324	10,326	91	2,644

Table 4.—U.S. imports for consumption of sodium sulfate

(Thousand short tons and thousand dollars)

Year	Crude (salt cake)		Anhydrous		Total [1]	
	Quantity	Value	Quantity	Value	Quantity	Value
1967	273	$4,312	15	$190	289	$4,508
1968	279	4,721	25	377	305	5,108
1969	264	4,477	22	324	286	4,808

[1] Includes glauber salt, as follows; 1967, 662 tons ($5,948); 1968, 1,277 tons ($10,107); 1969, 153 tons ($6,935).

At yearend, new tariff rates were established for imports of sodium compounds effective January 1, 1970, as follows:

	Tariff rate per short tons
Sodium carbonate:	
Calcined (soda ash)	$8.40
Hydrated and sesquicarbonate	8.00
Sodium sulfate:	
Crude (salt cake)	Free
Anhydrous	.35
Crystallized (glauber salt)	.70

WORLD REVIEW

Canada.—Early in 1969 a 100,000-ton-per-year sodium sulfate refinery began production at Cabri, Saskatchewan. Crude material was obtained from nearby Snakehole Lake. Refined material will be sold mainly to pulp and paper manufacturers. The following plants produced sodium sulfate in 1969:

	Plant	*Annual capacity, tons*
Midwest Chemicals Ltd	Palo	100,000
Ormiston Mining and Smelting Co	Ormiston	75,000
Sybouts Sodium Sulphate Co	Gladmar	30,000
Saskatchewan Minerals Ltd	Chaplin	150,000
	Fredrick	50,000
	Far Valley	150,000
Sodium Sulphate (Saskatchewan) Ltd	Alsask	50,000
Francana Minerals Co	Cabri	100,000

Columbia.—Construction of new facilities at the caustic soda plant at Mamonal was reported to have begun in November 1968, equipment was to be installed in 1969, and production was scheduled for August 1970.[5] The new installation will have a capacity to produce 500 metric tons of sodium carbonate per day, 95 tons of which will be converted into 70 tons of caustic soda by the Solvay process. Additional expansion, expected to go on stream in 1971–72, will be an electrolytic process with annual capacity of 39,600 tons of caustic soda and 34,000 tons of chlorine. Demand for caustic soda in Colombia was reportedly expanding at about 9 percent per year. Production capacity of caustic soda plants in 1968 was 61,000 tons, in 1969 it was 75,000 tons, and in 1972 it is expected to be 93,000 tons; for sodium carbonate plants, the figures were 1968, 46,000 tons; 1969, 52,000 tons; and 1972, 73,000 tons.

India.—The Indian Government was asked by the Bengal and National Chambers of Commerce and Industry to build a 72,000-ton-per-year soda ash plant at Durgapur.[6] A letter of intent was issued for a 130,000-ton-per-year soda ash plant to be built at Gujarat.

Italy.—Plans were made by Società Chimica del Mediterraneo, a company formed by Ente Minerario Siciliano, and Orinico and Chimica Meridionale, to build a sodium carbonate plant at Termini Imerese capable of a 200,000-ton-per-year output.[7]

Turkey.—A soda ash plant with a 300,000-ton-per-year production capacity costing $13.3 million was planned for construction.

TECHNOLOGY

The monovalent, ionic nature of sodium aluminate solutions was reported as established.[8] This information is of value in understanding the equilibria and kinetics of the extraction and decomposition reactions occurring in the Bayer method for processing bauxite.

The U.S. Bureau of Mines reported research on the use of sodium sulfate to reduce the copper content of ferrous scrap, such as automobile scrap.[9]

The U.S. Geological Survey published a professional paper concerning trona deposits in Wyoming which discussed geology, stratigraphy, geochemistry, source of the components in the deposit, and probable environmental conditions prevailing when the deposit was laid down.[10]

[5] Mineral Trade Notes. V. 66, No. 2, February 1969, pp. 37–38.
[6] European Chemical News. Soda Ash Requested for Durgapur. V. 15, No. 379, May 9, 1969, p. 10.
[7] Chemical Age (London). New Plant in Sicily To Produce Sodium Carbonate. V. 99, No. 2585, Jan. 31, 1969, p. 30.
[8] Glastonburg, J. R. Nature of Sodium Aluminate Solutions. Chem. and Ind., v. 5, Feb. 1, 1969, pp. 121–125.
[9] Makar, Harry V., and Bevely W. Dunning, Jr. Use of Sodium Sulfate for Copper Removal From Molton Iron. J. Metals, v. 21, No. 7, July 1969, pp. 19–22.
[10] Bradley, W. H., and H. P. Engster. Geochemistry and Paleolimnology of the Trona Deposits and Associated Authigenic Minerals of the Green River Formation of Wyoming. U.S. Geol. Survey Prof. Paper 496–B, 1969, 71 pp.

Stone

By S. O. Wood, Jr.,[1] and M. Carrales, Jr.[1]

Domestic production of stone increased 5 percent from 820 million tons in 1968 to 863 million tons in 1969. Total value increased to a new record high of $1.42 billion in 1969. Pennsylvania, with a production of 67 million tons, was the Nation's leader. Other large producers, in order of output, were Illinois, Ohio, Texas, Florida, and Missouri. These six leading States produced 305 million tons—35 percent of the Nation's output. Production of stone was reported in all States except Delaware. Although dimension stone production decreased 9 percent, its value of $99 million was virtually the same in 1968. Dimension stone accounted for less than 0.3 percent of total stone output. Crushed stone accounted for more than 99 percent of the total volume of stone produced, but its value was only 93 percent of the total value. Production of crushed stone was 861 million tons valued at $1.33 billion compared with 818 million tons valued at $1.22 billion in 1968. The main uses of crushed stone were dense graded road base stone, 25 percent; concrete aggregate (coarse), 14 percent; cement manufacture, 12 percent; unspecified construction aggregate and roadstone, 11 percent; and bituminous aggregate, 8 percent.

Legislation and Government Programs.—The Tax Reform Act of 1969 authorized changes in certain mineral and metal depletion rates effective with taxable years beginning after October 9, 1969. The depletion rate for dimension stone was lowered from 15 to 14 percent of gross income. The 5 percent depletion rate for common stone products used for riprap, ballast, road materials, rubble, concrete aggregate, and similar construction purposes was unchanged.

Pursuant to the Federal Metal and Nonmetallic Mine Safety Act of 1966 (Public Law 89–577), the first Federal health and safety standards to be established for all domestic metal and nonmetal mines were published in August 1969 in the Federal Register.[2] The standards were promulgated to provide better on-the-job protection for nearly 200,000 workers in noncoal mines. Some included items were fire prevention and control; air quality; storage and handling of explosives; drilling, loading, hauling, and dumping operations; electrical equipment use and installation; radiation exposure; and maintenance and use of mining equipment.

The U.S. 4th Circuit Court of Appeals reversed a ruling of the National Labor Relations Board (NLRB) on what should be an appropriate bargaining unit in the pit and quarry and ready-mix concrete business of Harry T. Campbell Son's Corp. of Towson, Md.[3] The company took the position that the NLRB acted unreasonably in selecting employees in only the calcite operations as an appropriate unit. The Appeals Court agreed with the company.

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[1] Petroleum engineer, Bureau of Mines, Dallas, Tex.
[2] Federal Register. V. 34, No. 145, July 31, 1969, pp. 12503–12527.
[3] Unterberger, S. Herbert. Labor Developments. Pit and Quarry, v. 61, No. 11, May 1969, pp. 13, 64.

Table 1.—Salient stone statistics in the United States [1]
(Thousand short tons and thousand dollars)

	1965	1966	1967	1968	1969
Shipped or used by producers:					
Dimension stone	2,403	2,327	2,011	2,060	1,873
Value	$92,235	$89,814	$95,472	$98,441	$98,647
Crushed stone	777,839	811,047	783,581	817,537	861,021
Value	$1,111,596	$1,170,901	$1,144,772	$1,219,469	$1,326,047
Total stone [2]	780,242	813,374	785,592	819,597	862,895
Value	$1,203,831	$1,260,715	$1,240,244	$1,317,911	$1,424,694
Exports (value)	r $9,631	r $11,134	r $11,156	$9,969	$10,223
Imports for consumption (value)	$20,414	$20,739	$19,823	$24,629	$29,306

r Revised.
[1] Includes slate.
[2] Data may not add to totals shown because of independent rounding.

DIMENSION STONE

DOMESTIC PRODUCTION

Of the total quanity of dimension stone sold or used by producers, granite comprised 37 percent; limestone, 31 percent; sandstone, 17 percent; slate, 8 percent; marble, 4 percent; and other stone, 3 percent.

The National Limestone Institute held its 24th annual convention in Washington, D.C.[4] The program covered virtually every facet of major significance affecting limestone producers individually and as an industry and included current and future highway construction, agriculture, labor, environmental controls, all phases of operation, and new markets. The Iowa Limestone Producers Association held its 24th annual convention in Des Moines.[5] The main topics considered were factors affecting the industry nationally, relationships between highway engineers and limestone producers, surface mining laws and reclamation, aglime research, and blasting and safety.

The Building Stone Institute held its 50th annual convention at Miami, Fla.[6] The highlight of the convention was "an effective executive program." Other topics included automation, a sales course, a transporation course, diamond wire, epoxies, thermal treatment of bluestone, and promotion and advertising.

Jim Walter Corp. acquired the Georgia Marble Co. of Atlanta, Ga., which has operations in seven States.[7]

CONSUMPTION AND USES

Consumption of dimension stone decreased 9 percent. A comparison of the quantity of various stone used in 1969 with 1968 revealed the following trends: Granite, up 2 percent; limestone, down 5 percent; marble, down 13 percent; slate, down 7 percent; and sandstone, unchanged.

Fabricating firms developed faster and less expensive erection methods in order to increase stone consumption. The Georgia Marble Co., Atlanta, Ga., described several labor-, time-, and money-saving erection processes.[8] Of particular importance were four different wall erection systems.

An unusual operation in this modern age of automation was conducted at the quarry of Jasper Stone Co., Jasper, Minn.[9] Stonecutters produced premium materials to specification and thus provided evidence that such manual art is not lost. The use of stonecutting machines for this operation was not satisfactory.

PRICES

Average values (dollars per ton) are listed below for dimension stone, as reported to the Bureau of Mines:

	Building		Monumental, rough and dressed	Flagging
	Rough	Dressed		
Granite	$14.22	$68.70	$92.46	-----
Marble	23.32	173.40	-----	-----
Limestone	17.15	52.08	-----	$18.00
Sandstone	15.38	44.67	-----	37.64
Slate	-----	171.43	-----	30.88
Miscellaneous	11.87	20.62	-----	17.63

FOREIGN TRADE

U.S. building stone and monumental stone exports were valued at $2.7 million. In terms of value, Canada received 44 percent of the exported stone, Chile received 28 percent, and Venezuela received 25 percent.

Total stone imported into the United States was valued at $29.3 million, of which $24.1 million, or 82 percent, was dimension stone. Marble, breccia, and onyx comprised 52 percent of the value of imported dimension stone. In descending order of value, other principal dimension

[4] Pit and Quarry. 24th Annual Convention of National Limestone Institute. V. 61, No. 9, March 1969, pp. 88–100.
[5] Pit and Quarry. 24th Annual Convention of Iowa Limestone Producers. V. 61, No. 12, June 1969, p. 36.
[6] Building Stone News. Effective Executive Program To Be BSI Convention Highlight. V. 9, No. 7, January 1969, p. 1.
[7] Hall, Dave. The Innovators. Stone Mag., v. 89, No. 10, October 1969, p. 9.
[8] Pages 6–9 of work cited in footnote 7.
[9] Herod, Buren C. Jasper Stone Co. Pit and Quarry, v. 62, No. 1, July 1969, pp. 74–79.

stone imports were granite, 22 percent; slate, 12 percent; and travertine, 10 percent.

Italy and Portugal were the principal suppliers of polished marble. Canada and Italy were the chief sources of supply for monumental, paving, and building granite. Italy and the United Kingdom furnished most of the slate imports, and Italy was the main supplier of travertine.

WORLD REVIEW

South Africa, Republic of.—According to the University of Witwatersrand Mining Department, Johannesburg, a "supersonic" camera was used to take photographs of underground rock blasts.[10] The objective was to determine what happens to rock formations underground when explosives are used.

Spain.—Marmoles Blancos de Maceal, operator of 30 white marble quarries in the mountains around Olula Del Rio in the province of Almería, mechanized operations with the addition of 25 tractor shovels over a 3½-year period.[11] This increased the flexibility and productivity of the quarry operations.

Thailand.—An investigation of Thailand's mineral resources was conducted from January 1963 to May 1966.[12] Limestone was one of the minerals in the 58 mineral prospects investigated. Economic development must await feasibility studies and additional geological work, including diamond drilling.

Togo.—According to the U.S. Department of State, the Société Togolaise de Marbrerie et de Materiaux (SOTOMA), a joint venture of Italian private interests and the Togolese Government, started operations to quarry marble at Gnaoulou, about 90 miles north of Lomé. About 2,500 metric tons of marble was produced in 1969.

United Kingdom.—The new Greenside-McAlpine rock tunneler, designed to cut a circular 10- to 14-foot-diameter tunnel, was used successfully to cut limestone with unconfined compressive strength ranging between 21,000 and 33,000 psi.[13] This tunneler thus provides capability for cutting hard limestone as opposed to drilling and blasting with attendant shattering and the necessity for more frequent use of steel rib supports.

The Highlands and Islands Development Board launched a campaign to encourage the exploitation of mineral resources in northwest Sutherland, Scotland.[14] The Board completed an assessment of the mineral potential of the area and is seeking inquiries from mining companies interested in developing the mineral prospects. Among the minerals found were dolomite, marble, and syenite.

TECHNOLOGY

Thermal treatment of bluestone was discussed at the 50th annual convention of the Building Stone Institute.[15] The treatment is similar to thermal finishing in the granite industry.

The Bushnell Machinery Co. of Pittsburgh, Pa., applied for a patent for the use of granite pickle tanks in continuous pickling operations using either sulfuric or hydrochloric acid.[16] This patent incorporates advantageous auxiliary facilities such as arrangement of steam sparging, water seal covers, and ventilation system.

The Bureau of Mines Twin Cities Mining Research Center at Minneapolis, Minn., continued to conduct theoretical and experimental studies on rock disintegration by application of energy. Researchers used a scanning electron microscope (SEM) for systematic mapping of fracture surfaces of various materials.[17] The Bureau of Mines issued a report noting the effect of increasing end constraint on the compressive strength of model rock pillars of limestone, marble, sandstone, and granite.[18] The results of compression testing are useful in the design of room-and-pillar mining operations.

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[10] Mining Magazine (London). Supersonic Camera Photographs Underground Rock Blasts. V. 120, No. 1, January 1969, p. 51.

[11] Mining and Minerals Engineering. Michigan's in Marble. V. 5, No. 6, June 1969, p. 16.

[12] Mining Journal (London). The Industry in Action: Exploration. V. 273, No. 7001, Oct. 24, 1969, p. 375.

[13] Mining Journal (London). Tunnelling Through Hard Limestone. V. 271, No. 6955, December 1968, p. 447.

[14] Mining Journal (London). The Industry in Action: Exploration. V. 273, No. 6985, July 4, 1969, p. 8.

[15] Page 3 of work cited in footnote 6.

[16] Christian, Robert N. Evaluation of Granite Facilities. Blast Furnace and Steel Plant, v. 57, No. 4, April 1969, pp. 310–311.

[17] Willard, Robert J. Scanning Electron Microscope Gives Researchers a Closer Look at Rock Fractures. Min. Eng. v. 21, No. 6, June 1969, pp. 88–90.

[18] Babcock, Clarence O. Effect of Increasing End Constraint on the Compressive Strength of Model Rock Pillars. BuMines Rept. of Inv. 7298, 1969, 18 pp.

Westinghouse Research Laboratories studied the potential uses of electron beams in cutting rock.[19] The laboratory has an experimental model electron beam rock cutter capable of melting rock in seconds and penetrating to depths as much as 4 inches. U.S. Army Corps of Engineers researchers tested an air-powered cannon that pulsed supersonic jets of water as a means to breach rock barriers and drill holes for demolition blasting. The cannon fires five jet pulses per second at pressures up to 100,000 pounds per square inch and could have applications in quarrying.

CRUSHED STONE

DOMESTIC PRODUCTION

Crushed stone production reached a record high of 861 million tons, 5 percent higher than the 818 million tons produced in 1968. Crushed stone comprised more than 99 percent of the volume but only 93 percent of the value of 1969 total stone production. About 43 percent of the crushed stone production was used as aggregate.

Descriptions of several new plants were published. Included among the plants that produced crushed stone from granite were two North Carolina operations. Superior Stone Co. built an 800-ton-per-hour aggregate plant to produce crushed granite and granite sand for the Charlotte, N.C., region, one of the fastest growing markets in the United States.[20] The flexibility of the operation is provided by control towers for the three operating divisions of the plant: Primary crushing, secondary crushing, and load out. Closed-circuit television facilitates remote control of truck load-out operations, and an automatic batching system utilizes punch cards to program the blending of aggregate fractions. Nello L. Teer Company built one of the most advanced plants in the crushed stone industry at Rocky Mount, N.C.[21] The 400-ton-per-hour plant can make straight or blended sizes to meet various specifications up to 4-inch filter stone. Riprap can also be produced in various sizes by installing a grizzly and conveyor at the primary station or adding a chute and conveyor at the secondary station. It is believed that this is the first crushed stone plant to utilize ultrasonics to monitor continuously and simultaneously the level of materials in bins.

Penry Stone Co. began production at its Radnor, Ohio, aglime plant.[22] The new plant has an agricultural lime capacity of 30 tons per hour. An Indiana sand, gravel, and concrete producer, Irving Materials, Inc., entered the crushed limestone business.[23] Capacity of the operation is estimated at 3,000 tons daily. The quarry is at McCordsville, Ind., near Indianapolis. Knob Rock, Inc., started development of a new limestone quarry near Shell Knob, Mo.[24] Products were agricultural lime, with high magnesium and calcium contents, and several sizes of construction stone.

Two plants that used basalt as raw material were operated in Hawaii. The H C & D, Ltd., new aggregate plant on the island of Oahu, helped supply the accelerated demand for construction materials.[25] This highly automated plant was supplied with quarried basalt as raw material and required only two operators for the crushing-and-screening layout. Pacific Cement & Aggregates, Inc., operated a $3 million plant in Hawaii.[26] Besides aggregates (rated capacity 750 tons per hour), the plant also produces other blends and miscellaneous fill materials from waste. There are no known large-size natural gravel deposits on the island; thus crushed basalt rock is used for aggregate and base-rock requirements.

Producers continued to modernize and increase plant capacity to fulfill crushed stone requirements. Campbell Limestone Co. increased capacity to 1,400 tons per hour at its Liberty, S.C., crushed granite

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[19] Construction Methods and Equipment. The Art of Tunneling. V. 51, No. 7, July 1969, pp. 143–146.

[20] Levine, Sidney. Versatility Keynotes New Superior Stone Operation. Rock Prod., v. 72, No. 9, September 1969, pp. 76–81.

[21] Pit and Quarry. Nello L. Teer Company's Newest Crushed Stone Plant. V. 61, No. 10, April 1969, pp. 92–98, 112.

[22] Pit and Quarry. New Ohio Aglime Plant. V. 61, No. 9, March 1969, p. 27.

[23] Rock Products. Irving Materials Starts Stone Production. V. 72, No. 8, August 1969, p. 18.

[24] Pit and Quarry. Knob Rock, Inc., To Open Missouri Limestone Quarry. V. 61, No. 11, May 1969, p. 34.

[25] Utley, Harry F. Only Two Operators Required for Highly Automated Crushing-and-Screening Layout. Pit and Quarry, v. 61, No. 11, May 1969, pp. 96–99, 123.

[26] Pit and Quarry. PC&A Constructs New 750-TPH Crushing-and-Screening Plant in Hawaii. V. 61, No. 8, February 1969, p. 120–123.

plant.[27] Equipment replacement and modernization of the primary and secondary crushing systems substantially increased the operating capacity. Pacific Cement & Aggregates, Inc., started an automation-expansion project for its Davenport facility in Santa Cruz County, Calif. The expansion includes installation of a 3-mile covered conveyor for transferring limestone from the Bonny Doon quarry.[28] The project, scheduled for completion in 1973, is expected to increase plant output of 3 million tons per year by 50 percent. Kelly Lime and Rock, Inc., completed revamping its plant in northeastern Missouri to boost aglime output capacity.[29] The long-term rebuilding program resulted in increased capacity to 1,200 tons per day. Agstone constituted 75 percent of total production. Texas Crushed Stone Co. of Austin, Tex., computerized material planning, inventory, and billing systems at its Georgetown, Tex. plant.[30] The computerized systems, although expensive, have proved very satisfactory by pinpointing necessary product or operating changes, as well as handling accounting functions. Vulcan Materials Co. doubled production of its Kennesaw, Ga., plant with completion of its expansion program.[31] This is the third modernization of its Atlanta-area granite aggregate plants since 1965. New equipment and structures included a primary crusher that doubled 8-inch crusher throughput to 800 tons per hour, four low-profile towers for screens and crushers, concrete reclaiming tunnels for surge piles and stockpiles, control house towers, and a railroad spur.

Also included in trade publications were descriptions of plants where changes were made to improve plant flexibility and increase production. Among those described were the L .G. Everist, Inc., plant at the site of the Dardenelle lock and dam project on the Arkansas River. The plant processes sand during the day and produces three sizes of crushed stone (to U.S. Army Corps of Engineers specifications) during the night.[32] By producing different materials on alternate shifts, coordination between the processing of materials and contractors' pouring schedules was achieved.

To provide operational flexibility, a marked change was made at Material Service Corp.'s Thornton, Ill., plant.[33] A new primary crusher was placed on the quarry floor. Also, a surge pile was established ahead of the plant feed conveyor to allow quarry and processing plant to operate independently of each other. The operation is one of the world's largest stone-production facilities and produces more than 8 million tons per year.

CONSUMPTION AND USES

Manufactured lightweight aggregates are the fastest growing segment of the entire rock products group.[34] The application of lightweight aggregate continues to be strong in the field of masonry units and in a number of areas has been increasingly favored for high-rise construction and highway construction, particularly in skid-resistant topping. Hercules, Inc., commenced building a plant at Snowden, Va., to make slate aggregate.[35] The plant will "expand" slate in large rotary kilns to produce a lightweight material suitable for use in construction such as building blocks and ready-mixed concrete.

Several uncommon uses of limestone were publicized during the year. Engineers at U.S. Steel's Applied Research Laboratory found that if tanks were installed in a bed of crushed limestone, a calcium salt coating formed over the steel surface.[36] This coating substantially reduced natural corrosion caused by ground water. The Bureau of Mines reported on the methods for filling underground cavities remotely with dry material pneumatically injected through a borehole.[37] The materials stud-

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[27] Levine, Sidney. Campbell Limestone Doubles Capacity at Liberty Quarry. Rock Products, v. 72, No. 3, March 1969, pp. 74–78.

[28] Pit and Quarry. Pacific Cement & Aggregates Continues Expansion in California. V. 61, No. 11, May 1969, p. 30.

[29] Herod, Buren C. Kelly Lime and Rock Designs for Market. Pit and Quarry, v. 61, No. 11, May 1969, pp. 152–156.

[30] Snead, E. deS., and Buren C. Herod. Production Planning by Computer. Pit and Quarry, v. 61, No. 8, February 1969, p. 96.

[31] Levine, Sidney. Georgia Aggregate Producer Doubles Production. Rock Prod., v. 72, No. 4, April 1969, pp. 72–74.

[32] Bergstrom, John H. Stone Plant by Night—Sand Plant by Day. Rock Prod., v. 72, No. 4, April 1969, pp. 64–67.

[33] Burkhardt, H. A. Chicago Area Quarry Gets a New Look. Pit and Quarry, v. 62, No. 2, August 1969, pp. 104–107.

[34] Rock Products. Lightweight Aggregates—Way Above Average. V. 72, No. 12, December 1969, pp. 49–50.

[35] Industrial Minerals (London). World Minerals: United States–Lightweight Slate Material. No. 21, June 1969, p. 44.

[36] Chemical Engineering News. Technology. V. 47, No. 16, Apr. 14, 1969, p. 41.

[37] Murphy, Edwin M., Malcolm O. Magnuson, Peter Suder, Jr., and John Nagy. BuMines Rept. of Inv. 7214, December 1968, 27 pp.

ied were fly ash, crushed and pulverized limestone, and sand. The best results were obtained with dry fly ash, though satisfactory seals were obtained with the other materials. Low cost and widespread availability were factors in considering limestone as a reactant for desulfurization of combustion gases. A study to determine the differences in the sulfur dioxide reaction characteristics of a large number of limestones and the physical and chemical properties responsible for these differences was made by the U.S. Department of Health, Education and Welfare.[38] Chaulk and oolitic limestone were the most efficient absorbents, and magnesite and Iceland spar were the least efficient of the samples tested.

PRICES

Quotations in Engineering News-Record for carload lots of 1½-inch crushed stone in 1969 ranged from $5.75 per ton in Minneapolis to $1.55 per ton in Birmingham. The average price reported for 18 major cities was $2.94 per ton, almost a 10-percent increase from the 1968 average. The prices for ¾-inch, crushed stone ranged from $5.75 per ton in Minneapolis to $1.60 per ton in Birmingham and Saint Louis. The average price for 18 major cities was $2.98 per ton, an increase of 8 percent over the 1968 average.

Prices for industrial fillers and extenders per ton, as reported in the American Paint Journal, were as follows:

Silica, amorphous, ultra-fine ground	$69.00
Silica, crystalline	$20.50–$45.40
Whiting precipitated, surface-treated	$48.00
Whiting, dry ground, 325 mesh	$14.25–$19.00
Whiting, precipitated, U.S.P	$50.00–$117.00
Whiting, precipitated, technical	$33.00–$44.00
Whiting, natural, water-ground	$39.00

FOREIGN TRADE

Canada, with 79 percent of the value, was the major receiver of crushed stone exports. Other principal receivers were the United Kingdon, 6 percent; Bahamas, 4 percent; and Mexico, 2 percent.

Crushed stone imports represented 18 percent of the total value of stone import. Canada, principal source of crushed stone, supplied 97 percent of the value of crushed stone. Principal imported crushed stone items included limestone chips and spalls (59 percent of quantity) and stone chips and spalls combined with stone, crushed or ground (40 percent of quantity). These items accounted for 68 percent and 30 percent, respectively, of the total value of crushed stone imports.

WORLD REVIEW

Australia.—More than 40,000 acres of offshore claims for limestone and limestone sand near the industrial center of Kwinana in Western Australia were staked by Australian Iron and Steel, a subsidiary of Broken Hill Pty. Ltd.[39] The claims extend from Carnac Island to near Point Peron on the mainland. These claims are expected to be the source of supply of limestone for the Australian Iron and Steel Works at Kwinana. Heretofore, limestone came from two areas in South Australia, more than 1,000 miles away.

Bahama Islands.—According to the U.S. Department of State, the Bahama Government set the royalty on mined aragonite at 6 cents per long ton. The estimated reserve of aragonite available in the Bahamas was nearly 50 billion tons.

Canada.—Laredo Limestone Ltd., Toronto, Ontario leased waterfront property in the Greater Vancouver region and at Stockton, Calif., to provide storage and distribution facilities for limestone mined on Aristazabal Island near Vancouver.[40]

Enercon Ltd. of Canada built a fly ash processing plant for the purpose of commercial utilization of the fly ash of a Hamilton, Ontario generating station.[41] Tests indicated that the lightweight aggregate produced was as good as the lightweight aggregates produced in Canada or the United States with more conventional raw materials.

India.—The Geological Survey of India (GSI) located sizable reserves of limestone and other mineral deposits of economic significance in Maharashtra.[42] Important limestone deposits were found in

[38] Potter, Allen E. Sulfur Oxide Capacity of Limestones. Ceramic Bull., v. 48, No. 9, September 1969, pp. 855–858.
[39] Mining Journal (London). The Industry in Action. V. 273, No. 7007, Dec. 5, 1969, pp. 515, 517.
[40] Pit and Quarry. Laredo Limestone Ltd. To Begin Servicing Portland, Ore. V. 62, No. 1, July 1969, p. 28.
[41] Boux, Joseph F. Canadians Pioneer New Fly Ash Processing System. Miner. Processing, v. 10, No. 3, March 1969, pp. 16–19.
[42] Mining Journal (London). The Industry in Action: Exploration. V. 272, No. 6981, June 6, 1969, p. 49.

the belts of Rajur, Guarala, and Kurli-Parthi. Generally, the limestone is low in magnesium, but rather high in silica content. The GSI also estimated the limestone reserve of the Naikari-Kusumbi belt in the Chanda district to be 100 million metric tons.

South Africa, Republic of.—The Pace Foster Corp., an American company, submitted a 10-year plan to the Economic Development Ministry to invest $55 million in Guyana.[43] A portion of the investment was scheduled for building a limestone plant and a ready-mix concrete plant.

United Kingdom.—Middle Peak quarry, Wirksworth, England, was developed by Derbyshire Stone Group into one of the largest and most efficient sandstone quarries in Britain.[44] The British National Coal Board reported a probable market for the unburnt shale stocks that were increasing by an estimated 30 million tons a year.[45] The material was subsituted for crushed stone as a subbase for roads and for an experimental embankment.

TECHNOLOGY

The Bureau of Mines continued its mining research studies and issued several reports pertaining to rock fragmentation. The elastic moduli of four types of rock measured at temperatures ranging from room temperature up to 1,500° F (1,089° K) were published.[46] Data for Young's modulus, shear modulus, and Poisson's ratio were given as a function of temperature for Dresser basalt. Reserve taconite, Jasper quartzite, and Charcoal granite. A description of laboratory studies of combining water and electricity to break rock was published.[47] The results of the experiments indicate that an "electrohydraulic pressure pulse" has the potential for development into a practical tool for rock fragmentation. Suggested possible areas of application include drilling, where an electrohydraulic device would be designed to fit a water-filled drill hole; in ore processing where rock crushing is necessary; and in blasting research as an energy source. A "user's guide" to commercial explosives and blasting agents for mining and other industrial rock-breaking jobs was released.[48] The guidebook lists and describes ingredients, detonation velocities, and other important characteristics, such as detonation pressure, density, fume class, and water resistance, of the explosives.

The Bureau of Mines reported on the hydraulic transportation of coarse solids including limestone, mine refuse, and bituminous coal.[49] The lock-hopper-feeder system was found practical for continuous hydraulic transporation of the materials, types, and size ranges tested. Construction of the first pipeline to transport limestone slurry from a distant quarry to a cement-manufacturing plant was started by Calaveras Cement Division of the Flintkote Co.[50] The 17.6-mile underground line will transport pulverized rock in liquid suspension from the quarry to the company's San Andreas, Calif., cement plant.

According to the National Crushed Stone Association (NCSA), there was increasing acceptance in the use of limestone (10 to 30 mesh) blended with urea to provide anti-icing and antiskid protection on runways, strips, and ramps at airports.[51] NCSA prepared a presentation on vibrating screens and their operation to assist operators in obtaining the maximum performance from their screening equipment.[52]

Operators and manufacturers of stone-crushing equipment found methods of lowering costs and increasing efficiency. Massachusetts Broken Stone Co., Inc., operator of three quarries in the Boston area, found that the use of water-gel explosives resulted in lower operating costs and increased rock fragmentation.[53] Olmos Rock

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[43] Pit and Quarry. $55-Million Project Includes Limestone Plant for Guyana. V. 62, No. 6, December 1969, p. 26.

[44] Ironman, Ralph. Quarrying the British Way. Rock Prod., v. 72, No. 8, August 1969, pp. 72–74.

[45] Mining and Mineral Engineering (London). Shale Sales. V. 5, No. 11, December 1969, p. 52.

[46] Wingquist, Carl F. Elastic Moduli of Rock at Elevated Temperatures. BuMines Rept. of Inv. 7269, 1969, 8 pp.

[47] Kutter, H. K. The Electrohydraulic Effect: Potential Application in Rock Fragmentation. BuMines Rept. of Inv. 7317, 1969, 35 pp.

[48] Dick, Richard A. Factors in Selecting and Applying Commercial Explosives and Blasting Agents. BuMines Inf. Circ. 8405, 1968, 30 pp.

[49] Fowkes, R. S., and G. A. Wancheck. Materials Handling Research: Hydraulic Transportation of Coarse Solids. BuMines Rept. of Inv. 7283, 1969, 36 pp.

[50] Mining Congress Journal. Mining Newsmonth. V. 55, No. 12, December 1969, p. 18.

[51] National Crushed Stone Association. Specialty Market for Fine Crushed Stone. Useful Information 8-18, Dec. 22, 1969.

[52] Pit and Quarry. Vibrating Screens and Their Operation. Part I. V. 61, No. 11, May 1969, pp. 100–105.

[53] Pit and Quarry. Water-Gel Explosives Reduce Costs at Massachusetts Quarry. V. 61, No. 7, January 1969, pp. 163–164.

Products Corp. of San Antonio, Tex., replaced its nine small hauling units with three 45-ton-capacity International 180 Payhaulers and increased production by 30 percent at its quarry in the Edwards Limestone formation.[54] A British company improved its design of stone-crushing machines by substituting double rollers for the traditional toggle system of operating the crushing jaws and thereby eliminated frictional losses inherent in the double toggle action.[55] This development in design provided higher output at the same cost.

Important studies pertaining to operating methods and dust pollution were described in the literature. Although the largest underground mining operations are in the 40,000- to 60,000-ton-per-day range, feasibility studies of considerably larger underground operations have been made. The results of a feasibility evaluation of a 100,000-ton-per-day operation were published.[56] The evaluation covered a central underground-to-surface transportation system and a ventilation system. A system for controlling product dryness based on three temperature measurements was developed at the Foxboro Co., Foxboro, Mass.[57] It is applicable to many types of dryers and provides better response to upsets or load disturbances than the conventional method, that of maintaining a constant outlet-air temperature. An experimental study was carried out at the National Aeronautics and Space Admininstration Langley Research Center, Hampton, Va., to explore the feasibility of sorting particles by shape with standard sieving equipment.[58] Included in this report are the basic considerations in sieving leading to formulation of the technique and the results of experiments with specially prepared particles and with randomly shaped crushed gravel. A study of in-plant control of dust pollution in aggregate plants was described.[59] The results of the study indicated that a dry dust collection system utilizing an abrasive bag-type collector was the most satisfactory solution.

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[54] Pit and Quarry. Olmos Rock Products Utilizes High-Capacity Off-Highway Haulers in Quarry Operations. V. 61, No. 8, February 1969, p. 56.

[55] South African Mining and Engineering Journal (Johannesburg). New Design For Stone Crusher. V. 80, No. 3977, Apr. 25, 1969, p. 935.

[56] Johnston, C. E., John J. Seerly, and A. B. Short. Transport Considerations for Underground Operations Over 100,000 TPD. Min. Cong. J., v. 55, No. 4, April 1969, p. 87.

[57] Shinskey, F. G. How To Control Product Dryness—A New System. Miner. Processing, v. 10, No. 4, April 1969, pp. 10–14.

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Table 2.—Stone shipped or used by producers in the United States, by States
(Thousand short tons and thousand dollars)

State	1968		1969	
	Quantity	Value	Quantity	Value
Alabama	20,643	$33,847	19,854	$37,512
Alaska	W	W	1,954	3,902
Arizona	3,293	6,239	2,827	5,812
Arkansas	16,322	22,256	16,463	23,134
California	36,125	52,671	38,033	57,757
Colorado	2,471	5,201	2,245	5,079
Connecticut	6,383	12,729	7,562	15,325
Delaware	200	500	------	------
Florida	36,692	46,563	[1] 42,332	[1] 56,611
Georgia	26,903	56,177	27,755	59,451
Hawaii	5,211	11,273	6,534	16,059
Idaho	2,195	5,209	3,750	6,426
Illinois	55,858	80,188	54,857	81,318
Indiana	26,307	46,790	25,559	45,400
Iowa	26,150	40,397	26,233	40,895
Kansas	r 14,372	r 20,650	15,828	22,645
Kentucky	30,105	43,266	[1] 30,158	[1] 44,644
Louisiana [1]	9,387	11,785	9,237	11,892
Maine	1,187	3,205	1,101	3,798
Maryland	13,344	26,606	15,067	30,504
Massachusetts	6,917	19,501	7,847	22,521
Michigan	37,279	41,092	39,186	43,572
Minnesota	4,427	13,045	5,035	14,253
Mississippi	747	833	W	W
Missouri	r 38,988	r 58,743	41,977	63,251
Montana	3,314	4,878	7,667	10,579
Nebraska	4,416	7,435	4,665	9,494
Nevada	1,325	2,041	1,494	2,433
New Hampshire	383	3,377	320	2,888
New Jersey	13,151	30,343	15,162	34,034
New Mexico	2,226	3,527	2,826	3,286
New York	35,441	63,510	37,561	66,839
North Carolina	24,543	42,429	26,812	47,829
North Dakota	165	326	72	99
Ohio	[1] 48,054	[1] 78,772	51,792	86,570
Oklahoma	17,290	21,950	18,799	23,650
Oregon	14,312	21,168	11,662	18,897
Pennsylvania	62,812	108,151	66,992	117,726
Rhode Island	W	W	W	1,417
South Carolina	8,942	13,717	8,846	13,506
South Dakota	1,860	9,687	2,092	10,839
Tennessee	[1] 32,083	[1] 43,854	33,265	46,192
Texas	48,480	58,006	46,638	64,986
Utah	1,953	4,312	2,582	4,434
Vermont	2,536	21,401	2,151	19,810
Virginia	31,217	53,533	33,461	58,713
Washington	14,331	16,690	15,742	21,069
West Virginia [1]	9,011	16,789	9,031	15,801
Wisconsin	17,000	25,223	18,954	27,571
Wyoming	1,434	2,754	1,584	3,012
Undistributed	1,811	r 5,272	1,331	1,260
Total [2]	r 819,597	r 1,317,911	862,895	1,424,694
Pacific island possessions	653	1,209	717	1,552
Panama Canal Zone	106	290	74	231
Puerto Rico	7,367	13,580	6,985	13,550
Virgin Islands	366	1,555	411	1,682

r Revised. W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] To avoid disclosing individual company data, certain State totals are incomplete, the portion not included being combined with "Undistributed." The class of stone omitted from such State totals is noted in the summary chapter of this volume.

[2] Data may not add to totals shown because of independent rounding.

Table 3.—Stone shipped or used by producers in the United States, by kinds

(Thousand short tons and thousand dollars)

Year	Granite Quantity	Granite Value	Traprock[1] Quantity	Traprock[1] Value	Marble Quantity	Marble Value	Limestone dolomite Quantity	Limestone dolomite Value	Shell Quantity	Shell Value
1965	60,028	$121,147	75,529	$121,278	2,172	$38,662	554,936	$765,927	21,560	$34,314
1966	65,888	128,558	88,623	147,594	2,244	36,203	569,577	794,279	21,662	32,783
1967	63,073	133,664	68,483	116,913	2,232	35,245	569,463	799,687	22,026	33,334
1968	70,506	148,333	73,117	125,476	2,559	32,372	r 603,740	r 873,634	20,268	28,563
1969	75,880	160,960	78,914	143,230	2,348	34,789	628,937	937,179	19,731	27,933

Year	Calcareous marl Quantity	Calcareous marl Value	Sandstone, quartz, and quartzite Quantity	Sandstone, quartz, and quartzite Value	Slate Quantity	Slate Value	Other stone[2] Quantity	Other stone[2] Value	Total[3] Quantity	Total[3] Value
1965	1,291	1,125	29,097	61,710	1,263	13,697	34,366	45,971	780,242	1,203,831
1966	1,358	1,195	27,493	57,037	1,356	13,680	35,173	49,386	813,374	1,260,715
1967	1,227	1,084	27,249	60,494	1,260	14,615	30,580	45,208	785,592	1,240,244
1968	1,211	1,166	27,010	63,416	1,273	14,412	19,914	30,539	r 819,597	r 1,317,911
1969	2,490	2,516	27,456	64,272	1,308	13,831	25,831	39,983	862,895	1,424,694

r Revised.
[1] Includes gabbro, basalt, diabase, etc.
[2] Includes mica schist, conglomerate, argillite, various light-colored volcanic rocks, serpentine not used as marble, soapstone sold as dimension stone, etc.
[3] Data may not add to totals shown because of independent rounding.

Table 4.—Dimension stone shipped or used by producers in the United States in 1969, by use and kind of stone

(Thousands)

Kind of stone and use	1968			1969		
	Short tons	Cubic feet	Value	Short tons	Cubic feet	Value
GRANITE						
Rough:						
Architectural	69	811	$2,300	28	326	$965
Construction [1]	122	1,491	1,036	130	1,403	1,282
Monumental	190	2,194	11,425	201	2,155	12,333
Uses not specified [2]	------	------	------	4	50	23
Dressed:						
Cut	46	555	10,442	55	607	11,146
Sawed	(3)	(3)	W	[4] 4	[4] 47	[4] 602
House stone veneer	5	61	331	5	57	138
Construction	16	200	1,251	14	170	1,101
Monumental [5]	52	579	11,077	56	650	11,429
Curbing	168	2,026	5,091	190	1,973	5,666
Flagging	W	W	W	(6)	4	11
Paving blocks	W	W	W	6	67	161
Other rough and dressed stone [7]	7	103	143	------	------	------
Total [8]	676	8,021	43,096	692	7,510	44,858
LIMESTONE AND DOLOMITE						
Rough:						
Architectural	245	2,823	4,130	224	2,643	4,262
Construction [1]	63	765	584	81	1,035	1,039
Flagging [9]	------	------	------	18	233	239
Other rough stone	8	109	58	------	------	------
Dressed:						
Cut	90	1,153	5,678	67	872	6,085
Sawed	76	963	2,717	64	813	2,734
House stone veneer	96	1,246	2,823	78	1,003	2,409
Construction	8	109	139	13	166	[10] 435
Flagging	15	184	143	3	37	54
Other uses not listed	------	------	------	26	304	W
Total [8]	602	7,352	16,273	574	7,106	17,256
MARBLE						
Rough:						
Architectural	15	164	1,117			
Construction [1]	6	256	116	[11] 25	296	583
Other rough stone	5	56	14			
Dressed:						
Cut	28	334	7,465	24	280	7,331
Sawed	8	94	1,332	8	100	1,407
House stone veneer	13	150	1,639			
Construction	[12] 5	[12] 64	[12] 365	[11] 20	233	3,468
Monumental	8	96	2,118			
Total [8]	89	1,214	14,166	77	909	12,789
SANDSTONE, QUARTZ, AND QUARTZITE						
Rough:						
Architectural	35	477	583	29	389	521
Construction [1]	69	834	961	92	1,238	1,340
Flagging [13]	------	------	------	20	207	W
Other rough stone	3	32	34	W	W	W
Dressed:						
Cut	88	1,234	3,733	77	1,055	3,831
Sawed [14]	42	r 525	2,103	38	521	1,984
House stone veneer	30	390	762	[15] 26	[15] 303	[15] 680
Flagging [16]	43	507	1,975	28	343	1,054
Other uses not listed or unspecified	[17] 2	[17] 25	[17] 882	2	32	[18] 1,569
Total [8]	312	r 4,024	11,033	311	4,088	10,979
SLATE [19]						
Roofing slate	19	48	2,006	[20] 16	------	[20] 1,698
Millstock:						
Electrical	17	2,309	2,504	W	------	W
Structural and sanitary	------	------	------	18	------	2,734
Blackboards, etc	2	575	553	(6)	------	357
Billiard table tops	W	W	W	[21] 2	------	[21] 509
Total [8]	19	2,884	3,057	21	------	3,600
Flagging	[22] 43	[22] 7,489	[22] 1,221	40	------	1,235
Miscellaneous uses [23]	73	258	3,008	------	------	------
Other uses not listed or unspecified	------	------	------	64	------	2,679
Total [8]	154	10,679	9,292	142	------	9,212

See footnotes at end of table.

Table 4.—Dimension stone shipped or used by producers in the United States in 1969, by use and kind of stone—Continued

(Thousands)

Kind of stone and use	1968			1969		
	Short tons	Cubic feet	Value	Short tons	Cubic feet	Value
OTHER STONE [24]						
Rough:						
Architectural	W	W	W	9	111	$86
Construction [1]	[25] 200	[25] 2,369	[25] $3,697	39	469	484
Other rough stone	------	------	------	([26])	7	21
Dressed:						
Cut	W	W	W	[27] 2	[27] 22	W
House stone veneer	W	W	W	([6])	10	24
Construction	W	W	W	[28] 5	62	W
Flagging	6	65	107	8	86	141
Other uses not listed [29]	4	51	50	------	------	------
Total [8]	r 210	r 2,486	r 3,855	65	767	[30] 2,682
TOTAL STONE						
Rough:						
Architectural	376	4,441	8,348	300	3,570	6,257
Construction [1]	r 449	r 5,590	r 3,267	356	4,337	4,361
Monumental	190	2,198	11,442	201	2,158	12,343
Flagging [31]	------	------	------	37	419	886
Other rough stone	18	217	134	[32] 13	[32] 158	[32] 133
Dressed:						
Cut	262	3,391	30,599	225	2,845	29,122
Sawed	130	r 1,640	6,346	118	1,515	6,822
House stone veneer	145	1,861	5,581	118	1,476	4,510
Construction	29	364	1,474	30	371	1,383
Roofing (slate)	19	------	2,006	[33] 16	------	[33] 1,698
Millstock (slate)	19	------	3,057	21	------	3,600
Monumental	r 60	r 669	r 13,210	64	739	13,348
Curbing	r 169	2,049	5,178	191	1,996	5,741
Flagging	108	1,396	3,452	81	494	2,539
Paving blocks	W	W	W	6	67	161
Miscellaneous use (slate)	73	------	3,008	------	------	------
Uses not listed or unspecified [34]	r 13	r 150	r 1,340	98	390	5,742
Total [8]	r 2,060	r 23,967	r 98,441	1,873	20,535	98,647

r Revised. W Withheld to avoid disclosing individual company confidential data.

1 Includes irregularly shaped stone and rubble.

2 Includes minor amount of flagging and other rough stone.

3 Less than ½ unit; included with house stone veneer.

4 Includes small amount of other uses not listed.

5 1968 data include stone for precision plates.

6 Less than ½ unit.

7 Includes paving blocks, refractory blocks, minor amounts of flagging, and unspecified uses.

8 Data may not add to totals shown because of independent rounding.

9 Comparable data not available in 1968; 1969 data include small amounts of monumental and other rough stone.

10 To avoid disclosing confidential data, figure shown includes value data for other uses not listed.

11 Data combined to avoid disclosing confidential data.

12 Data include curbing, flagging, and uses not listed or unspecified.

13 Comparable data not available in 1968. 1969 quantity data include small amounts of other rough stone.

14 1968 data include stone for refractory blocks.

15 Includes dressed stone used for construction.

16 Includes stone for curbing.

17 Includes stone used for monumental purposes.

18 To avoid disclosing confidential data, figure shown includes value data for flagging and other rough stone.

19 With the exception of the data on roofing slate, which are given in thousand squares, data are reported in thousand square feet.

20 Includes minor amount of house stone veneer.

21 Includes slate used for electrical purposes.

22 Includes slate used for walkways and stepping stones.

23 Includes slate used for aquarium bottoms, buildings, fireplaces, flooring, headstones, shims, and billiard table tops.

24 Produced by the following States in 1969 in order of value of output and with number of quarries: Virginia (8); Maryland (5); California (30); Hawaii (4); Pennsylvania (4); New Jersey (1); Oregon (2); Arizona (1); New Mexico (1); and Washington (2).

25 Revised figure; data include stone used for architectural work and cut and sawed stone.

26 Less than ½ unit; includes a minor amount of rough stone used for flagging.

27 Includes sawed stone.

28 Includes stone used for structural and sanitary purposes.

29 1968 data include stone used for house stone veneer and construction.

30 To avoid disclosing confidential data, figure shown includes value data for construction and cut and sawed stone.

31 Comparable data not available in 1968.

32 Includes data for unspecified uses of rough stone.

33 Includes a minor amount of slate used for house stone veneer.

34 1968 data include paving blocks, refractory blocks, and slate used for aquarium bottoms, buildings, fireplaces, flooring, headstones, shims, and unspecified uses. 1969 data include stone used for structural and sanitary purposes.

Table 5.—Granite (dimension stone) shipped or used by producers in the United States in 1969, by States

State	Active quarries	Short tons	Value (thousands)	State	Active quarries	Short tons	Value (thousands)
California	8	5,748	$593	South Carolina	5	11,814	$470
Connecticut	4	2,855	73	South Dakota	7	44,121	7,620
Georgia	29	200,028	6,100	Wisconsin	9	7,013	2,126
Minnesota	15	21,994	5,287	Other States [1]	53	382,073	20,511
Missouri	1	1,779	288				
New Mexico	1	120	17	Total [2]	142	691,744	44,858
Oklahoma	9	12,199	1,274	Puerto Rico	3	16,200	49
Rhode Island	1	2,000	500				

[1] Includes quarries in Colorado (3), Maine (7), Massachusetts (8), New Hampshire (2), New York (4), North Carolina (13), Pennsylvania (2), Texas (3), Vermont (8), and Washington (3).
[2] Data may not add to totals shown because of independent rounding.

Table 6.—Limestone and dolomite (dimension stone) shipped or used by producers in the United States in 1969, by States

State	Active quarries	Short tons	Value (thousands)	State	Active quarries	Short tons	Value (thousands)
California	2	25,837	W	New Mexico	1	30	W
Illinois	3	12,137	$141	Ohio	4	8,085	$85
Indiana	32	357,321	11,285	Oklahoma	3	1,550	23
Iowa	5	13,495	255	Wisconsin	36	71,296	1,421
Kansas	7	18,907	391	Other States [2]	15	38,490	1,887
Michigan	4	4,242	59				
Minnesota	5	17,636	1,624	Total [3]	121	574,324	17,256
Missouri	3	2,698	69	Puerto Rico	11	101,200	292
Nebraska	1	2,600	16				

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Count may be duplicated for quarries that produce more than one kind of stone.
[2] Includes quarries in Alabama (1), Colorado (2), Florida (1), New York (1), Rhode Island (1), Texas (5), Utah (1), and Virginia (3).
[3] Data may not add to totals shown because of independent rounding.

Table 7.—Sandstone, quartz, and quartzite, (dimension stone) shipped or used by producers in the United States in 1969, by States

State	Active quarries [1]	Short tons	Value (thousands)	State	Active quarries [1]	Short tons	Value (thousands)
Arizona	26	10,792	$180	Pennsylvania	30	60,668	$1,489
Arkansas	4	9,381	323	South Dakota	2	112	W
Colorado	28	11,830	205	Tennessee	6	9,672	425
Indiana	4	6,962	193	Utah	5	1,727	54
Maryland	5	17,464	308	Virginia	3	W	61
Michigan	1	1,000	10	Wisconsin	7	2,198	46
Montana	1	10	(2)	Wyoming	1	400	14
New York	11	34,937	1,739	Other States [3]	29	50,050	1,456
Ohio	29	93,856	4,476				
Oregon	1	311	W	Total [4]	193	311,370	10,979

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Count may be duplicated for quarries that produce more than one kind of stone.
[2] Less than ½ unit.
[3] Includes quarries in California (6), Connecticut (3), Georgia (2), Kansas (1), Massachusetts (2), Minnesota (1), Missouri (2), New Jersey (2), New Mexico (5), North Carolina (1), Texas (1), Washington (2), and West Virginia (1).
[4] Data may not add to totals shown because of independent rounding.

Table 8.—Crushed and broken stone shipped or used by producers in the United States in 1969, by kind of stone and use

(Thousand short tons and thousand dollars)

Kind of stone and use	1968		1969	
	Quantity	Value	Quantity	Value
CALCAREOUS MARL [1]				
Agricultural purposes [2]	186	$150	141	$124
Surface treatment aggregates	------	------	3	2
Cement manufacture [3]	1,025	1,016	2,346	2,391
Total [4]	1,211	1,166	2,490	2,516
GRANITE				
Agricultural purposes [5]	105	994	68	486
Concrete aggregate (coarse)	8,151	12,358	12,953	19,273
Bituminous aggregate	7,940	12,793	6,847	11,375
Macadam aggregates	2,171	3,087	2,208	3,680
Dense-graded road-base stone	37,756	56,334	34,428	54,429
Surface treatment aggregates	4,875	6,224	4,124	6,605
Unspecified construction aggregate and roadstone	(6)	(6)	6,531	8,016
Riprap and jetty stone	2,351	4,933	2,587	4,609
Railroad ballast	3,244	4,322	3,532	4,960
Filter stone	94	159	103	206
Manufactured fine aggregate (stone sand) [7]	1,153	1,120	668	734
Special uses and products	------	------	250	W
Fill	W	W	136	123
Other uses	[8] 1,806	[8] 2,614	[9] 754	[9] 1,492
Uses not listed or unspecified	184	299	W	113
Total [4]	69,830	105,236	75,189	116,102
LIMESTONE AND DOLOMITE				
Agricultural purposes [5]	r 38,402	r 69,033	35,011	62,805
Concrete aggregate (coarse)	r 102,665	r 146,013	89,501	139,685
Bituminous aggregate	r 43,951	r 65,945	46,429	70,285
Macadam aggregates	r 30,047	r 42,570	23,422	34,730
Dense-graded road-base stone	r 143,015	r 186,395	142,271	188,966
Surface treatment aggregates	r 47,064	r 66,799	38,808	55,884
Unspecified construction aggregate and roadstone	(6)	(6)	53,641	78,680
Riprap and jetty stone	12,934	16,799	11,639	15,091
Railroad ballast	5,721	7,374	6,173	7,982
Filter stone	486	913	686	1,382
Manufactured fine aggregate (stone sand)	3,203	5,204	2,815	4,753
Terrazzo and exposed aggregate	139	825	164	984
Cement manufacture	97,773	104,682	97,632	108,992
Lime manufacture	r 27,380	r 50,380	29,565	53,248
Dead-burned dolomite	r 3,168	r 5,019	2,935	4,626
Ferrosilicon	------	------	148	202
Flux	r 28,262	r 43,254	30,360	45,673
Refractory	r 467	r 1,255	419	1,028
Chemical stone for alkali works	2,520	3,705	3,273	5,641
Special uses and products [10]	3,531	20,092	3,373	21,539
Fill	W	W	2,739	1,885
Glass	W	W	992	3,133
Other uses [11]	r 6,749	r 11,427	3,660	6,454
Uses not listed or unspecified	r 5,659	r 9,677	2,707	6,276
Total [4]	r 603,136	r 857,361	628,362	919,923
MARBLE				
Agricultural purposes [5]	424	1,313	W	W
Concrete aggregate (coarse), Macadam aggregates, Dense-graded road-base stone, Surface treatment aggregates	[12] 795	[12] 1,904		
Unspecified construction aggregate and roadstone	(6)	(6)		
Riprap and jetty stone	W	W		
Filter stone	------	------		
Manufactured fine aggregate (stone sand)	W	W		
Concrete aggregate (coarse) through Manufactured fine aggregate (stone sand) (1969, combined)			[12] 793	[12] 5,209
Terrazzo and exposed aggregate	201	3,349		
Cement manufacture	[13] 31	[13] 171	W	W
Special uses and products	[10] 951	[10] 10,641	[5] 1,378	[5] 15,678
Other uses	[8] 29	[8] 386	[14] 64	[14] 679
Uses not listed or unspecified	39	442	36	434
Total	2,470	18,206	2,271	22,000

See footnotes at end of table.

Table 8.—Crushed and broken stone shipped or used by producers in the United States in 1969, by kind of stone and use—Continued

(Thousand short tons and thousand dollars)

Kind of stone and use	1968		1969	
	Quantity	Value	Quantity	Value
SANDSTONE, QUARTZ, AND QUARTZITE [15]				
Concrete aggregate (coarse)	4,110	$7,605	2,818	$ 4,689
Bituminous aggregate	2,859	5,353	2,536	5,109
Macadam aggregates	961	1,007	358	530
Dense-graded road-base stone	9,497	14,029	8,703	12,722
Surface treatment aggregates	1,042	2,062	711	1,279
Unspecified construction aggregate and road-stone	(6)	(6)	3,006	5,716
Riprap and jetty stone	2,856	4,227	2,543	4,730
Railroad ballast	1,269	1,782	1,232	1,885
Filter stone	140	272	37	98
Manufactured fine aggregate (stone sand)	340	698	250	509
Terrazzo and exposed aggregate	56	1,095	71	1,240
Cement manufacture	672	1,081	994	1,244
Ferrosilicon	303	1,620	[16] 254	[16] 1,172
Flux	818	2,962	896	3,574
Refractory	632	5,311	718	4,587
Special uses and products	[10] 59	[10] 366	68	445
Other uses [17]	792	2,101	1,849	3,365
Uses not listed or unspecified	292	810	102	399
Total [4]	26,698	52,382	27,145	53,293
SHELL				
Agricultural purposes [5]	236	2,378	W	W
Concrete aggregate (coarse)	6,830	8,313	[18] 7,089	[18] 8,916
Dense-graded road-base stone	5,835	7,592	5,325	7,506
Cement manufacture	[19] 5,520	[19] 7,807	5,169	7,146
Lime manufacture	W	W	[20] 2,149	[20] 4,365
Other uses not listed	[21] 1,847	[21] 2,474	W	W
Total [4]	20,268	28,563	19,731	27,933
TRAPROCK				
Concrete aggregate (coarse)	11,447	22,480	8,343	18,332
Bituminous aggregate	10,651	20,240	10,999	21,622
Macadam aggregates	2,869	5,108	2,366	4,087
Dense-graded road-base stone	20,467	35,481	18,190	31,576
Surface treatment aggregates	7,755	12,512	8,488	12,226
Unspecified construction aggregate and road-stone	(6)	(6)	20,701	38,323
Riprap and jetty stone	2,552	5,655	2,603	5,071
Railroad ballast	1,400	2,212	1,350	2,119
Filter stone	68	114	104	195
Manufactured fine aggregate (stone sand)	151	374	91	313
Special uses and products [10]	147	306	133	312
Fill	W	W	[22] 5,534	[22] 3,321
Other uses	[8] 5,564	[8] 7,518	W	4,862
Uses not listed or unspecified	10,029	12,748	W	W
Total [4]	[23] 73,099	[23] 124,749	78,901	142,360
OTHER STONE				
Concrete aggregate (coarse)	809	1,575	737	1,478
Bituminous aggregate	2,564	4,329	2,770	4,813
Macadam aggregates	264	365	215	309
Dense-graded road-base stone	7,669	9,370	6,281	7,566
Surface treatment aggregates	606	832	469	567
Unspecified construction aggregate and road-stone	(6)	(6)	[24] 7,083	[24] 9,856
Riprap and jetty stone	1,665	2,980	3,962	5,721
Railroad ballast	1,221	869	[25] 1,654	[25] 1,270
Special uses and products	------	------	[26] 411	[26] 839
Fill	W	W	1,659	W
Other uses [8]	[27] 3,900	[27] 5,187	524	[28] 4,881
Uses not listed or unspecified	1,008	1,176	W	W
Total [4]	r 19,704	r 26,684	25,766	37,301

See footnotes at end of table.

Table 8.—Crushed and broken stone shipped or used by producers in the United States in 1969, by kind of stone and use—Continued

(Thousand short tons and thousand dollars)

Kind of stone and use	1968		1969	
	Quantity	Value	Quantity	Value
TOTAL STONE				
Agricultural purposes [5]	r 39,364	r $73,897	35,881	$67,066
Concrete aggregate (coarse)	r 134,730	r 199,820	120,805	191,872
Bituminous aggregate	r 67,964	r 108,660	69,580	113,205
Macadam aggregates	r 36,312	r 52,137	28,570	43,337
Dense-graded road-base stone	224,309	309,608	215,258	302,861
Surface treatment aggregates	r 61,350	r 88,451	52,692	76,692
Unspecified construction aggregate and roadstone	(6)	(6)	90,949	140,539
Riprap and jetty stone	23,154	35,619	23,334	35,222
Railroad ballast	12,855	16,559	13,841	18,091
Filter stone	1,318	2,191	975	1,926
Manufactured fine aggregate (stone sand)	4,958	7,587	3,899	6,684
Terrazzo and exposed aggregate	406	5,346	555	6,219
Cement manufacture	104,093	113,518	106,186	119,870
Lime manufacture	r 28,375	r 51,597	31,591	55,571
Dead-burned dolomite	r 3,168	r 5,019	2,995	5,016
Ferrosilicon	303	1,620	342	984
Flux	r 29,081	r 46,217	31,257	49,247
Refractory	r 1,099	r 6,566	1,136	5,615
Chemical stone for alkali works	2,890	4,215	3,273	5,641
Special uses and products	[10] 4,951	[10] 32,008	5,032	37,560
Fill	W	W	8,470	6,008
Glass	W	W	1,313	4,565
Other uses [29]	r 19,648	r 33,677	8,069	22,639
Uses not listed or unspecified	17,211	25,157	5,018	9,617
Total [4]	r 817,537	r 1,219,469	861,021	1,326,047

r Revised. W Withheld to avoid disclosing individual company confidential data.
[1] Produced by the following States in 1969, in order of tonnage: South Carolina, Mississippi, Virginia, Texas, Michigan, Indiana, Minnesota, and Nevada.
[2] Includes marl used in agricultural limestone, other soil conditioners and nutrients, and a small amount of marl used in mineral fillers, or extenders.
[3] 1969 data include small amount of fill.
[4] Data may not add to totals shown because of independent rounding.
[5] Includes agricultural limestone, agricultural marl and other soil conditioners, and poultry grit and mineral food.
[6] Comparable data not available for 1968.
[7] 1969 data include terrazzo and exposed aggregates.
[8] 1968 data include some stone used for fill, roofing aggregates, dam construction, and other uses in smaller quantities.
[9] To avoid disclosing confidential data, includes quantity data for uses not listed or unspecified and value data for special uses and products.
[10] Includes stone used for asphalt filler, other fillers or extenders, and other uses in smaller quantities.
[11] 1969 data include some stone used for roofing aggregates, dam construction, and other uses in smaller quantities. 1968 data also include stone used for glass and fill.
[12] Data combined to avoid disclosing confidential data.
[13] Includes stone sand and a small amount of riprap and jetty stone.
[14] Data include cement.
[15] Includes ground sandstone, quartz, and quartzite. Friable sandstone is reported in the chapter on sand and gravel.
[16] Includes small amount of dead-burned dolomite.
[17] Includes stone used for agricultural purposes, dam construction, roofing aggregates, fill, glass, and other uses in smaller quantities.
[18] Includes asphalt filler and uses not specified.
[19] Includes data for lime manufacture.
[20] Includes agricultural purposes.
[21] Data include stone for alkali works, asphalt filler, filter stone, riprap and jetty stone.
[22] To avoid disclosing confidential data, figure includes data for uses not listed and quantity data for other uses.
[23] Includes filter stone, stone sand, terrazzo, flux and stone used in cement manufacture.
[24] Includes cement and a small amount of flux stone.
[25] Includes filter stone, manufactured fine aggregate, and a small amount of terrazzo and exposed aggregate.
[26] Includes agricultural limestone and uses not listed or unspecified.
[27] Revised 1968 data includes filter stone, stone sand, terrazzo, flux and stone used in cement manufacture.
[28] To avoid disclosing confidential data, figure includes value data for fill.
[29] Data includes roofing aggregates, dam construction, expanded slate, and other uses in smaller quantities. Revised 1968 data also include stone used for fill and glass.

Table 9.—Number and production of crushed-stone quarries in the United States, by size of operation

Annual production (short tons)	1968 r			1969		
	Number of quarries	Production		Number of quarries	Production	
		Thousand short tons	Percent of total		Thousand short tons	Percent of total
Less than 25,000	1,681	14,867	1.8	1,753	15,354	1.8
25,000 to 49,999	593	20,935	2.6	606	22,397	2.6
50,000 to 74,999	338	20,913	2.6	334	20,611	2.4
75,000 to 99,999	273	23,466	2.9	265	22,639	2.6
100,000 to 199,999	587	83,782	10.3	636	89,328	10.4
200,000 to 299,999	315	77,813	9.5	267	65,641	7.6
300,000 to 399,999	211	71,656	8.8	239	82,661	9.6
400,000 to 499,999	153	67,785	8.3	163	73,236	8.5
500,000 to 599,999	82	44,378	5.4	84	45,517	5.3
600,000 to 699,999	74	48,001	5.9	78	50,639	5.9
700,000 to 799,999	64	47,530	5.8	74	55,109	6.4
800,000 to 899,999	44	37,169	4.6	40	33,709	3.9
900,000 and over	159	258,123	31.6	172	284,182	33.0
Total [1]	4,574	[2] 816,417	100.0	4,711	861,021	100.0

r Revised.
[1] Data may not add to totals shown because of independent rounding.
[2] 1968 data do not include slate operations.

Table 10.—Crushed stone shipped or used in the United States, by methods of transportation

Method of transportation	1968		1969	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Truck	r 567,256	69	616,745	72
Rail	r 89,414	11	97,107	11
Waterway	72,930	9	75,343	9
Other	45,527	6	39,768	4
Unspecified	42,410	5	32,059	4
Total [1]	r 817,537	100	861,021	100

r Revised.
[1] Data may not add to totals shown because of independent rounding.

Table 11.—Granite (crushed and broken stone) shipped or used by producers in the United States in 1969, by States

(Thousand short tons and thousand dollars)

State	Quantity	Value	State	Quantity	Value
Alaska	416	W	New Mexico	9	$11
Arizona	1	$1	North Carolina	18,857	30,843
Arkansas	4,920	6,093	South Carolina	6,668	9,967
California	3,582	4,923	Virginia	9,193	16,513
Georgia	20,249	29,476	Washington	328	433
Idaho	2,201	W	Wisconsin	1,218	327
Massachusetts	1,374	2,440	Wyoming	534	W
Minnesota	662	1,125	Other States [1]	2,959	9,914
Montana	4	6			
Nevada	111	111	Total [2]	75,189	116,102
New Jersey	1,903	3,918	Puerto Rico	254	542

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes Colorado, Connecticut, Maine, Maryland, Michigan, Missouri, New Hampshire, New York, Pennsylvania, Texas, and Vermont.
[2] Data may not add to totals shown because of independent rounding.

Tble 12.—Traprock (crushed and broken stone) shipped or used by producers in the United States in 1969, by States

(Thousand short tons and thousand dollars)

State	Quantity	Value	State	Quantity	Value
Arizona	23	$67	Oregon	10,825	$17,297
California	2,207	2,868	Pennsylvania	3,647	7,803
Colorado	83	226	South Dakota	3	8
Connecticut	6,972	12,830	Virginia	4,665	8,556
Hawaii	4,920	12,342	Washington	14,440	17,637
Idaho	896	1,235	Other States [1]	4,874	10,763
Maryland	4,482	9,275			
Massachusetts	4,594	8,966	Total [2]	78,901	142,360
Minnesota	90	W	Panama Canal Zone	74	231
New Jersey	12,336	26,345	Virgin Islands	411	1,682
New Mexico	340	490	Pacific island possessions	9	62
North Carolina	3,502	5,653			

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes Alaska, Michigan, Missouri, Montana, New York, Texas, Wisconsin, and Wyoming.
[2] Data may not add to totals shown because of independent rounding.

Table 13.—Limestone and dolomite (crushed and broken) shipped or used by producers in the United States in 1969, by States and uses

(Thousand short tons and thousand dollars)

State	Agriculture [1]		Aggregates		Riprap		Railroad ballast		Fluxing stone		Miscellaneous and undistributed		Total [2]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	949	$1,548	8,890	$10,844	W	W	99	W	1,010	$1,657	6,802	$8,322	17,751	$22,371
Alaska	-----	-----	-----	-----	5	$8	-----	-----	-----	-----	-----	-----	5	8
Arizona	W	W	W	W	-----	-----	-----	-----	209	434	2,130	3,459	2,340	3,893
Arkansas	551	1,206	2,155	3,724	W	W	-----	-----	W	W	2,969	3,441	5,676	8,370
California	199	918	W	W	55	W	-----	-----	W	W	17,911	24,243	18,165	25,161
Colorado	-----	-----	W	W	W	W	-----	-----	W	W	W	W	W	W
Connecticut	65	330	-----	-----	-----	-----	-----	-----	W	W	138	806	202	1,137
Florida	820	3,066	33,549	44,288	-----	-----	W	W	-----	-----	6,361	6,271	40,730	53,626
Georgia	170	336	2,764	4,349	-----	-----	-----	-----	-----	-----	1,400	1,914	4,334	6,599
Hawaii	W	W	505	1,333	(3)	(3)	-----	-----	-----	-----	678	1,705	1,184	3,038
Idaho	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	W	W	W	W
Illinois	4,374	7,192	43,614	64,670	777	1,070	197	$289	980	1,420	4,902	6,534	54,844	81,174
Indiana	1,473	2,485	19,979	27,109	242	476	452	590	41	60	2,970	3,166	25,157	33,885
Iowa	2,084	4,467	19,369	29,783	569	941	216	241	W	W	3,982	5,207	26,219	40,640
Kansas	755	1,241	10,241	15,124	959	1,150	63	92	-----	-----	3,317	4,038	15,334	21,645
Kentucky	1,844	3,095	23,409	35,289	W	3,450	501	W	-----	-----	4,405	2,810	30,158	44,644
Maine	W	W	174	338	-----	-----	23	47	-----	-----	W	836	W	1,221
Maryland	W	W	7,321	12,266	W	W	W	W	W	W	2,483	5,646	9,804	17,911
Massachusetts	140	741	W	W	-----	-----	-----	-----	W	W	531	W	671	W
Michigan	649	798	6,940	8,340	W	W	107	124	12,351	15,591	19,019	18,516	39,067	43,368
Minnesota	280	518	3,624	4,839	72	91	44	59	(3)	1	107	277	4,127	5,785
Mississippi	186	233	-----	-----	-----	-----	-----	-----	-----	-----	W	W	W	W
Missouri	3,806	6,394	24,452	32,504	2,741	2,965	W	63	W	W	10,201	17,217	41,200	59,144
Montana	-----	-----	-----	-----	W	W	-----	-----	88	W	1,355	1,791	1,443	1,791
Nebraska	313	1,176	2,380	4,072	977	1,413	-----	-----	-----	-----	993	2,817	4,663	9,478
Nevada	W	W	96	72	-----	-----	-----	-----	W	W	1,191	W	1,286	W
New Jersey	W	W	131	346	-----	-----	-----	-----	W	W	W	W	W	W
New Mexico	-----	-----	462	602	8	10	-----	-----	W	W	W	W	956	1,443
New York	306	1,139	23,826	43,471	187	431	412	681	W	W	8,725	10,022	33,456	55,744
North Carolina	W	W	W	W	W	W	-----	-----	-----	-----	W	W	W	W
Ohio	1,675	3,328	31,406	45,961	351	574	1,495	1,997	4,849	7,340	10,819	19,971	50,596	79,171
Oklahoma	W	W	7,341	9,058	158	194	W	W	-----	-----	9,370	11,369	16,870	20,622
Oregon	W	W	W	W	-----	-----	-----	-----	W	W	W	W	W	W
Pennsylvania	1,423	3,767	33,358	50,533	119	173	194	285	5,075	9,740	16,499	25,574	56,667	90,073
Rhode Island	W	W	-----	-----	-----	-----	-----	-----	W	W	W	W	W	W
South Carolina	W	W	W	W	W	W	-----	-----	W	W	W	W	W	W
South Dakota	-----	-----	591	831	5	5	W	W	-----	-----	394	371	989	1,207
Tennessee	2,418	3,253	26,986	35,445	W	W	W	W	W	W	3,705	5,815	33,109	44,512
Texas	299	418	25,116	35,167	363	558	633	585	920	1,179	9,508	12,010	36,838	49,918
Utah	W	W	107	168	W	W	-----	-----	W	W	793	2,027	899	2,195
Vermont	80	311	260	389	W	W	-----	-----	-----	-----	191	2,258	532	2,958
Virginia	1,275	2,304	10,700	15,494	W	W	386	501	W	W	5,467	8,970	17,829	27,270
Washington [4]	11	48	-----	-----	1	2	-----	-----	W	W	736	1,181	749	1,231
West Virginia	118	290	2,902	4,650	W	W	701	878	W	W	4,684	8,514	8,405	14,331

Wisconsin	866	1,242	14,672	16,964	156	234	W	W	36	54	207	614	15,937	19,108
Wyoming	-----	-----	40	77	W	W	W	W	-----	-----	609	1,252	649	1,330
Total [2]	27,129	51,846	387,360	558,099	7,743	13,746	5,524	6,431	25,561	37,477	165,552	228,964	618,840	896,002
Undistributed	7,882	10,960	6,712	10,131	3,896	1,346	649	1,551	4,799	8,197	9,493	23,361	9,522	23,920
Pacific island possessions	-----	-----	681	1,458	7	10	-----	-----	-----	-----	21	22	708	1,489
Puerto Rico	44	128	2,692	7,097	-----	-----	-----	-----	-----	-----	2,502	2,155	5,238	9,380

W Withheld to avoid disclosing individual company confidential data; included with "Miscellaneous and Undistributed."
[1] Includes agricultural limestone, agricultural marl, and other soil conditioners, and poultry grit and mineral food.
[2] Data may not add to totals shown because of independent rounding.
[3] Less than ½ unit.
[4] Data for dolomite included with "Undistributed."

Table 14. Shell shipped or used by producers in the United States in 1969, by States

(Thousand short tons and thousand dollars)

State	Quantity	Value
Florida	1,603	$2,986
Louisiana	9,237	11,892
Texas	7,177	8,558
Other States [1]	1,714	4,498
Total [2]	19,731	27,933

[1] Includes Alabama, California, Maryland, Pennsylvania, and Virginia.
[2] Data may not add to totals shown because of independent rounding.

Table 15.—Calcareous marl shipped or used by producers in the United States in 1969, by States

(Thousand short tons and thousand dollars)

State	Quantity	Value
Indiana	32	$30
Michigan	99	86
Other States [1]	2,359	2,401
Total [2]	2,490	2,516

[1] Includes Minnesota, Mississippi, Nevada, South Carolina, Texas, and Virginia.
[2] Data may not add to totals shown because of independent rounding.

Table 16.—Sandstone, quartz, and quartzite (crushed and broken stone) shipped or used by producers in the United States in 1969, by States

(Thousand short tons and thousand dollars)

State	Quantity	Value	State	Quantity	Value
Arizona	427	$1,389	Oklahoma	474	$712
Arkansas	5,758	7,381	Oregon	319	678
California	4,225	8,297	Pennsylvania	4,108	9,066
Colorado	169	390	South Dakota	1,055	2,001
Illinois	(1)	3	Texas	1,945	3,175
Indiana	6	6	Utah	W	437
Kansas	382	W	Virginia	741	1,226
Kentucky	W	156	Washington	185	1,229
Montana	150	W	West Virginia	626	1,471
Nevada	96	96	Other States [2]	4,862	11,731
New York	449	1,011			
North Carolina	72	W	Total [3]	27,145	53,293
Ohio	1,095	2,839			

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Less than ½ unit.
[2] Includes Alabama, Connecticut, Georgia, Idaho, Maryland, Minnesota, Missouri, New Hampshire, New Mexico, Tennessee, and Wisconsin.
[3] Data may not add to totals shown because of independent rounding.

Table 17.—Miscellaneous varieties of stone (crushed and broken) shipped or used by producers in the United States in 1969, by States

(Thousand short tons and thousand dollars)

State	Quantity	Value	State	Quantity	Value
Alaska	1,503	W	North Dakota	72	$99
Arizona	6	$23	Oklahoma	1,441	1,019
California	9,355	14,092	Oregon	63	W
Colorado	56	151	Pennsylvania	2,057	2,842
Hawaii	422	559	Wyoming	209	324
Idaho	1	14	Other States [1]	9,032	17,531
Massachusetts	1,071	W			
Missouri	56	113	Total [2]	25,766	37,301
New Mexico	421	534	Puerto Rico	1,272	2,962

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes Kansas, Louisiana, Maine, Maryland, Montana, Nevada, New Hampshire, New Jersey, New York, Rhode Island, South Dakota, Texas, Utah, Vermont, Virginia, and Washington.
[2] Data may not add to totals shown because of independent rounding.

Table 18.—U.S. exports of stone

(Thousand short tons and thousand dollars)

Year	Building and monumental stone			Crushed, ground, or broken				Other manufactures of stone (value)
	Dolomite		Other (value)	Limestone		Other		
	Quantity	Value		Quantity	Value	Quantity	Value	
1967	113	$1,756	$958	1,159	$3,496	306	$3,743	$1,203
1968	102	1,518	849	1,297	3,294	292	3,278	1,030
1969	93	1,809	863	1,382	3,189	284	3,569	793

Table 19.—U.S. imports for consumption of stone and whiting, by classes

Class	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)
Granite:				
Monumental, paving and building stone:				
Rough ---------------cubic feet--	252,023	$1,088	178,442	$1,095
Dressed, manufactured------do----	406,042	3,115	366,224	4,025
Not manufactured and not suitable for monumental, paving or building stone short tons--	788	18	755	25
Other, n.s.p.f.	------	73	------	77
Total	------	4,294	------	5,222
Marble, breccia, and onyx:				
In block, rough or squared--cubic feet--	33,537	283	38,638	333
Sawed or dressed over 2 inches thick do----	8,951	82	3,416	38
Slabs and paving tiles superficial feet--	8,395,719	6,706	7,608,162	6,878
All other manufactures	------	4,163	------	5,214
Total	------	11,234	------	12,463
Travertine stone:				
Rough, unmanufactured----cubic feet--	43,793	129	30,003	83
Dressed, suitable for monumental, paving and building stone-------short tons--	r 40,858	r 1,405	47,393	2,169
Other, n.s.p.f.	------	68	------	51
Total	------	r 1,602	------	2,303
Limestone:				
Monumental, paving, and building stone:				
Rough---------------cubic feet--	4,636	8	1,200	2
Dressed, manufactured-short tons--	6,809	35	426	26
Crude, not suitable for monumental, paving, or building stone-----short tons--	20,911	68	19,752	72
Other, n.s.p.f.	------	43	------	55
Total	------	154	------	155
Slate:				
Roofing-----------------square feet--	2,826	1	15,520	5
Other, n.s.p.f.	------	2,130	------	2,876
Total	------	2,131	------	2,881
Quartzite-------------------short tons--	7,147	273	30,294	392
Stone and articles of stone, n.s.p.f.:				
Statuary and sculptures	------	251	------	251
Stone, unmanufactured-----short tons--	40,765	198	38,849	147
Building stone, rough-------cubic feet--	3,471	6	3,867	8
Building stone, dressed-----short tons--	515	16	1,276	21
Other	------	210	------	236
Total	------	681	------	663
Stone, chips, spalls, crushed or ground:				
Marble, breccia and onyx chips short tons--	6,436	89	5,062	97
Limestone, chips and spalls, crushed or ground-------------------do----	1,677,410	2,075	1,720,936	3,254
Stone chips and spalls and stone crushed or ground, n.s.p.f.-------short tons--	1,368,243	1,599	1,188,180	1,425
Slate chips and spalls and slate crushed or ground----------------short tons--	304	1	22	(1)
Total	3,052,393	3,764	2,914,200	4,776
Whiting:				
Whiting, dry, ground, or bolted short tons--	15,904	326	11,683	281
Chalk whiting, precipitated------do----	2,339	170	2,134	170
Total	18,243	496	13,817	451
Grand total	------	r 24,629	------	29,306

r Revised.
[1] Less than ½ unit.

Sulfur and Pyrites

By Arnold M. Lansche [1]

The price of sulfur declined sharply during 1969 because of reduced demand for phosphate fertilizers and increased competition from foreign sulfur producers. Although new Frasch mines came into operation in the sedimentary sulfur deposits in west Texas, output of native sulfur dropped in 1969. Production of recovered sulfur established a new record.

Table 1.—Salient sulfur statistics

(Thousand long tons, sulfur content)

	1965	1966	1967	1968	1969
United States:					
Production (native)	6,116	7,002	7,014	7,460	7,146
All forms	8,212	9,155	9,136	9,739	9,540
Exports, sulfur	2,635	2,373	2,193	1,602	1,547
Imports, pyrites and sulfur	1,646	1,674	1,639	1,712	1,795
Stocks Dec. 31: Producer, Frasch and recovered sulfur	3,425	2,704	1,954	2,790	3,461
Consumption, apparent, all forms [1]	7,981	9,145	9,301	9,007	9,175
World production:					
Sulfur, elemental	15,286	16,442	17,604	18,619	p 19,655
Pyrites	9,560	9,627	10,035	10,009	e p 9,827

e Estimate. p Preliminary.
[1] Measured by quantity sold, plus imports, minus exports.

DOMESTIC PRODUCTION

Native Sulfur.—In 1969, 21 Frasch mines produced sulfur; two of these were closed during the year. The producers and mines in Lousiana were Freeport Sulphur Co. at Caminada (offshore–closed March 25), Grand Isle (offshore), Garden Island Bay, Grande Ecaille, and Lake Pelto; Texas Gulf Sulphur Co. at Bully Camp; Jefferson Lake Sulphur Co. at Lake Hermitage; U.S. Oil of Louisiana, Ltd., at Chacahoula; and Union Texas Petroleum at Sulfur. The producers and mines in Texas were Texas Gulf Sulphur Co. at Fannett Dome, Spindletop Dome, Moss Bluff Dome, Gulf, and Boling Dome; Duval Corp. at Pecos (began operating in October), Orchard Dome, and Fort Stockton; Jefferson Lake Sulphur Co. at Long Point Dome; Phelan Sulphur Co. at Nash Dome (closed in November); Pan American Petroleum Corp. at High Island (began operating in January); and Atlantic Richfield Co. at Fort Stockton (formerly Sinclair Oil Corp.).

Elcor Chemical Corp. continued development of its facility for producing sulfur from gypsum at Rock House, Culberson County, Texas. The plant will have an annual capacity of 350,000 long tons.

In October, Duval Corp. began using the Frasch process at its Pecos plant to extract sulfur from a sedimentary sulfur deposit located in the Rustler Springs area of Culberon County, Tex. The new mine was expected to be fully operational in 1970 with a daily output of about 4,000 long tons of molten sulfur. The sulfur was transported 930 miles by a unit-train system of the Santa Fe Railway to Duval's

[1] Physical scientist (retired), Bureau of Mines, Bartlesville, Okla.

Table 2.—Production of sulfur and sulfur-containing raw materials by producers in the United States

(Thousand long tons)

	1966		1967	
	Gross weight	Sulfur content	Gross weight	Sulfur content
Native sulfur or sulfur ore:				
Frasch-process mines	7,001	7,001	7,014	7,014
Other mines	1	(1)	1	(1)
Total	----	7,002	----	7,014
Recovered elemental sulfur	1,244	1,240	1,270	1,268
Byproduct sulfuric acid (basis 100 percent) produced at Cu, Zn, and Pb plants	1,297	424	1,115	364
Other [2]	1,034	490	1,018	489
Total [3]	----	9,155	----	9,136

	1968		1969	
	Gross weight	Sulfur content	Gross weight	Sulfur content
Native sulfur or sulfur ore:				
Frasch-process mines	7,458	7,458	7,146	7,146
Other mines	3	2	----	----
Total	----	7,460	----	7,146
Recovered elemental sulfur	1,359	1,354	1,422	1,414
Byproduct sulfuric acid (basis 100 percent) produced at Cu, Zn, and Pb plants	1,315	430	1,583	517
Other [2]	r 1,035	r 495	971	463
Total [3]	----	r 9,739	----	9,540

r Revised.
[1] Less than ½ unit.
[2] Pyrites combined with hydrogen sulfide and liquid sulfur dioxide to avoid disclosing individual company confidental data.
[3] Data may not add to totals shown because of independent rounding.

Table 3.—Sulfur produced and shipped from Frasch mines in the United States

(Thousand long tons and thousand dollars)

Year	Production			Shipments	
	Texas	Louisiana	Total [1]	Quantity	Approximate value
1965	2,534	3,582	6,116	7,251	$164,654
1966	2,916	4,085	7,001	7,721	201,292
1967	2,956	4,059	7,014	7,682	251,670
1968	3,203	4,255	7,458	6,645	268,146
1969	3,289	3,857	7,146	6,551	176,659

[1] Data may not add to totals shown because of independent rounding.

Table 4.—Sulfur ore (10 to 70 percent S) produced and shipped in the United States [1]

(Long tons)

Year	Production		Shipments		
	Gross Weight	Sulfur Content	Gross Weight	Sulfur Content	Value (thousands)
1965	2,592	133	2,852	238	$11
1966	557	143	557	143	5
1967	568	284	568	284	3
1968	3,125	1,563	3,125	1,563	46

[1] California, Nevada, and Utah. No production or shipments reported for 1969.

new terminal and storage facility at Galveston, Tex.

Phelan Sulfur Co. closed its Nash Dome operation in November because of the decline in the price of sulfur. The facility will be maintained ready for operation.

Freeport Sulphur Co. reported production of 3.4 million long tons of sulfur in 1969; sales totaled about 3.6 million tons, of which approximately 80 percent went to domestic markets with the remainder exported.[2] Caminda mine, a relatively

[2] Freeport Sulphur Co. Annual Report, 1969, p. 5.

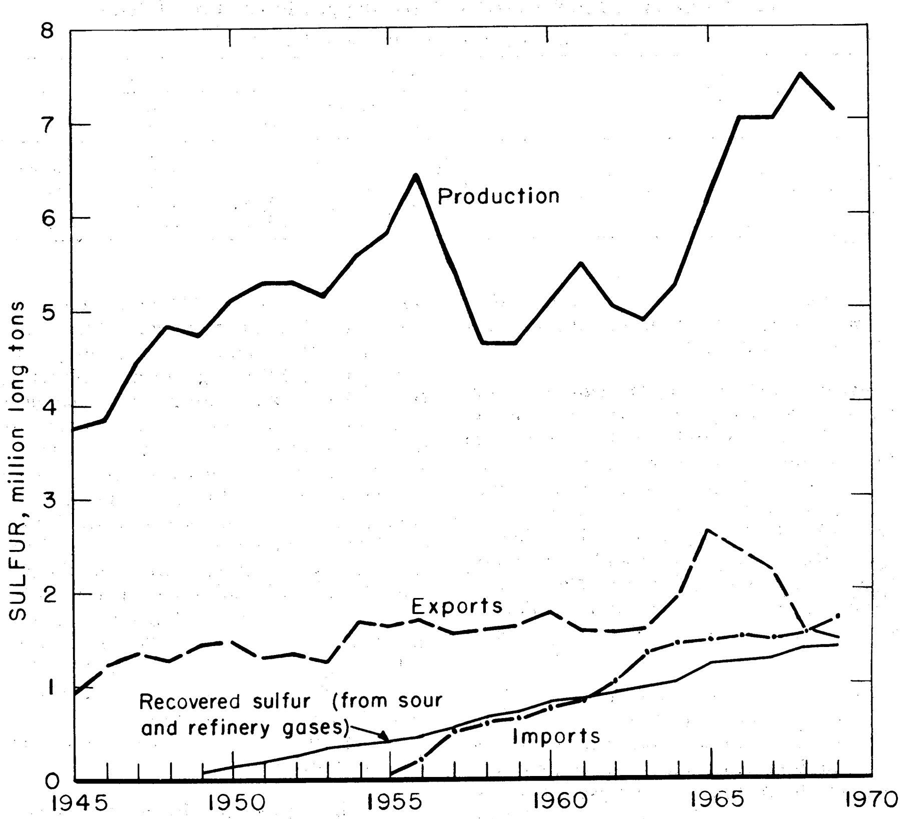

Figure 1.—Domestic Frasch and recovered sulfur production, and imports for consumption and exports of native sulfur.

high-cost Frasch sulfur property, was closed in favor of maintaining operations at Freeport's other four mines.

Texas Gulf Sulphur Co. reported production in 1969 of about 2.5 million long tons of native sulfur at its Texas and Louisiana Frasch operations.[3]

No sulfur ore production was reported during the year.

Recovered Sulfur.—Production of recovered sulfur in 1969 broke all records and exceeded 1968 output by nearly 5 percent. Shipments of recovered sulfur in 1969 set a new record, exceeding the previous record (1967) by 9 percent and 1968 shipments by 10 percent. Statistics on shipments of recovered sulfur and value for 1969 are given below:

State	Quantity (long tons)	Value (thousands)
Arkansas	25,386	$573
California	182,764	5,847
Colorado	1,003	16
New Jersey	55,238	2,164
New Mexico	19,702	518
Pennsylvania	19,178	581
Texas	728,978	19,811
Wyoming	45,695	933
Other States[1]	322,417	10,594
Total	1,400,361	41,037

[1]Combined to avoid disclosing individual company confidential data; includes Delaware, Illinois, Indiana, Kansas, Louisiana, Michigan, Minnesota, Mississippi, Montana, North Dakota, Ohio, Oklahoma, and Virginia.

Phillips Petroleum Co. and Pan American Petroleum Corp. abandoned plans, at

[3] Texas Gulf Sulphur Co. Annual Report, 1969, p. 3.

Table 5.—Recovered sulfur produced and shipped in the United States

(Thousand long tons and thousand dollars)

Year	Production		Shipments		
	Gross Weight	Sulfur Content	Gross Weight	Sulfur Content	Value
1965	1,219	1,215	1,173	1,169	$24,574
1966	1,244	1,240	1,265	1,261	30,166
1967	1,270	1,268	1,286	1,284	40,984
1968	1,359	1,354	1,278	1,273	49,696
1969	1,422	1,414	1,408	1,400	41,037

least temporarily, for recovering sulfur from sour gas found in the Black Creek district of Mississippi.

Pyrites and Hydrogen Sulfide.—Companies reporting the sale or use of pyrites in 1969 were as follows: Magma Copper Co., Magma mine, Ariz. (sales); Division of American Metal Climax, Inc., Climax Molybdenum Co., (sales); R.J. Dalton & Sons, Lincoln County, Nev. (sales); Bethlehem Mines Corp., Cornwall and Grace mines, Pa. (use); Commercialores, Inc., Henry Knob Kyanite, S.C. (sales); Tennessee Copper Co., Copperhill Mine, Tenn. (use).

Byproduct Sulfur.—Byproduct sulfuric acid was produced in 14 States in 1969 and totaled 1.77 million short tons valued at $27.5 million. Acid was produced at copper smelters in Arizona, Tennessee, Utah, and Washington, at lead smelters in California and Missouri, and at zinc smelters and roasters in Idaho, Illinois, Kansas, Montana, Ohio, Oklahoma, Pennsylvania, and Texas.

Sulfuric acid production from copper smelters totaled nearly 686,000 short tons valued at $10.07 million. Lead and zinc smelters and roasters produced nearly 1.09 million tons of sulfuric acid valued at $17.4 million.

Hydrogen sulfide was recovered from sour gas and petroleum refinery gas. Sulfur dioxide was recovered from smelter operations.

Bunker Hill Co. announced plans to build a $3.5 million, 300-ton-per-day, sulfuric acid plant at its Kellogg, Idaho lead smelter with production beginning the latter part of 1970. Eagle-Picher Industries, Inc., Galena, Kans., installed a Brinks mist eliminator in its sulfuric acid plant for air pollution control at a cost of $100,000. St. Joseph Lead Co. completed in October 1969 a 300-ton-per-day sulfuric acid plant at its Herculaneum, Missouri smelter, which produced 20,554 tons before yearend. In 1969, American Metal Climax, Inc., and Homestake Mining Co. jointly operated a 56,000-ton-per-year sulfuric acid plant at Bixby, Mo. National Zinc Co. in 1968 began a $3 million expansion of its zinc plant at Bartlesville, Okla., and as part of the expansion program, the 41-year-old sulfuric acid plant was replaced by a new 275-ton-per-day acid unit.

Table 6.—Byproduct sulfuric acid [1] (100-percent basis) produced in the United States

(Thousand short tons)

Year	Copper plants [2]	Lead and zinc plants [3]	Total
1965	369	962	1,331
1966	470	983	1,453
1967	348	900	[4] 1,249
1968	483	990	1,473
1969	686	1,087	1,773

[1] Includes acid from foreign materials.
[2] Includes acid produced at a lead smelter in 1965–68. Excludes acid made from pyrites concentrates in Arizona, Montana, Tennessee, and Utah.
[3] Excludes acid made from native sulfur.
[4] Data do not add to total shown because of independent rounding.

CONSUMPTION

The apparent consumption of sulfur, in all forms, was the second largest in history and only 1.3 percent less than the record of 1967. Sulfur was consumed mostly as acid, principally to produce fertilizers; other uses included petroleum refining; producing inorganic pigments, rayon, and explosives; pickling iron and steel, leaching copper ores; and producing pulp, paper, and cellulosic fibers. Sulfuric acid and hydrochloric acid competed as pickling agents for some iron and steel. The use of sulfuric acid to leach oxidized copper has grown rapidly in the past several years. Competitive, nonsulfuric acid methods for treating pulp and paper have been developed.

Estimated world consumption of sulfur in all forms in 1969 was 27.9 million long tons; about half was used to produce fertilizers.

Table 7.—Apparent consumption of native sulfur in the United States
(Thousand long tons)

	1965	1966	1967	1968	1969
Apparent sales to consumers	6,938	7,687	7,729	6,649	6,551
Imports	831	799	724	742	745
Total	7,769	8,486	8,453	7,391	7,296
Exports:					
Crude	2,624	2,326	2,043	1,549	1,536
Refined	11	47	150	53	11
Total	2,635	2,373	2,193	1,602	1,547
Apparent consumption	5,134	6,113	6,260	5,789	5,749

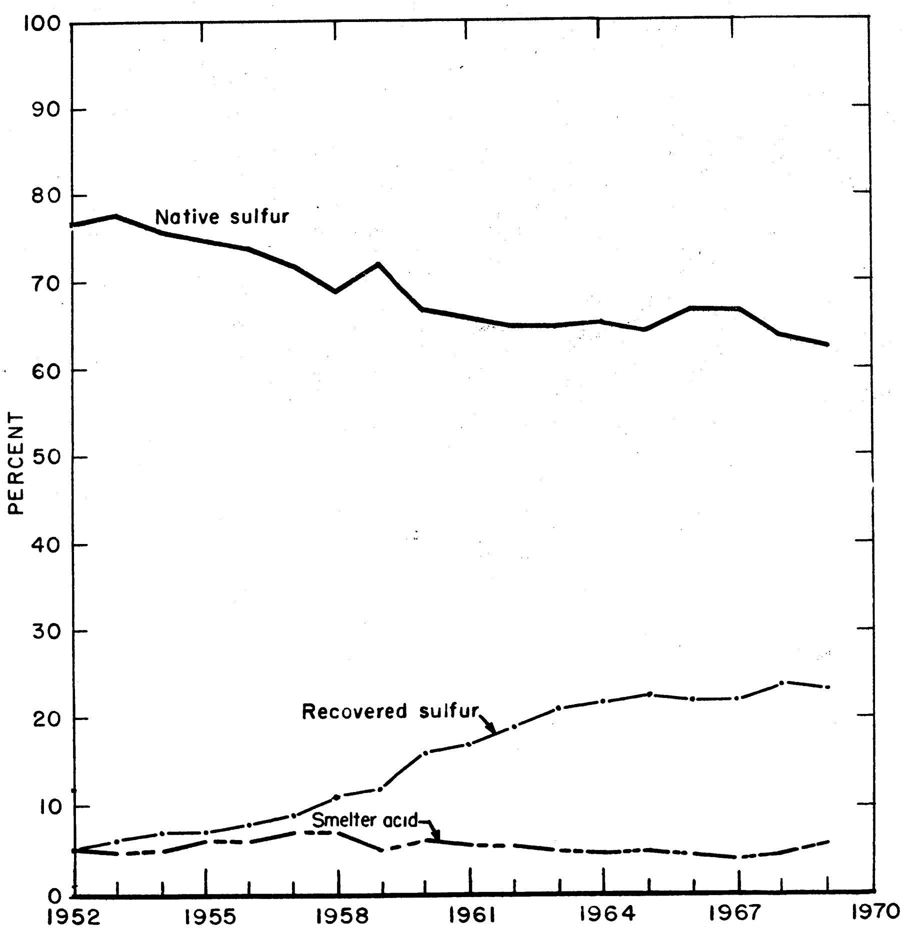

Figure 2.—Sulfur supply sources as a percent of total apparent consumption based on sulfur content.

Table 8.—Apparent consumption of sulfur in all forms in the United States [1]

(Thousand long tons)

	1965	1966	1967	1968	1969
Native sulfur	5,134	6,113	6,260	5,789	5,749
Recovered sulfur:					
Sales	1,167	1,258	1,287	1,332	1,400
Imports	656	715	750	830	929
Pyrites:					
Imports [e]	160	160	165	140	120
Smelter acid	388	424	364	430	517
Grand total [2]	7,981	9,145	9,301	[r] 9,007	9,175

[e] Estimated. [r] Revised.

[1] Crude sulfur or sulfur content.

[2] Includes consumption of domestically produced pyrites and consumption of hydrogen sulfide and liquid sulfur dioxide. Figures for these categories have been withheld to avoid disclosing individual company confidential data.

STOCKS

At yearend, producers' stocks of Frasch sulfur totaled 3,366,087 long tons; producers' stocks of recovered sulfur totaled 95,312* long tons. Producers' stocks of recovered sulfur were highest for the year in June when 134,461 long tons were reported.

PRICES

The Oil, Paint, and Drug Reporter quoted the price of crude, domestic, dark, bulk sulfur, f.o.b. cars, mines, and f.o.b. vessels, Gulf ports (for U.S. and Canada), at $41 per long ton until January 27, after which it was quoted at $39 per ton until near yearend. Bright sulfur was $1 per ton higher. Near yearend, this journal ceased quoting prices on dark and bright sulfur because conditions were unsettled and prices were declining. The quoted prices were virtually meaningless much of the year as sales were made at lower prices negotitated between buyer and seller. Economic factors involved in the price decline included new mines, reduced requirements by agriculture, and rapidly rising foreign output.

Sulfuric acid, 100 percent, tanks, works, was quoted at $34.65 per short ton all year. Canadian pyrite, containing 48 to 50 percent sulfur, was quoted at $4.50 to $5 per long ton at mines.

FOREIGN TRADE

U.S. exports included crude sulfur, other sulfur in the form of crushed, ground, refined, sublimed, and flowers, and unroasted iron pyrites. Exports of crude sulfur in 1969 declined slightly from those of 1968 and were the lowest since 1962. The Netherlands received 39 percent of the exports of crude sulfur with the remainder divided among 36 other countries. Exports of other sulfur declined 83 percent from exports in 1968 to 8,768 long tons. Brazil received half of the other sulfur exported; the remaining half was shipped to 31 other countries. Unroasted iron pyrites exported totaled 1,494 short tons valued at $53,532. Sweden received approximately 36 percent of the pyrite exports, and the remainder was shipped to Brazil, Canada, France, India, New Zealand, the Republic of South Africa, Spain, the United Kingdom, and Venezuela.

Imports for consumption of sulfur in 1969 increased nearly 7 percent in quantity over those of 1968 and decreased 11 percent in value as a result of the decline in the price of sulfur in world markets. Imports of sulfur dioxide, all from Canada, totaled 8,990 short tons valued at $276,260. Imports of sulfuric acid totaling 98,666 short tons and valued at $1,881,261 were obtained from Canada, Netherlands, Sweden, the United Kingdom, and West Germany; Canada was the major source and supplied 89,950 tons valued at $1,646,055. Estimated imports of pyrites in 1969 were 240,000 tons containing 120,000 tons of sulfur. (Bureau of the Census data do not include all shipments.)

Table 9.—U.S. exports and imports for consumption of sulfur

(Thousand long tons and thousand dollars)

Year	Exports				Imports	
	Crude		Crushed, ground, refined, sublimed, and flowers			
	Quantity	Value	Quantity	Value	Quantity	Value
1967	2,043	$81,492	150	$9,522	1,474	$47,612
1968	1,549	65,650	53	3,855	1,572	64,277
1969	1,536	56,186	11	1,495	1,675	57,222

Table 10.—U.S. exports of sulfur, by countries

Destination	Crude				Crushed, ground, refined, sublimed and flowers			
	1968		1969		1968		1969	
	Long tons (thousands)	Value (thousands)	Long tons (thousands)	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)
Argentina	15	$686	31	$1,076	109	$29	105	$38
Australia	82	3,436	57	2,342	262	67	420	161
Belgium-Luxembourg	57	2,382	60	2,118	24	3	10	1
Brazil	132	5,710	120	4,040	17,472	925	5,144	399
Canada	81	3,343	46	1,651	1,874	380	1,867	337
Chile	----	------	4	139	4,486	219	-----	-----
Colombia	----	------	3	123	133	32	46	16
El Salvador	4	184	2	76	5	1	10	1
France	22	913	----	------	123	34	-----	-----
Germany, West	9	356	5	208	40	6	462	133
India	46	2,261	17	782	10,172	690	197	23
Ireland	95	4,016	89	3,276	-----	-----	-----	-----
Israel	18	827	25	878	20	4	10	3
Italy	48	2,215	79	3,207	10,000	620	7	1
Jamaica	1	56	2	84	7	2	-----	-----
Korea, South	----	------	1	66	-----	-----	9	4
Mexico	----	------	(1)	1	459	82	1,200	136
Netherlands	549	22,673	610	21,857	-----	-----	-----	-----
New Zealand	64	2,626	54	2,063	95	25	148	47
Norway	2	98	----	------	36	3	-----	-----
Pakistan	(1)	1	(1)	3	117	20	-----	-----
Peru	(1)	5	(1)	4	149	31	56	9
Philippines	(1)	5	5	158	80	37	249	43
Saudi Arabia	1	62	----	------	406	35	-----	-----
South Africa, Republic of	56	2,027	31	1,007	249	41	141	31
Sweden	10	443	----	------	21	8	-----	-----
Switzerland	12	491	31	1,197	-----	-----	2	(1)
Taiwan	29	1,466	----	------	4,208	300	1	(1)
Trinidad and Tobago	21	900	18	588	-----	-----	-----	-----
Tunisia	48	2,053	34	1,524	-----	-----	-----	-----
United Kingdom	110	4,562	201	7,236	442	28	-----	-----
Uruguay	3	150	7	258	912	62	7	3
Venezuela	11	674	(1)	8	397	74	134	41
Other	23	1,029	4	216	488	97	339	68
Total	1,549	65,650	1,536	56,186	52,786	3,855	10,564	1,495

[1] Less than ½ unit.

Table 11.—U.S. imports for consumption of sulfur, by countries

(Thousand long tons and thousand dollars)

Country	1968		1969	
	Quantity	Value	Quantity	Value
Australia	(1)	$1	----	------
Boliva	----	------	(1)	$3
Canada	830	26,442	929	23,334
Chile	----	------	(1)	(1)
Guatemala	----	------	(1)	6
Germany, West	(1)	17	(1)	15
Mexico	742	37,817	745	33,850
Philippines	----	------	(1)	14
Total [2]	1,572	64,277	1,675	57,222

[1] Less than ½ unit.
[2] Data may not add to totals shown because of independent rounding.

WORLD REVIEW

World production of elemental sulfur in 1969 reached a record high of 19.8 million long tons, 5 percent more than in 1968. The boost in world output was due principally to increased production of native sulfur in Poland and increased output of recovered sulfur from sour gas in Alberta, Canada.

Canada.—Extraction plants obtaining sulfur from sour gas in 1968 were listed in an article along with prospective producers and the expansion planned for 1969–70.[4] In 1968 the estimated total recovery of sulfur from hydrogen sulfide in sour gas was 3.75 million short tons from 28 plants. The daily rated capacity of plants recovering sulfur from sour gas was 12,420 long tons. Planned additional daily rated capacity for 1969–70 totaled 5,656 long tons from 11 plants, of which the Atlantic Richfield Co.'s plant at Gold Creek, Alberta, was the only new company. Capital outlay for the proposed plants and expansions will be about $95 million.

Production of sulfur from smelter gases in 1968 was 565,696 tons valued at $6,951,687. Canadian sulfur shipments in 1968 totaled about 2.59 million long tons valued at $81,276,703. Shipments of sulfur contained in pyrite and pyrrhotite concentrates totaled 159,036 tons valued at $2,215,161. Canada exported 2.1 million long tons of sulfur in 1968.

Total reserves of recoverable sulfur in Canada were reported to be 116 million long tons. Estimated recoverable sulfur reserves in Alberta were 350 million long tons, associated with natural gas, and 780 million tons in Athabasca-type oil sands.

Texas Gulf Sulphur Co. announced plans to build a $50 million zinc smelter and sulfuric acid plant next to its concentrator near Timmins, Ontario. This plant may process approximately one-half of the concentrator output with the remainder being exported to Europe, Japan, and the United States. Plans call for the smelter to be expanded in the next 5 years to process 75 percent of the concentrator output.

Great Canadian Oil Sands Ltd. operated a 65,000-barrel-per-stream-day refinery at Fort McMurray, Alberta, and extracted sulfur from Athabasca tar sands.[5] Production of sulphur from tar sand in 1968 totaled 23,400 tons.

Unit-train systems were used for the first time to transport sulfur from Shell Canada Ltd.'s sour gas plants in Alberta to Vancouver, British Columbia. The use of unit trains reduced transporation costs to $5.12 per ton or as much as 37 percent below tariff rates set for the other kinds of rail shipment. Canadian Pacific Railway's contract calls for shipment of 500,000 tons of sulfur annually fron Shell's Waterson plant near Pincher Creek.

India.—The first sulfuric acid plant obtaining its supply of sulfur from domestic pyrites went on stream.[6] The new plant has a capacity to produce about 400 short tons per day of acid, which is used in the manufacture of fertilizer at the Sindri factory, Bihar State. Travancore Titanium Products, Ltd., at Trwendrum in southern India was reportedly planning to increase its sulfuric acid plant capacity fourfold to increase output of white titania and other titanium products.[7] The present plant capacity for sulfuric acid is 300,000 tons per year, 100 percent acid basis. Estimates of India's sulfur requirements for 1969–70 were 600,000 to 800,000 tons. Demand for sulfur was expected to increase to 1.2 million tons by 1975–76. The State Trading Corp. of India signed a contract with Canada's leading sulfur producers, Shell Canada Ltd., Cansulex Ltd., and Brimstone Exports Ltd., to supply India with 100,000 tons of sulfur.

Mexico.—Cía de Azufre Veracruz, a subsidiary of Gulf Resources & Chemical Corp., was given notice in January 1969 by the Government's National Properties Ministry that its sulfur production in 1969 would be limited to 254,000 long tons and that it must sell 152,000 tons of sulfur in Mexico during the year.[8] Previously the subsidiary had not sold more than 35,000 to 40,000 tons of sulfur annually in Mexico. Gulf Resources negotiated with some of the corporations in Mexico to

[4] Engineering and Mining Journal. Kidd Creek. V. 170, No. 9, September 1969, pp. 182–183.

[5] Sulphur (London). Current Events. No. 83, July–August 1969, p. 42.

[6] Chemical Age (London). India First Pyrites-based Sulphuric Acid Plant on Stream. V. 99, No. 2616, Sept. 5, 1969, p. 12.

[7] European Chemical News. V. 15, No. 380, May 16, 1969, p. 11; V. 16, No. 394, Aug. 22, 1969, p. 4.

[8] Wall Street Journal. Sulphur Output Ouota, Sale of 150,000 tons in Mexico Ordered of Gulf Resources Unit. Jan. 23, 1969, p. 12.

Table 12.—World production of elemental sulfur, by countries

(Thousand long tons)

Country [1]	1967	1968	1969 p
Native sulfur:			
Frasch:			
Mexico	r 1,793	1,582	1,606
Poland	r 226	816	e 1,279
United States	7,014	7,458	7,146
Total	r 9,033	9,856	10,031
From sulfur ores:			
Argentina	32	33	e 33
Bolivia (exports)	r 50	35	36
Chile	r 55	62	97
China, mainland e	118	118	118
Colombia	24	28	e 26
Ecuador	(2)	(2)	5
Indonesia	r 3	e 1	e 1
Italy	82	96	e 64
Japan [3]	250	256	201
Mexico	24	24	26
Poland	484	479	e 640
Taiwan	3	4	5
Turkey	25	24	25
U.S.S.R. e	r 1,033	1,033	1,102
United States	(2)	1	------
Total	r 2,183	2,194	2,379
Total native sulfur	11,216	12,050	12,410
Other elemental sulfur: Recovered:			
Austria	31	31	40
Belgium	5	e 5	e 5
Brazil [4]	6	7	7
Bulgaria [5]	8	9	e 9
Canada [6]	2,231	2,304	2,665
China, mainland e [4] [5]	128	128	128
Colombia e [4]	------	3	4
Finland	r 100	123	110
France [7]	1,639	1,589	1,669
Germany:			
East	121	117	e 118
West	103	125	e 126
Hungary	3	e 3	e 3
Iran e [8]	r 36	37	39
Israel	2	6	e 8
Italy e	2	2	3
Japan [4]	61	74	140
Kuwait	------	-----	15
Mexico [7]	48	52	57
Netherlands [5]	42	e 42	e 42
Portugal	r 4	4	e 3
Saudi Arabia	------	-----	e 4
South Africa, Republic of [4]	6	6	e 6
Spain [9]	41	36	e 39
Sweden [10]	r 2	-----	------
Taiwan [4]	3	NA	NA
Trinidad [4]	NA	20	71
U.S.S.R. e	443	443	472
United Arab Republic [8]	9	3	e 2
United Kingdom [8]	46	46	e 46
United States	1,268	1,354	1,414
Total other elemental sulfur	r 6,388	6,569	7,245
Grand total [11]	r 17,604	18,619	19,655

e Estimate. p Preliminary. r Revised. NA Not available.

[1] In addition to countries listed, Uruguay produces other elemental sulfur in small quantities; Iran, in some years, produces 250–1,500 tons of sulfur in sulfur ores (in addition to the listed petroleum refinery byproduct sulfur); and the Philippines produces small quantities of sulfur in sulfur ores.

[2] Less than ½ unit.

[3] Includes sulfur from mined sulfur-sulfide ore.

[4] From refinery gases.

[5] From sulfide ore.

[6] Produced from natural gas; includes small quantities from domestic crude oil and from treatment of nickel-sulfide matte.

[7] From natural gas.

[8] Including sulfur recovered from petroleum refineries.

[9] Includes output of Canary Islands.

[10] From shale oil.

[11] Totals are of listed figures only.

Table 13.—World production of pyrites (including cupreous pyrites)

(Thousand long tons)

Country [1]	1967 Gross weight	1967 Sulfur content	1968 Gross weight	1968 Sulfur content	1969 p Gross weight	1969 p Sulfur content
North America:						
Canada (shipments)	337	r 163	281	e 136	289	e 140
United States [2]	861	355	872	362	W	W
Europe:						
Bulgaria	r 161	e r 64	161	e 64	e 167	e 66
Czechoslovakia	370	e 157	374	e 158	e 394	e 167
Finland	700	336	762	365	e 790	e 372
France	84	35	81	e 33	83	e 36
Germany:						
East	127	53	e 138	e 57	e 138	e 57
West	547	232	606	248	e 628	e 260
Greece	177	e 83	207	e 96	241	112
Italy	1,389	625	1,384	623	1,452	639
Norway	627	282	682	309	746	e 337
Poland e	236	r 90	221	87	221	87
Portugal	520	239	552	250	e 523	e 236
Rumania e	354	138	354	138	354	138
Spain	2,255	1,070	2,365	1,132	2,436	1,131
Sweden	475	242	467	e 238	e 472	e 240
U.S.S.R. e	3,445	1,821	3,445	1,821	3,445	1,821
Yugoslavia	418	r 176	270	113	268	e 112
Africa:						
Algeria	r 34	r 16	45	22	49	24
Morocco (pyrrhotite)	348	108	411	123	385	116
South Arica, Republic of	r 855	e r 342	693	e 277	824	e 330
Asia:						
China, mainland e	1,476	669	1,476	669	1,772	803
Cyprus	848	411	860	413	813	394
Japan [3]	4,457	1,878	4,401	1,845	4,382	e 1,840
Korea:						
North e	492	197	492	197	492	197
South	4	e 1	NA	NA	NA	NA
Philippines	144	67	179	e 84	95	e 44
Taiwan	38	15	38	e 14	38	e 14
Turkey	123	59	134	64	128	61
Oceania: Australia	253	111	163	71	e 123	e 53
Total [4]	r 22,155	r 10,035	22,114	10,009	21,748	e 9,827

e Estimate. p Preliminary. r Revised. NA Not available. W Withheld to avoid disclosing individual company confidential data.

[1] Pyrites is produced in Cuba, but there is too little information to estimate production. Pyrites is also produced in Southern Rhodesia, but production figures have been withheld by the Government.

[2] Sold and used.

[3] Pyrite data covering pyrites, cupreous pyrites, and pyrrhotite only are as follows: 1967, 3,443,557; 1968, 3,351,169; and 1969, NA.

[4] Totals are of listed figures only.

Mexicanize ownership. Inversiones Azufreras S.A., a subsidiary of Metalúrgica Mexicana Peñoles S.A., and Crédito Minero y Mercantil S.A. offered to buy the subsidiary outright for $24 million. Late in the year the Government refused to issue rulings that would enable the proposed sale to take place.[9] Restrictions placed on production and sales caused a severe economic loss to Gulf Resources. After cancellation of the sale, the company decided to cease production of sulfur in Mexico but try to keep the concession agreement in force and to protect the company's investment.

Sulfur exported from Mexico, f.o.b. vessel, was priced at an average of $29.50 per long ton at yearend. Mexico's proved sulfur reserves total about 77.4 million long tons.[10]

Poland.—Sulfur mining in the Tarnobrzeg area of Poland, particularly the open pit operations at Piaseczno and Machow was described.[11] Frasch techniques were used in the underground mines at Grzybow and significantly boosted sulfur output in Poland. Native sulfur production increased 48 percent in 1969 compared with that of 1968. Sulfur produced in Poland does not contain arsenic, selenium, tellurium, or bituminous compounds.

Spain.—Compañia Española de Minas de Rio Tinto, S.A., and Rio Tinto-Patiño, S.A., borrowed $81.4 million from the English banking firm, Samuel Hill Co. to com-

[9] Mining Journal. Gulf to Suspend Sulphur Operations. V. 273, No. 7009, Dec. 19, 1969, p. 558.

[10] Engineering and Mining Journal. V. 170, No. 10, Oct. 1969, p. 154.

[11] Singhal, R. K., Sulphur Mining in Poland. Min. and Miner. Eng., v. 5, No. 3, March 1969, pp. 35–39.

plete financing of two mining development projects: Corte Atalaya, a 12-million-ton-pyrite deposit, and Cerro Colorado.[12] In 1968, Rio Tinto's new treatment and handling facilities enabled the company to ship 1.1 million tons of pyrite fines from its Huelva mine. Huelva City was the site of construction of a custom copper smelter capable of producing about 55,000 tons of metallic copper in the next 2 years.

TECHNOLOGY

The Bureau of Mines reported research on removal of sulfur dioxide from smelter gases.[13] Pale yellow, high-purity, crystalline sulfur precipitates when smelter gas containing sulfur dioxide is introduced into sodium citrate solution into which hydrogen sulfide gas is injected.

The concept of centralized plants to recover sulfur or sulfuric acid from the stack gas of coal-buring electric power plants was proposed as being an economic solution to the air pollution problem associated with these plants.[14] Each plant would be equipped with a scrubber containing a chemical, such as sodium carbonate or magnesium oxide, in solution for absorbing sulfur dioxide from stack gas. The used scrubber solution from several plants would be sent to a central processing plant for recovery of sulfur or sulfuric acid. Estimated capital cost for a scrubber operation at a new electric powerplant was $5 to $7 per kilowatt, and $6 to $9 per kilowatt for conversion of an existing plant.

A catalytic-oxidation process was described for converting the 0.2 percent sulfur dioxide in boiler flue gas into sulfuric acid with almost 90-percent efficiency.[15]

Tests using dry, powdered limestone to remove sulfur dioxide from powerplant stack gases were reported completed by TVA.[16] In the present state of development, about 60 percent of the sulfur dioxide can be removed.

Monsanto Co.'s Cat-Ox process for removing fly ash and sulfur dioxide from flue gas was described.[17] Sulfur dioxide is catalytically oxidized to sulfur trioxide, which is made into sulfuric acid. About 99.5 percent of the fly ash is removed from the flue gas by a combination mechanical separator and electrostatic precipitator.

Various limestones were tested for their capacity to absorb sulfur dioxide from a synthetic flue gas.[18] Chalk and oolite had the greatest sulfur dioxide saturation capacity.

Pan American Sulfur Co. sponsored an improved thermal process to handle all sulfur-containing surface ores.[19] Ground-up surface sulfur ore and heated pebbles are fed into an externally heated conveyor retort from which air is excluded. The ore temperature is raised above the boiling point of sulfur. Both sulfur vapor and water vapor are ducted to a condenser where only the sulfur vapor condenses. The relationship between sulfur content and moisture content of the ore and fuel cost per long ton of sulfur is given graphically for several fuel costs and thermal efficiencies.

Investigation of the thermal reactions of pyrite in neutral, reducing, and oxidizing gases was reported.[20] In atmospheres of dry nitrogen, wet nitrogen, or carbon monoxide, pyrite decomposes between 550° and 700° C to sulfur vapor and ferrous sulfide. Pyrite heated in oxygen initially forms ferrous sulfide and sulfur dioxide between 445° and 520° C. Further heating to between 620° and 660° C converts the ferrous iron to ferric oxide, and additional sulfur dioxide evolves. In carbon dioxide the iron in pyrite oxidizes to magnetite above 650° C.

First Manhattan Co. published a report updating the comprehensive study on sulfur issued in 1968.[21]

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[12] Engineering and Mining Journal. News Briefs in Europe—Spain. V. 170, No. 5, May 1969, p. 164.

[13] George, D. R., L. Crocker, and Joe B. Rosenbaum. Recovery of Elemental Sulphur from Base Metal Smelters. Min. Eng., v. 22, No. 1, Jan. 1970, pp. 75–77.

[14] Sulphur. Chemico's Proposal for Centralized SO_2 Recovery Operations. No. 83, July–August 1969, pp. 39–40.

[15] Stites, Joseph G., and John L. C. Bachofer, Jr. Successful Removal of Sulfur Dioxide From Flue Gas. Min. Cong. J., 55, v. 6, June 1969, pp. 56–59.

[16] Sulphur. (London). Sulphur Oxide Removal from Power Plant Stack Gases by the Dry Limestone Process. No. 81, March–April 1969. p. 38.

[17] Remirez, Raul. Catalytic Route Is Ready for Flue-Gas Cleanup Jobs. Chem. Eng., v. 76, No. 9. Apr. 21, 1969, pp. 86–88.

[18] Potter, Allan E. Sulfur Oxide Capacity of Limestones. Ceram. Bull., v. 48, No. 9, September 1969, pp. 855–858.

[19] Dale, John M. A New Thermal Process for Every Surface Sulfur Ore. Min. Eng., v. 21, No. 4, April 1969, pp. 80–81.

[20] Schoenlaub, Robert A. Oxidation of Pyrite. J. Am. Ceram. Soc., v. 52, No. 1, January 1969, pp. 40–43.

[21] Frank, Ernest H. Sulfur: Review and Outlook. First Manhattan Co., New York, June 13, 1969, 38 pp.

Talc, Soapstone, and Pyrophyllite

By John W. Hartwell [1]

The United States, with a 1969 production of talc, soapstone, and pyrophyllite of over 1 million short tons, was the second leading producing country in the world. Japan was the largest producer with a reported 1.9 million tons. The U.S. producers passed the 1-million-ton mark for the first time since records have been kept. The greater number of mines in operation, increased output from a few mines, and increased prices per unit for the mined product contributed to the increased quantity and value.

Legislation and Government Programs.—The Government stockpile objective for talc (steatite block) remained the same, 200 short tons. New depletion allowances for talc were established effective with the taxable year beginning October 9, 1969. The new rates were 22 percent for domestic and 14 percent for foreign allowances, compared with 23 and 15 percent, respectively, for previous years.

Table 1.—Salient talc, soapstone, and pyrophyllite statistics
(Thousand short tons and thousand dollars)

	1965	1966	1967	1968	1969
United States:					
Mine production	863	895	903	958	1,029
Value	$6,343	$6,479	$6,871	$6,656	$7,508
Sold by producers	838	850	824	886	985
Value	$19,794	$19,269	$20,488	$22,968	$26,294
Exports [1]	70	70	66	66	69
Value [1]	$3,486	$3,917	$3,450	$3,521	$3,713
Imports for consumption	21	22	15	24	20
Value	$833	$827	$653	$973	$749
World: Production	3,934	4,093	4,369	4,866	5,015

[1] Excludes powders—talcum (in package), face, and compact.

DOMESTIC PRODUCTION

Domestic production and value of talc, soapstone, and pyrophyllite during 1969 increased 7 percent and 13 percent, respectively. Production was from 15 States with seven States accounting for 96 percent of the total quantity and 97 percent of the value. These States, in order of decreased production, were New York, Texas, Vermont, California, Montana, North Carolina, and Georgia. California dropped from second place to fourth place in 1969. Output from California during the year was 20,000 short tons less than that reported in 1968; however, value increased by over $250,000. Montana increased production by 48 percent; Texas, 30 percent; Vermont, 10 percent; and North Carolina, 6 percent.

The Bonny mine located near Shoeshone, Calif. and the Western mine near Tecopa have converted their operations from underground mines to open pits. The International Talc Company, Inc., has decided to modernize some of its mills in the Gouverneur district of New York with dust-collection devices.

The ownership of the White Eagle talc mine, near Independence, Calif., was in error on page 2 of the 1968 Minerals Yearbook "Talc" chapter. The owner is Standard Industrial Minerals, Inc., Bishop, Calif.

[1] Mining engineer, Bureau of Mines, Pittsburgh, Pa.

Table 2.—Crude talc, soapstone, and pyrophyllite produced in the United States, by States

State	1968 Short tons	1968 Value (thousands)	1969 Short tons	1969 Value (thousands)
California	165,396	$2,075	145,158	$2,329
Georgia	45,600	288	47,790	301
Nevada	3,029	38	6,434	81
North Carolina	100,030	520	105,728	586
Oregon	3	1	W	W
Texas	125,880	517	163,812	668
Virginia	3,928	10	4,600	12
Other States [1]	514,396	3,207	555,716	3,531
Total	958,262	6,656	1,029,238	7,508

W Withheld to avoid disclosing individual company confidential data.
[1] Includes Alabama, Arkansas, Maryland, Montana, New York, Pennsylvania, Vermont, Washington, and States indicated by symbol W.

Table 3.—Talc, soapstone, and pyrophyllite sold by producers in the United States, by classes

Year	Crude Short tons	Crude Value at shipping point (thousands)	Ground [1] Short tons	Ground [1] Value at shipping point (thousands)	Total [2] Short tons	Total [2] Value at shipping point (thousands)
1965	63,345	$255	775,079	$19,539	838,424	$19,794
1966	[3] 110,856	493	738,736	18,776	849,592	19,269
1967	[3] 42,758	280	780,998	20,208	823,756	20,488
1968	[3] 64,877	331	821,601	[r] 22,637	886,478	[r] 22,968
1969	[3] 81,015	362	904,318	25,931	985,333	26,294

[r] Revised.
[1] Includes crushed and sawed and manufactured material to avoid disclosing individual company confidential data.
[2] Data may not add to total shown because of independent rounding.
[3] Includes exports to grinders in Belgium and Mexico.

CONSUMPTION AND USES

U.S. consumption of talc, soapstone, and pyrophyllite in 1969 was 11 percent greater, in quantity, than consumption in 1968 and 14 percent greater in value. The principal uses for talc products were, in order of decreasing demand, ceramics, paint, paper, and insecticides. The paper industry had the greatest increased use for talc in 1969, followed by the insecticide industry and ceramics. The largest decrease of talc usage was in roofing, toilet preparations, and the textile industries.

Table 4.—Pyrophyllite [1] produced and sold by producers in the United States

Year	Production Short tons	Total sales Short tons	Total sales Value (thousands)
1965	126,266	136,308	$1,824
1966	125,202	126,874	1,627
1967	117,457	118,337	1,579
1968	130,624	120,319	1,748
1969	104,347	110,816	1,632

[1] Includes sericite schist.

Table 5.—Talc, soapstone, and pyrophyllite sold or used by producers in the United States, by uses

(Short tons)

Uses	Talc and soapstone		Pyrophyllite	
	1968	1969	1968	1969
Ceramics	227,327	245,704	20,657	26,860
Insecticides	38,739	53,722	W	W
Paint	166,336	166,170	W	W
Paper	38,897	54,554	—	—
Roofing	84,699	30,526	—	W
Rubber	20,897	24,464	W	W
Textile	13,520	7,974	W	W
Toilet preparations	33,930	12,235	W	W
Other	[1] 141,814	[1] 279,168	[2] 99,662	[2] 83,956
Total	766,159	874,517	120,319	110,816

W Withheld to avoid disclosing individual company confidential data.

[1] Includes asphalt filler, crayons, exports, fertilizer, floor and wall tile, foundry facings, insulated wire and cable, joint cement, plastics, rice polishing, and miscellaneous products.

[2] Includes asphalt filler, brick, enamel coating, exports, foundry facings, joint cement, refractories, miscellaneous products, and items indicated by symbol W.

PRICES

Although yearend trade-journal quotations remained virtually unchanged, certain grades of New York and California talc were reported with increased prices. New York talc, 99.9 percent through 325 mesh, increased in price $2 per ton. Increases in California standard-talc prices ranged from $2 to $6 per ton; fractionated- and micronized-grade increases ranged from $2 to $2.50; and cosmetic-grade steatite increases ranged from $1.50 to $6 depending upon quality and specifications of the material involved.

FOREIGN TRADE

The U.S. producers of talc, soapstone, and pyrophyllite increased exports in 1969 by 5 percent in quantity and value over those of 1968. Fifty-two percent of exports went to Canada, 15 percent to Mexico, and the balance to 51 other countries.

Table 6.—U.S. exports of talc, soapstone, and pyrophyllite, crude and ground

(Thousand short tons and thousand dollars)

Year	Quantity	Value
1967	66	$3,450
1968	66	3,521
1969	69	3,713

Imports, which were largely from Canada, Italy, and France, decreased in quantity and value approximately 16 and 23 percent respectively. Imports of unmanufactured material from Canada, decreased 26 percent from 1968 receipts. French shipments decreased nearly 16 percent; the quantity from Italy increased about 4 percent. Imports were reported from three new sources, Israel, Poland, and the United Kingdom. West Germany, India, and the United Arab Republic were deleted as exporters to the United States.

Table 7.—U.S. imports for consumption of talc and steatite or soapstone, by classes and countries

(Short tons and thousand dollars)

Year and country	Crude and unground		Ground, washed, powdered, or pulverized		Cut and sawed		Total unmanufactured	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value[1] (thousands)
1967	2,914	$32	12,229	$487	218	$134	15,361	$653
1968:								
Canada	9,048	90	2,014	45	2	2	11,064	137
France	------	----	5,968	160	1	1	5,969	161
Germany, West	------	----	------	----	3	188	3	188
India	22	2	------	----	----	----	22	2
Italy	959	41	4,407	246	----	----	5,366	287
Japan	------	----	165	7	210	126	375	133
Korea, South	------	----	1,501	62	6	2	1,507	64
Mexico	2	(2)	------	----	----	----	2	(2)
United Arab Republic	5	1	------	----	----	----	5	1
Total	10,036	134	14,055	520	222	319	24,313	973
1969:								
Canada	5,899	55	2,281	54	3	2	8,183	111
France	------	----	5,046	124	2	1	5,048	125
Israel	------	----	14	2	----	----	14	2
Italy	3,293	137	2,265	144	2	1	5,560	282
Japan	------	----	------	----	258	159	258	159
Korea, South	------	----	1,222	54	----	----	1,222	54
Mexico	1	(2)	------	----	----	----	1	(2)
Poland	------	----	33	3	----	----	33	3
United Kingdom	3	2	36	11	----	----	39	13
Total	9,196	194	10,897	392	265	163	20,358	749

[1] Does not include talc, n.s.p.f.: 1967, $4,938; 1968, $12,722; 1969, $12,479.
[2] Less than ½ unit.

WORLD REVIEW

Australia.—Three Springs Talc Pty., Ltd., which produces steatite talc from an open pit mine in Western Australia, started operation of its new crushing and screening plant late in 1968. The new facilities, capable of producing up to 70 tons of minus-3-inch steatite lump in 1 hour, will enable the company to expand production.

Canada.—Changes were made in the Customs Tariff and Excise Tax Act, June 3, 1969, which affected the duty on pyrophyllite entering the country for use by Canadian manufacturers. No duty is charged when entering the country under the tariff categories titled "British Preferential" and "Most Favoured Nation," however, under the section titled "General Tariff," the rate of duty is 25 percent.

Baker Talc Ltd. built a new mill and warehouse and acquired a wet magnetic separator to improve the quality of its products. The new mill will produce 10 tons per shift. The separator was installed to upgrade talc which then could be used by the paint and cosmetic industries.

Italy.—Production of talc and steatite has remained relatively stable because of competition in foreign markets from Red China and India. Exports to West Germany, the United Kingdom, France, and the United States in 1968, however, rose 25 percent because of the high quality of the Italian products. Mines and mills were being expanded to further improve the product in quality and quantity.

Norway.—A fire in August 1969 destroyed a large part of a Norwegian talc-processing mill near Bergen, including all nine of the micronizing mills used to produce the better grades of talc. The micronized talcs, generally in the 20-micron range, are used throughout Europe as fillers and extenders. The United Kingdom

Table 8.—World production of talc, soapstone, and pyrophyllite, by countries
(Short tons)

Country	1967	1968	1969 p
North America:			
Canada (shipments)	60,664	78,401	e 82,000
Mexico	3,217	707	NA
United States	902,512	958,262	1,029,238
South America: [1]			
Argentina	r 28,712	30,943	NA
Chile	3,176	3,101	NA
Colombia	1,102	1,484	1,678
Paraguay	79	83	99
Peru (pyrophyllite)	6,096	NA	NA
Uruguay	2,908	1,960	2,537
Europe:			
Austria	85,685	93,009	e 88,000
Finland	r 3,231	e 3,300	e 11,000
France	r 239,088	232,576	240,419
Germany, West (marketable)	r 46,380	46,056	e 52,700
Greece	4,304	4,950	4,950
Italy	130,586	127,445	150,151
Norway (ground talc)	88,974	84,346	e 85,000
Portugal	154	1,210	e 2,200
Rumania	143,299	e 143,300	e 143,300
Spain	35,112	31,930	e 33,000
Sweden	r 27,653	e 22,000	e 22,000
U.S.S.R. e	396,000	407,000	418,000
United Kingdom	10,022	12,679	e 12,100
Africa: [2]			
South Africa, Republic of	10,071	9,978	9,693
Swaziland	660	640	e 660
United Arab Republic e	33,000	33,000	33,000
Asia:			
China, mainland e	165,000	165,000	165,000
India	148,953	193,577	205,292
Japan	r 1,518,422	1,865,815	1,876,593
Korea:			
North e	66,000	66,000	66,000
South	135,443	164,692	204,067
Pakistan (soapstone)	2,920	2,879	e 2,640
Philippines	489	959	1,036
Taiwan	45,542	32,026	26,810
Thailand (pyrophyllite)	14	3,707	2,180
Oceania: Australia	r 23,095	42,972	e 44,000
Total [3]	r 4,368,563	4,865,987	5,015,343

e Estimate. p Preliminary. r Revised. NA Not available.
[1] Brazil is believed to produce in excess of 50,000 tons annually, but available data are incomplete.
[2] Southern Rhodesia is known to be a producer but no data are available.
[3] Total is of listed figures only.

imported over 20,000 tons in 1969. It is expected that repairs will be completed and production will be resumed early in 1970.

United Arab Republic.—A talc-carbonate deposit was reported in the southeastern desert region between the Nile River and the Red Sea. This deposit reportedly contains hard, red crystals of magnesite in a soft, green groundmass of talc flakes. Presently it is thought this rock could be economically processed to produce Egypt's needs for basic refractory material. No mention was made concerning reserves or possible use of the talc portion of the mineral.[2]

United Kingdom.—The Board of Trade was considering an application for lifting the import duty on tremolite talc imported from the Gouverneur district of New York State. This material is ideally suited for use in some paints and certain ceramics because of its excellent color and fibrous character. Presently, this grade of talc is subject to an 8-percent duty.

Zambia.—Currently, Crushed Stone Sales Ltd., a company controlled by the Zambian Government, is developing two talc deposits located near Lilaya and Chipata. Reserves are estimated at 300,000 tons including 100,000 tons of block steatite. The talc is reported to compare favorably with the best French grades. Another deposit 16 miles southeast of this operation contains talc and pyrophyllite, with reserves of about 1 million tons.

[2] Yousef, A. A., L. G. Girgis, and T. R. Boulos. Egypt's Talc-Carbonate. Min. Miner. and Eng., v. 5, No, 6, June 1969, pp. 30–33.

TECHNOLOGY

A new publication entitled "Talc deposits of the southern Death Valley-Kingston Range region" was issued in April 1970 as Special Report 95 by the California Division of Mines and Geology. Talc mines in the area lie in a talc-bearing belt 75 miles long. Within this belt are 29 mines which have accounted for most of the production. Maps of most of the mines are included in the well-illustrated text.[3]

Rock similar to that mined for industrial talc near Fowler, N.Y., since 1880 was mapped at a new locality in western De Kalb Township, St. Lawrence County, N.Y.[4]

In grinding talc or other nonlamellar minerals to obtain a product for use in the paint and paper industries, a slurry of the ore is ground in the presence of nylon pellets or other nonabrasive resilient grinding media to produce a mineral finer than 200-mesh while reducing its viscosity.[5]

A method of floating nonmetallic minerals, including talc, was described. Minerals investigated were used in the purest form and as crystals when available. Because the information obtained proved helpful in solving a number of flotation problems, the results were published.[6]

Froth-flotation beneficiation of talc ore was recommended as a method of recovering talc from an ore containing large percentages of magnesite or other alkaline-earth carbonate gangue.[7]

A method of improving the color of gray West Texas talc was described. The talc is processed normally and then treated with sulfuric acid and hydrous aluminum sulfate, washed and filtered, and calcined.[8]

A composition of talc and other nonmetallic minerals was proposed for insulating, fireproofing, and weatherproofing steel columns, beams, and gas tanks.[9]

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[3] Mineral Information Service, California Division of Mines and Geology, v. 23, No. 4, April 1970, p. 66.

[4] Brown, C. E. New Talc Deposit in St. Lawrence County, New York. U.S. Geol. Survey Bull. 1272–D, 1969, 13 pp.

[5] Sennett, P. S., K. L. Turner, and H. H. Morris (assigned to Freeport Sulphur Co.). Comminution and Sizing of Talc and Other Nonlamellar Minerals. U.S. Pat. 3,476,576, Nov. 4, 1969.

[6] Wyman, R. A. A Guide to Floatability of Nonmetallic Minerals. Minerals Processing (Ottawa, Canada), v. 11, No. 2, pp. 10–13, 23.

[7] Mercade, V. (assigned to Englehard Minerals and Chemicals Corp.). Froth Flotation of Talc Ore. U.S. Pat. 3,459,299, Aug. 5, 1969.

[8] Lundquist, J. D. (assigned to Georgia Kaolin Co.). Decolorization Process for Talc. Canadian Pat. 819,619, Aug. 5, 1969.

[9] Fraser, J. H. (assigned to Vonco Corp, Inc.). Coating Composition and Method. U.S. Pat. 3,458,327, July 29, 1969.

Thorium

By John G. Parker [1]

All thorium continued to be recovered as a byproduct in the chemical processing of monazite beach sands for their rare-earth oxide (REO) content. Prices for thorium materials, including metal and alloys such as thorium-magnesium hardener, remained relatively stable. The use of thorium in nuclear applications showed little change; in nonenergy uses consumption of thorium-magnesium hardener alloy rose more than 15 percent.

No immediate shortage of thorium is foreseeable, but future widespread acceptance of certain thorium-consuming nuclear reactors could lead to a potential annual demand of hundreds of tons within 10 years.

Legislation and Government Programs.—In early 1969 the Office of Emergency Preparedness established a new reduced objective for thorium nitrate, equivalent to 40 tons of thorium dioxide, as the stockpile objective. An excess of 1,793 tons of thorium oxide equivalent remained in the supplemental stockpile.

Thorium stocks, under the control of the Division of Production, U.S. Atomic Energy Commission (AEC), totaled nearly 1,560 tons of thorium in various forms, including concentrates, oxides, nitrate, and metal.

DOMESTIC PRODUCTION

Mine Production.—Output of monazite in the United States in 1969 was nearly 13 percent less than that in the previous year. By far, most production came from Folkston, Ga., where Humphreys Mining Co. recovered byproduct monazite in the mining and processing of titaniferous and zirconiferous sands on property owned by E. I. du Pont de Nemours & Co., Inc. The only other monazite production was at Climax Molybdenum Company's mine and mill near Leadville, Colo., where a small quantity was a byproduct of molybdenum mining. Byproduct recovery of monazite is scheduled by mid-1972 from zircon- and titanium-bearing deposits in northern Florida. The operating company, Titanium Enterprises, is a joint venture of American Cyanamid Co. and Union Camp Corp. The latter firm, the owner of extensive forest holdings in the southeastern United States, owns the reserves, and Cyanamid, a leading supplier of titanium oxide pigment, will presumably take the output of ilmenite.[2]

Reserves of 15 to 25 million tons of thorium-bearing materials are estimated in Idaho, with a possible total content of 250,000 tons of thorium oxide. In the Victor area, 6.5 million cubic yards of placer sands are estimated to contain, on the average, about 1 pound of thorium oxide per cubic yard. The Idaho deposits were said to occur in alluvial or placer deposits in intermountain valleys extending from Owyhee County in the south to Clearwater County in the north. Also, they occur as thorite in vein or shear deposits in and near Hall Mountain in Boundary County near the Canadian border. In Lemhi County, one deposit about 30 miles north of Salmon is principally monazite in highly metamorphosed Precambrian rocks, and another near Lemhi Pass, 26 miles southeast of Salmon, is principally thorite.[3]

In the Lemhi Pass area of Montana it was estimated that there were 693,000 tons

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[1] Physical scientist, Intermountain Field Operation Center, Denver, Colo.

[2] Industrial Minerals (London). No. 22, July 1969 p. 30.

[3] Williams, George A. Thorium Mineral Reserves of Idaho. Trans. Thorium Information Meeting, Salmon, Idaho, Sept. 18, 1968, Idaho Nuclear Energy Commission, pp. 19–22.

of thorium-bearing materials averaging 0.67 percent thorium oxide.[4]

Refinery Production.—The only domestic firms processing monazite to recover thorium and rare-earth compounds continued to be American Potash & Chemical Corp., a subsidiary of Kerr-McGee Corp., West Chicago, Ill., and Davison Chemical Division of W. R. Grace & Co., Chattanooga, Tenn., and Pompton Plains, N.J. These firms were the principal suppliers of crude and refined thorium compounds. Because monazite is now processed primarily for its rare-earth oxide content, the supply of byproduct thorium from this source probably exceeded demand, and an increase in thorium stocks continued. No thorium-magnesium master alloys (most of which contain about 40 percent thorium) were produced in this country, but Magnesium Elektron, Inc., New York City, continued as the distributor in the United States for an English producer. The thorium for these alloys probably came from raw materials derived as a byproduct from Canadian uranium-mining operations.

Table 1.—Principal firms having capacity to process and fabricate thorium during 1969

Company	Location	Status (p–processor; f–fabricator)
American Potash & Chemical Corp., div. of Kerr-McGee Corp	West Chicago, Ill	p
General Electric Co	San Jose, Calif	f
Do	Wilmington, N.C	f
Gulf General Atomic, Inc	San Diego, Calif	p,f
Kerr-McGee Corp	Oklahoma City, Okla	p,f
Metal Hydrides, Inc	Beverly, Mass	p
National Lead Co	Albany, N.Y	p,f
Nuclear Fuel Services, Inc	Erwin, Tenn	p,f
Nuclear Materials & Equipment Corp. (NUMEC)	Apollo, Pa	p,f
Do	Leechburg, Pa	f
United Nuclear Corp	Hematite, Mo	p,f
Westinghouse Electric Corp	Columbia, S.C	f

Source: U.S. Atomic Energy Commission. The Nuclear Industry 1969. Dec. 3, 1969, pp. 69, 85.

Table 2.—Producers and fabricators of magnesium-thorium alloy [1]

Company	Plant location
American Light Alloys, Inc	Little Falls, N.J.
Bendix Foundries	Teterboro, N.J.
Brooks and Perkins, Inc	Detroit, Mich.
Controlled Castings Corp	Plainview, N.Y.
The Dow Chemical Co	Madison, Ill.
Hills-McCanna Co	Carpentersville, Ill.
Howard Foundry Co	Chicago, Ill.
R. C. Hitchcock and Sons, Inc	Minneapolis, Minn.
Rolle Manufacturing Co	Lansdale, Pa.
Wellman Dynamics Corp	Bay City, Mich.

[1] Three percent thorium alloys.

CONSUMPTION AND USES

Nonenergy Uses.—Total apparent consumption of thorium in nonenergy applications decreased about 10 tons in 1969 to 115 tons of equivalent ThO_2 (thoria). The principal uses, in order of relative importance, were thorium nitrate for manufacturing Welsbach-type incandescent gas mantles (a little over 50 percent of total thoria consumption); thorium-magnesium hardener (about 40 percent thorium content) for making magnesium-base alloys containing about 3 percent thorium, 15 to 20 percent; and thoria used in making dispersion-hardened metal alloys (for example, nickel, tungsten, stainless steel). Minor amounts of thoria were used in specialized refractory crucibles and in catalysts for making organic chemicals. Thoria and thorium boride show promise for high-temperature applications. Use of thoria in structural alloys for specialized space and military projects was small but important enough to justify retaining thorium as a strategic and critical material.

Energy Uses.—There was little indication that demand for thorium for use in reactors and reactor experiments showed any growth over the small demand in 1968; supplies for this purpose have come from the stockpile of AEC. The most advanced and promising of the five concepts regarding use of the thorium fuel cycle (conver-

[4] Geach, Robert D. Thorium Reserves in Montana. Pp. 19–22 of work cited in footnote 3.

sion of fertile thorium to fissionable uranium-233) are the high-temperature, gas-cooled reactor (HTGR) and the molten salt reactor experiment (MSRE). (See "Technology" section.) About 25 tons of thorium oxide will be used in the initial charge for the Fort St. Vrain HTGR to be operated by Public Service Company of Colorado in Platteville, Colo. The plant is scheduled for initial operation in 1972. If the HTGR concept proves economically successful, there may be a market of about 500 tons of thorium oxide by 1980.[5]

PRICES

The domestic nominal price of monazite sand concentrate (based on periodic quotations in Metals Week for 1969) ranged from $180 to $200 per long ton, or from 8 to 9 cents per pound. The average price of imported thorium ore, including monazite, in 1969 was nearly $117.50 per short ton, more than $11 per ton less than the average price in the previous year. Monazite with a minimum content of 55 percent REO was quoted on the London market at £65 ($156) to £75 ($180) per long ton c.i.f. for the first 9 months of 1969 and raised to £70 ($168) to £80 ($192) per long ton c.i.f. in October.[6]

Quotations on thorium pellets by American Metal Market remained at $15 per pound; a large chemical processor of monazite offered thorium metal powder for $65 per pound in 1- to 25-pound lots. Thorium nitrate was available at $2.75 per pound in 100-pound lots or more at the works.[7] In 100-pound lots, 99 percent minimum content thorium oxide was quoted at $7 per pound. Other thorium oxides, in smaller lot sizes and of higher purity, ranged up to $20 per pound. Thorium-magnesium hardener alloys (about 40 percent thorium content) sold for about $12 per pound of contained thorium plus the market value of the contained magnesium (35.25 cents per pound). On this price basis, 40 percent thorium hardener alloys cost about $5 per pound.

FOREIGN TRADE

Exports.—Shipments of thorium ore and concentrate from the United States during 1969 (about 90 percent to France and the rest to Japan and West Germany), totaled 1,544 pounds of contained thorium oxide worth $11,181. Exports of thorium and uranium metals and alloys to seven countries totaled 788 pounds (gross weight) valued at $26,182, with almost half being sent to Canada and about one-quarter to West Germany. Uranium and thorium compounds sent to 16 countries, including 32 percent to the United Kingdom, 19 percent to Japan, and 9 percent to South Vietnam, totaled 105,620 pounds worth $316,561.

Imports.—Monazite concentrate (an ore of thorium and rare-earth elements) shipped from three foreign sources (59 percent from Australia, 37 percent from Malaysia, and the rest from Hong Kong) decreased nearly 4 percent to 4,206 short tons valued at $493,802. The unit value of $117.40 per short ton was nearly 9 percent less than that of 1968. Imports of thorium oxide, essentially all from West Germany, totaled 442 pounds valued at $2,514. Other thorium compounds from Switzerland (125 pounds or 53 percent), West Germany (108 pounds or 46 percent), and the United Kingdom totaled 236 pounds worth $25,848. There were no imports of metal, nitrate, or salts reported for the year. Imports from the United Kingdom of thorium-magnesium hardener alloy, containing about 40 percent thorium, were three times those in 1968. Imports of thoriated gas mantles from the United Kingdom (88 percent), West Germany (9 percent), Austria (2 percent), and four other countries totaled nearly 4.1 million units valued at $398,414, an increase in weight and value of about 20 percent. This represents a use of about 4,100 pounds of thorium dioxide, as about 1,000 mantles can be made from 1 pound of thorium dioxide.

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[5] U.S. Atomic Energy Commission. The Nuclear Industry, 1969. Dec. 3, 1969, p. 41.

[6] Industrial Minerals (London). Nos. 16–27, January–December 1969.

[7] Oil, Paint and Drug Reporter. V. 195, Nos. 1–26, Jan. 6–June 30, 1969; v. 196, Nos. 1–26, July 7– Dec. 29, 1969.

Table 3.—U.S. imports for consumption of monazite, by country

Country	1965		1966		1967		1968		1969	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Australia	1,278	$111	1,542	$176	1,540	$195	2,810	$369	2,478	$300
Brazil	64	6	-----	----	-----	----	-----	----	-----	----
Ceylon	141	14	-----	----	-----	----	-----	----	-----	----
Germany, West	-----	----	-----	----	24	4	24	4	-----	----
Hong Kong	-----	----	-----	----	-----	----	-----	----	167	20
Indonesia	-----	----	-----	----	72	13	-----	----	-----	----
South Korea	22	2	-----	----	49	7	-----	----	-----	----
Malaysia	447	50	785	92	273	38	1,514	188	1,561	174
Nigeria	76	6	-----	----	133	13	19	2	-----	----
South Africa, Republic of	-----	----	115	9	-----	----	-----	----	-----	----
Total	2,028	189	2,442	277	2,091	270	4,367	563	4,206	494
ThO_2 content [e]	120	----	145	----	125	----	262	----	252	----

[e] Estimate.

WORLD REVIEW

Australia.—Based on figures for one-half of the year, gross output of concentrate containing monazite was about 4,300 short tons, with a monazite tenor of 90 percent or about 3,880 short tons. This was about 8 percent greater than 1968 production.

Table 4.—World production of monazite concentrates, by countries

(Short tons)

Country [1]	1967	1968	1969 [p]
Australia	[r] 2,590	2,287	[e] 4,250
Brazil	1,189	1,202	2,203
Ceylon	22	46	62
India	[e] 2,900	[e] 2,900	3,850
Korea, South	14	NA	NA
Malagasy Republic	28	2	NA
Malaysia	[2] 1,060	[2] 2,356	[e] 2,400
Nigeria [3]	126	7	14
Thailand	------	44	72
Total [4]	7,929	8,844	12,851

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.

[1] United States production data withheld to avoid disclosing individual company confidential data. Monazite is produced in Indonesia, North Korea, and the Congo (Kinshasa), but quantities are insignificant or not available.

[2] Exports.

[3] Year ended March 31 of year following that stated.

[4] Totals are of listed figures only.

Canada.—Thorium was recovered as a byproduct of uranium operations in the Elliot Lake area, where about ¾ to 1 pound per ton was contained in the ores. Estimated resources of thorium oxide are about 200,000 tons.[8]

Output of thorium oxide in concentrate was less than that in the previous year. Shipments of thorium oxide in concentrate were only 29,014 pounds compared with 139,191 pounds in 1968, but the price per pound was slightly higher than that in 1968.

India.—Output of monazite was considerably more than production estimates for the previous few years, but thorium production figures were not available. Indian Rare Earths Ltd. continued its production of thorium hydroxide at its Alwaye plant in Kerala State, where the capacity was said to be about 800 tons per year. All the hydroxide is used in a plant near Bombay that makes thorium nitrate and oxide. This plant, the largest of its kind in the world, has an annual production capacity of about 300 tons of nitrate. The nitrate supplies virtually all the needs of the Asian gas-mantle industry, as well as some other overseas markets.

United Kingdom.—Thorium salts manufactured from Canadian concentrate may be too high in alpha radiation, under revised Factory Act regulations. It appears that the 25 percent thoria content material may be too difficult to handle and that in the long term the industry may have to switch to alternative material, probably monazite, which contains a different thorium isotope having lower alpha-activity.[9]

[8] Kostuik, John. Production, Reserves and Future Sources of Uranium. Canadian Min. and Met. Bull. v. 62, No. 686, June 1969, pp. 609–613.

[9] Industrial Minerals (London). No. 21, June 1969, p. 41.

TECHNOLOGY

Much of the research on thorium is directed toward securing data which can lead ultimately to usage in energy applications. Attention was directed, however, toward methods for preparing the metal and using it or the oxide in certain alloys. A laboratory technique was developed at the Argonne National Laboratory for making the metal by reducing the oxide with zinc and magnesium.[10] Potential economic advantages are involved because the method uses no calcium, an expensive metal used as a reductant in the commercial production of thorium metal, and requires no prior hydrofluorination step.

In adding thorium oxide (thoria) particles to a 20-percent-chromium nickel-base alloy, it was found that small particle size is necessary to maintain stability and that larger dispersoid particles promote grain growth, which weakens the alloy.[11] Two of these alloys made by different companies showed significant improvement in elevated-temperature structural stability over a dispersion-free 80 percent nickel-20 percent chromium alloy.

Serious consideration has been given to thorium as a fertile material because of the need to develop economic breeder reactors that would produce more fissionable material than they consume. In the process called breeding, thorium can be converted to U233, a fissionable material, by bombardment in a reactor with neutrons in excess of those needed for maintaining the fissioning process.

Core development and fuel irradiation and testing research continued on the gas-cooled breeder reactor concept at Oak Ridge National Laboratory (ORNL) and Gulf General Atomic (GGA), La Jolla, Calif. GGA, with a number of utilities, created a conceptual design for a 330-megawatts electrical (MWE) gas-cooled, breeder plant.

The reactor of the Fort St. Vrain HTGR plant will initially require about 50,200 pounds of thorium dioxide, equivalent to about 44,100 pounds of thorium, and 2,710 pounds of fully enriched uranium (in the form of pyrocarbon-coated thorium and uranium carbide particles) in graphite blocks. The graphite acts as a moderator, and heat is transferred by helium gas coming out of the reactor at about 1,400° C. and 700 pounds per square inch to a steam generator which drives an electricity-producing turbine. Compared with a light-water reactor or fossil-fuel plant, this type of reactor has a high efficiency (about 40 percent) and low reject heat. This means it needs less cooling water and presents fewer thermal pollution problems. A 1,000 MWE reactor, which has been designed, initially will need about 80,250 pounds of thorium dioxide (70,525 pounds of thorium) and 3,900 pounds of fully enriched uranium (equal to about 420 tons U_3O_8). Every year after the second, about 10 tons of ThO_2 and about 1,300 pounds of uranium (equivalent to about 140 short tons of U_3O_8) will be needed to replace fuel removed for reprocessing.[12]

Work continued at AEC's Bettis Atomic Power Laboratory, Pittsburgh, Pa., on developing a reactor core that would demonstrate the potential for breeding in a completely light-water reactor system. The light-water breeder reactor (LWBR) uses the seed-blanket reactor concept along with the thorium and uranium-233 fuel cycle.

A report, based largely on information provided by designers of various thorium-fueled reactors, was published as part of an overall assessment of the civilian nuclear power program.[13] The report considered the thorium cycle, requirements and economics for nuclear fuels and their resources, and the use and economic evaluation of the thorium cycle in specific reactor types. Examples cited were the high-temperature, gas-cooled reactors (HTGR) at Peach Bottom, Pa., and Fort St. Vrain; the current molten-salt reactor experiment (MSRE) at ORNL; light-water moderated reactors (LWR), at Indian Point, N.Y., and Elk River, Minn.; the heavy-water moderated reactor (HWR) such as the Canadian CANDU reactor; and the fast-breeder reactor (FBR). Total fuel-cycle costs potentially could be as low

[10] Light Metal Age. Magnesium-Zinc Alloy Used in Thorium Reduction Process. V. 27, Nos. 5–6, June 1969, p. 37.

[11] Raymond, L., and J. P. Neumann. The High-Temperature Stability of Thoria-Strengthened Nickel-Chromium Alloys. Internat. J. Powder Met., v. 5, No. 2, 1969, pp. 97–104.

[12] Matheson, A. R. Thorium Market Estimates for the HTGR. Pp. 23–26 of work cited in footnote 3.

[13] U.S. Atomic Energy Commission. The Use of Thorium in Nuclear Power Reactors. WASH Rept. 1097, June 1969, 144 pp.

as 1.0 mill per kilowatt hour for the HTGR and approximately 0.5 mill or less per kilowatt hour for the MSBR.

A more detailed report became available late in the year on the HTGR.[14] Estimated costs were presented on designed 1,000-MWE plants, with thorium and uranium fuel costs and details on the fuel elements. Projections were made on industry-size plants up to 12,000 MWE.

The competition of plutonium (Pu) with thorium as a future nuclear fuel was assessed. Byproduct plutonium is made from uranium-238 that has captured neutrons during reactor operations. Estimates indicate that at least 200 kilograms of Pu are produced for each 1,000 megawatts of installed electrical capacity and that by 1980 over 70,000 kilograms of Pu with a value of $700 million (at $10 per gram) would be available. Pu will probably be recycled for economic reasons in thermal reactors or used with uranium in fast-breeder reactors, where it has a better breeding ratio than the uranium-223–thorium cycle. The latter cycle can be used in thermal breeders, in which Pu cannot be used as fuel. Detrimental to thermal reactors, however, is their low breeding rate compared with that of fast breeders. Offsetting this in part is a higher specific power (a measure of how hard the fissionable material in the reactor is being driven to produce new fuel).[15]

On the other hand, with the CANDU reactor (the Canadian deuterium-uranium reactor), which uses the natural uranium fuel cycle, thorium could possibly be used economically to supply part of the fueling requirements in a so-called "Valubreeder," a near-breeder. The system would be particularly useful when the price per pound of uranium (in Canadian reserves) rose to over $15 per pound.[16]

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[14] U.S. Atomic Energy Commission. An Evaluation of High-Temperature Gas-Cooled Reactors. WASH Rept. 1095, December 1969, 220 pp.

[15] Novick, M. The Role of Plutonium as a Competitor to Thorium as a Future Nuclear Fuel. Pp. 31–38 of work cited in footnote 3.

[16] Church, T. G. The Role of Thorium in CANDU-Type Reactors. Pp. 52–59 of work cited in footnote 3.

Tin

By John R. Lewis [1]

The use of primary and secondary tin by the metal-consuming sector of U.S. industry during 1969 remained about at par with consumption in recent years. There were no important gains or losses.

The strike of dock workers at east and gulf coast ports, which began in December 1968, was settled in mid-February 1969, and the men returned to work on February 17. For the most part, tin buyers in the United States had hedged in anticipation of the strike, and had fairly successfully anticipated the duration and dislocations of the strike so that problems for most tin consumers were few. A number of shipments of tin were stymied in New York Harbor, however, which created uncomfortable financial pressure on U.S. tin traders.

Almost all primary tin used in the United States came from foreign sources during the year, but the Nation led the world in its recovery and use of recycled, or secondary, tin and tin alloys. Most American supplies came from Malaysia and Thailand in 1969. Less than 100 long tons were mined in the United States; all of it came from widely scattered mines in the West and Alaska. There were no known tin shortages anywhere in the free world.

During the year, the Nation went temporarily out of the primary tin smelting business. No tin concentrates had been brought into the country since December 1968, and the only tin smelter, at Texas City, Tex. had consumed its stock of concentrate (Bolivian) by midsummer 1969. For the remainder of the year, the electrolytic tin facilities of the plant were operated as a secondary smelter, using residues, drosses, and dusts purchased from smelters and detinning plants around the country. Primary tin smelting was to resume during 1970, however.

The International Tin Council (ITC), operating under terms of the Third International Tin Agreement, met four times during 1969 and declared that each of the four calender quarters of the year were to be periods of export control for the purpose of adjusting supply and demand so as to maintain the price of tin metal between ITC-established floor and ceiling prices. This was made necessary, it was announced, by weakening tin prices in late 1968, which were a result of world oversupply. Export controls were eliminated, because of improvement in the demand-price situation at the end of 1969. The ITC also requested the Secretary General of the United Nations to convene a negotiating conference for a Fourth International Tin Agreement, and this was set up for the spring of 1970 at Geneva, Switzerland. The Second Technical Conference on Tin, jointly sponsored by the ITC and the Government of Thailand, was held in Bangkok in November and was very well attended.

Legislation and Government Programs.—Under the Tax Reform Act of 1969, which was signed by the President on December 30, 1969, the percentage depletion rates on tin were reduced from 23 percent for domestically produced tin and 15 percent on foreign production to 22 and 14 percent, respectively. The new rates applied to taxable years beginning after October 9, 1969.

The General Services Administration (GSA) did not dispose of any tin during 1969 through commercial channels. About 1,700 tons were shipped out during the year through programs of the Agency for International Development (AID). The strategic stockpile objective for tin was raised in March from 200,000 long tons to

[1] Physical scientist, Division of Nonferrous Metals.

232,000 long tons. This action left about 25,000 long tons remaining as surplus in the stockpile. Disposal of the surplus remained a subject of study and consultation, particularly with ITC member countries. during the remainder of the year. Early in January the GSA announced that it would be willing to exchange excess materials from the national stockpile for other commodities whose stock levels were below certain national objectives. Tin was included among the commodities available for barter. There was, however, no tin bartered during the year.

Table 1.—Salient tin statistics

(Long tons)

	1965	1966	1967	1968	1969
United States:					
Production:					
Mine	47	97	W	W	W
Smelter	3,098	3,825	3,048	3,453	345
Secondary	25,076	25,349	22,667	22,495	22,775
Exports (exports and reexports)	2,829	2,847	2,479	4,495	2,903
Imports for consumption:					
Metal	40,816	41,699	50,223	57,358	54,950
Ore (tin content)	4,326	4,372	3,255	2,439	-----
Consumption:					
Primary	58,505	60,185	57,848	58,859	57,730
Secondary	25,461	25,277	22,790	23,102	23,060
Price: Straits tin, in New York, average cents per pound	178.17	164.02	153.405	148.111	164.435
World: Production:					
Mine	201,115	208,071	214,233	227,935	223,609
Smelter	197,181	200,510	219,175	230,768	224,457

W Withheld to avoid disclosing individual company confidential data.

DOMESTIC PRODUCTION

PRIMARY TIN

Mine Production.—A small but persistent tin mining industry exists within the United States. As has been the case for about a decade, annual production in 1969 was less than 100 tons of tin metal. In 1969, it was mined and concentrated in Alaska, Colorado, New Mexico, and South Dakota.

California Time Petroleum, Inc. (CTP), in July acquired the Majuba Hill mines in the Antelope Mining District of Pershing County, northwestern Nevada. The property has been mined several times, principally during World War II, as part of the Government's tin-silver stockpiling program. CTP studied the area and was sufficiently encouraged by its findings to conduct a 6-month mineralization and feasibility study, which was undertaken during the second half of 1969. The existence of a reportedly high grade of cassiterite, found very sparingly in North America, had been particularly encouraging to the company, it was reported.

Smelter Production.—Production of primary tin in the United States slowed and finally halted during the year when the Texas City, Tex., tin smelter, the only such facility in the U.S., consumed the last of its stocks of low-grade Bolivian concentrates and did not renew its supply agreement. In all, only 345 long tons was produced during the year as against recent production of about 10 times that amount. The output of tin was 99.96-percent-pure electrolytically refined metal in the form of 85-pound ingots. All output found its way into tinplate. In the fall the plant began processing secondary tin from various residues, drosses, and dusts which it collected from many metal smelting and detinning installations around the country.

The ownership of the smelter was modified during the year. In the spring, the Lenway Chemical & Metallurgical Co. gave way to the Gulf Chemical & Metallurgical Co. as owner-operator of the plant. Associated Metals and Minerals Corp. held the controlling interest in Gulf Chemical & Metallurgical Co.; Fred H. Lenway, and Southern California Chemical Co. were minority owners. The smelter, once a major producer of primary tin, had also turned to the production of tungsten, molybdenum, bismuth, and ferric chloride.

As the volume of tin concentrates from Boliva has dropped in recent years, the volume of tin metal entering the country has increased and has more than displaced the tin formerly smelted in the United States.

SECONDARY TIN

Secondary, or recycled, tin used in the United States in recent years has constituted 28 to 30 percent of the total tin consumption. Likewise, secondary tin used in recent years has been running at about 40 percent of the amounts of primary (new metal) tin consumed. Both of these ratios held true for 1969, indicating a somewhat static situation. On the other hand, although the amount of tin recovered from scrap rose only 280 long tons in 1969, the value of all tin so recovered rose 12 percent, from $75 to $84 million. This marked increase in the value was mostly due to higher world tin prices. Imports of tinplate scrap rose rapidly (35 percent) in 1969 and were up more than 76 percent over those of 1967. Exports of tin scrap rose more than 400 percent in the 1967–69 period, but the volumes exported in 1969 were only one-fourth of those imported. Secondary tin metal, as differentiated from that tin which is recovered as a constituent of an alloy, was again recovered to a greater degree in the United States than in any other country in the free world, but detailed data are not available except for the United States. The International Tin Council estimated that five nations use 80 percent of the free world's secondary tin metal as follows: United States, 35 percent; United Kingdom, 18 percent; West Germany, 12 percent; Austria, 9 percent; and Australia, 6 percent.[2]

Most secondary tin is not recovered as tin metal, but as a constituent of one of several alloys and sometimes in a chemical compound. In 1969, 87 percent of all tin recovered from scrap processed in the United States was thus recovered as an alloy in bronzes, brasses, solders, type metal, Babbitts, etc. Although some tin metal was removed from chemical solutions to reenter the metal markets as pig or ingot, still other tin remained in certain chemical compounds as a constituent.

[2] International Tin Council. Statistical Bulletin, March 1970, p. 41.

Table 2.—Secondary tin recovered from scrap processed at detinning plants in the United States

	1968	1969 [1]
Tinplate scrap treated [2] long tons	778,346	831,713
Tin recovered in the form of—		
Metal long tons	2,447	2,420
Compounds (tin content) long tons	492	560
Total [3] do	2,939	2,980
Weight of tin compounds produced long tons	893	871
Average quantity of tin recovered per long ton of tinplate scrap used pounds	8.46	8.03
Average delivered cost of tinplate scrap per long ton	$21.58	$26.35

[1] 1969 figures not comparable to 1968; 1969 includes one more reporting company.
[2] Tinplate clippings and old tin-coated containers have been combined to avoid disclosing individual company confidential data.
[3] Recovery from tinplate scrap treated only. In addition, detinners recovered 413 long tons (400 tons in 1968) of tin as metal and in compounds from tin-base scrap and residues in 1969.

Table 3.—Tin recovered from all types of scrap processed in the United States, by form of recovery

(Long tons)

Form of recovery	1968	1969
Tin metal:		
At detinning plants	2,815	2,813
At other plants	163	209
Total	2,978	3,022
Bronze and brass:		
From copper-base scrap	11,624	11,513
From lead and tin-base scrap	271	146
Total	11,895	11,659
Solder	4,215	4,645
Type metal	1,604	1,497
Babbitt	838	817
Antimonial lead	400	510
Chemical compounds	524	584
Miscellaneous [1]	41	41
Total	7,622	8,094
Grand total	22,495	22,775
Value (thousands)	$74,631	$83,825

[1] Includes foil, cable lead and terne metal.

CONSUMPTION

After enjoying a 1.6-percent improvement in 1968 (81,961 long tons consumed), combined primary—secondary tin consumption drifted back to 80,790 long tons in 1969. At this level, the combined consumption was almost the same as it had been in 1967 at 80,638 long tons. Taken separately, the consumption of neither primary tin nor of secondary tin shows any appreciable difference in ratio across the 3-year span.

Despite an estimated increase in the metal-can market in 1969 of about 5 percent, the big growth was in the beverage segment, where aluminum dominated. One company estimated that more than 23 billion aluminum or part-aluminum cans (with ring-pull ends) for beverages and food were sold in 1969, which was an increase of 4 billion over 1968 sales. It should be remembered, however, that while shipments from aluminum can manufacturers rose 26.1 percent in 1969, these cans constituted only 8.5 percent of all cans shipped by can manufacturers during the year. Shipments of nonaluminum cans (tinplate and tin-free steel) rose 3.1 percent in 1969.

Table 4.—Shipments of metal cans [1]

(Thousand base boxes)

Type of can	1968 r	1969	1969 change, percent
FOOD AND BEVERAGES			
Fruit and fruit juices	14,251	15,300	+7.4
Vegetables and vegetable juices	24,541	23,367	−4.8
Milk, evaporated and condensed	2,854	2,939	+.3
Other dairy products	731	594	−18.7
Soft drinks	20,055	23,509	+17.2
Beer	30,684	33,416	+8.9
Meat and poultry	3,919	3,859	−.2
Fish and other seafoods	2,833	2,653	−6.4
Coffee	4,117	4,215	+2.4
Lard and shortening	1,696	1,658	−.2
Baby foods	870	1,010	+16.1
Pet foods	6,200	6,169	−.1
All other foods, including soups	13,509	13,847	+2.5
Total or average	126,260	132,536	+5.0
NONFOOD			
Oils	3,166	2,959	−6.4
Paint and varnish	4,387	4,846	+10.5
Antifreeze	923	888	−3.8
Pressure packing (valve type)	4,751	5,123	+7.8
All other nonfood	6,375	6,274	−1.6
Total or average	19,602	20,090	+2.5
BY METAL			
Steel base boxes [2]	136,046	140,297	+3.1
Short tons (thousand)	5,508	5,683	+3.2
Aluminum base boxes	9,816	12,375	+26.1
Short tons (thousand)	209	271	+29.7

r Revised.
[1] Includes tinplate and aluminum cans.
[2] The base box, a unit commonly used in the tinplate industry, equals 31,360 sq. in. of plate or 62,720 sq. in. of total surface area.

Sources: U.S. Department of Commerce; The Malayan Tin Bureau, Washington, D.C.

Table 5.—Stocks, receipts, and consumption of new and old scrap and tin recovered in the United States in 1969

(Long tons)

Type of scrap and class of consumers	Gross weight of scrap					Stocks Dec. 31	Tin recovered		
	Stocks Jan. 1	Receipts	Consumption						
			New	Old	Total		New	Old	Total
Copper-base scrap:									
Secondary smelters:									
Auto radiators (unsweated)	3,058	55,021	-----	55,792	55,792	2,287	-----	2,399	2,399
Brass, composition or red	3,748	84,399	20,595	64,037	84,632	3,515	782	2,381	3,163
Brass, low (silicon bronze)	521	5,573	4,695	920	5,615	479	-----	5	5
Brass, yellow	5,108	65,269	8,085	56,013	64,098	6,279	27	531	558
Bronze	2,547	30,020	5,514	24,776	30,290	2,277	429	1,946	2,375
Low-grade scrap and residues	8,445	52,450	46,978	8,552	55,530	5,365	18	-----	18
Nickel silver	592	5,378	659	4,805	5,464	506	6	38	44
Railroad-car boxes	163	2,193	-----	2,209	2,209	147	-----	105	105
Total	24,182	300,303	86,526	217,104	303,630	20,855	1,262	7,405	8,667
Brass mills:[1]									
Brass, low (silicon bronze)	3,082	42,714	42,714	-----	42,714	3,346	2	-----	2
Brass, yellow	16,904	288,121	288,121	-----	288,121	22,663	410	-----	410
Bronze	652	5,094	5,094	-----	5,094	700	247	-----	247
Mixed alloy scrap	3,134	2,806	2,806	-----	2,806	1,196	-----	-----	-----
Nickel silver	6,298	13,896	13,896	-----	13,896	2,868	-----	-----	-----
Total	30,070	352,631	352,631	-----	352,631	30,773	659	-----	659
Foundries and other plants:[2]									
Auto radiators (unsweated)	870	5,893	-----	6,038	6,038	725	-----	272	272
Brass, composition or red	607	3,970	1,191	2,882	4,073	504	57	137	194
Brass, low (silicon bronze)	29	378	200	190	390	17	-----	-----	-----
Brass, yellow	667	6,300	3,630	2,763	6,393	574	8	20	28
Bronze	471	1,057	333	957	1,290	238	29	76	105
Low-grade scrap and residues	2,477	2,302	1,358	3,009	4,367	412	-----	-----	-----
Nickel silver	4	72	21	48	69	7	-----	-----	-----
Railroad-car boxes	1,176	20,934	-----	21,663	21,663	447	-----	1,029	1,029
Total	6,301	40,906	6,733	37,550	44,283	2,924	94	1,534	1,628
Total tin from copper-base scrap	-----	-----	-----	-----	-----	-----	2,015	8,939	10,954

See footnotes at end of table.

Table 5.—Stocks, receipts, and consumption of new and old scrap and tin recovered in the United States in 1969—Continued

(Long tons)

Type of scrap and class of consumers	Gross weight of scrap						Tin recovered		
	Stocks Jan. 1	Receipts	Consumption			Stocks Dec. 31			
			New	Old	Total		New	Old	Total
Lead-base scrap: Smelters, refiners, and others:									
Babbitt	363	10,872	-----	10,911	10,911	324	-----	529	529
Battery lead plates	r 23,544	479,303	-----	465,101	465,101	37,746	-----	489	489
Drosses and residues	20,946	101,757	102,668	-----	102,668	20,035	2,142	-----	2,142
Solder and tinny lead	202	10,721	-----	10,583	10,583	340	-----	1,848	1,848
Type metal	3,052	28,859	-----	28,983	28,983	2,928	-----	1,377	1,377
Total	r 48,107	631,512	102,668	515,578	618,246	61,373	2,142	4,243	6,385
Tin-base scrap: Smelters, refiners, and others:									
Babbitt	34	315	3	312	315	34	3	260	263
Block-tin pipe	18	199	-----	207	207	10	-----	205	205
Drosses and residues	452	2,836	3,128	-----	3,128	160	1,551	-----	1,551
Pewter	3	25	-----	27	27	1	-----	24	24
Total	507	3,375	3,131	546	3,677	205	1,554	489	2,043
Tinplate scrap: Detinning plants	-----	-----	831,713	-----	831,713	-----	3,393	-----	3,393
Grand total	-----	-----	-----	-----	-----	-----	9,104	13,671	22,775

r Revised.
[1] Brass mill stocks include home scrap; purchased scrap consumption assumed equal to receipts; therefore, lines and totals in brass mill section do not balance.
[2] Omits "machine-shop scrap."

Table 6.—Consumption of primary and secondary tin in the United States

(Long tons)

	1965	1966	1967	1968	1969
Stocks Jan. 1 [1]	32,591	37,277	32,718	30,087	28,152
Net receipts during year:					
Primary	64,302	56,869	56,324	r 59,018	55,125
Secondary	2,530	2,713	2,884	2,101	2,325
Scrap	24,676	23,654	21,492	r 21,919	21,624
Total receipts	91,508	83,236	80,700	r 83,038	79,074
Total available	124,099	120,513	113,418	r 113,125	107,226
Tin consumed in manufactured products:					
Primary	58,505	60,185	57,848	58,859	57,730
Secondary	25,461	25,277	22,790	23,102	23,060
Total	83,966	85,462	80,638	81,961	80,790
Intercompany transactions in scrap	2,856	2,333	2,693	3,012	2,995
Total processed	86,822	87,795	83,331	84,973	83,785
Stocks Dec. 31 (total available less total processed)	37,277	32,718	30,087	r 28,152	23,441

r Revised.
[1] Stocks shown exclude tin in transit or in other warehouses on Jan. 1, as follows: 1965—220 tons; 1966—135 tons; 1967—90 tons; 1968—20 tons; 1969—1,185 tons; and 1970—80 tons.

Table 7.—Tin content of tinplate produced in the United States

Year	Tinplate (hot-dipped)			Tinplate (electrolytic)			Tinplate waste—waste, strips, cobbles, etc., gross weight (short tons)	Total tinplate (all forms)		
	Gross weight (short tons)	Tin content (long tons)	Tin per short ton of plate (pounds)	Gross weight (short tons)	Tin content (long tons)	Tin per short ton of plate (pounds)		Gross weight (short tons)	Tin content[1] (long tons)	Tin per short ton of plate (pounds)
1965	80,645	914	25.4	5,245,642	29,105	12.4	599,400	5,925,687	30,019	11.3
1966	42,290	366	19.4	5,154,550	28,194	12.3	675,558	5,872,398	28,560	10.9
1967	26,612	263	22.2	5,544,987	29,289	11.9	743,689	6,315,288	29,552	10.5
1968	(2)	(2)	(2)	(2)	(2)	(2)	682,792	6,088,345	28,839	10.6
1969	(2)	(2)	(2)	(2)	(2)	(2)	581,594	5,944,758	26,886	10.1

[1] Includes small tonnage of secondary tin and tin acquired in chemicals.
[2] Hot-dipped and electrolytic tinplate have been combined to avoid disclosing individual company confidential data.

Table 8.—Consumers receipts of primary tin, by brands

(Long tons)

Year	Banka	English	Katanga	Straits	Thaisarco	Others	Total
1965	3,112	425	850	38,434	1,950	[1] 19,531	64,302
1966	709	433	95	30,560	9,815	[1] 15,257	56,869
1967	404	704	91	31,980	13,400	[1] 9,745	56,324
1968	305	950	12	r 41,048	11,600	5,103	r 59,018
1969	95	1,275	30	37,350	13,200	3,175	55,125

r Revised.
[1] Includes GSA not reported under specific brands.

Table 9.—Consumption of tin in the United States, by finished products

(Long tons of contained tin)

	1968			1969		
	Primary	Secondary	Total	Primary	Secondary	Total
Alloys (miscellaneous)	442	182	624	477	192	669
Babbitt	2,143	1,440	3,583	2,128	1,378	3,506
Bar tin	970	115	1,085	1,009	34	1,043
Bronze and brass	3,851	11,631	15,482	4,155	12,371	16,526
Chemicals, including tin oxide	1,744	1,423	3,167	1,857	1,250	3,107
Collapsible tubes and foil	1,114	55	1,169	1,114	29	1,143
Pipe and tubing	53	37	90	43	5	48
Solder	14,685	6,685	21,370	14,936	6,347	21,283
Terne metal	295	185	480	207	181	388
Tinning	2,105	55	2,160	2,238	51	2,289
Tinplate [1]	28,839	-----	28,839	26,886	-----	26,886
Tin powder	1,103	53	1,156	1,213	61	1,274
Type metal	108	1,109	1,217	116	994	1,110
White metal [2]	1,330	66	1,396	1,266	118	1,384
Other	77	66	143	85	49	134
Total	58,859	23,102	81,961	57,730	23,060	80,790

[1] Includes secondary pig tin and tin acquired in chemicals.
[2] Includes pewter, britannia metal, and jewelers' metal.

STOCKS

Total tin stocks in the hands of, or on the way to, U.S. industrial users at yearend 1969 were off 14.8 percent from those in 1968. This was the largest annual reduction since December 31, 1964, when tin stocks dropped 18.3 percent below a year earlier. Some of the lowered stocks could be attributed to the skyrocketing prices which, on an annual average, rose by 11 percent in 1969 over the average price of 1968. The biggest cutback was in primary tin in the hands of the tinplate makers, whose stocks of pig tin were down 23.1 percent at the end of 1969 as compared to those at the end of 1968. After the east coast dock strike ended on February 17, 1969, the backed-up volumes of tin afloat to the United States moved rapidly into domestic consuming channels so that by yearend the amount of tin in transit in the Nation was back to normal. Despite reduced inventories for the year, the increase in tin afloat to the United States was apparently due to quick shipments of readily available tin from ports in Southeast Asia when the ITC exports controls were eased in December.

Table 10.—U.S. industry yearend tin stocks

(Long tons)

	1965	1966	1967	1968	1969
Plant raw materials:					
Pig tin:					
Virgin	25,319	20,531	17,044	r 15,975	12,281
Secondary	202	276	283	215	253
In process [1]	11,756	11,911	12,760	r 11,962	10,907
Total	37,277	32,718	r 30,087	r 28,152	23,441
Additional pig tin:					
In transit in United States	135	90	20	1,185	80
Jobbers-importers	[2] 2,000	[3] 1,790	[4] 1,315	1,182	1,210
Afloat to United States	1,875	3,415	4,890	5,390	5,865
Total	4,010	5,295	6,225	7,757	7,155
Grand total	41,287	38,013	r 36,312	r 35,909	30,596

r Revised.
[1] Tin content, including scrap.
[2] Includes GSA as follows: 975 tons end of December 1965, sold but not delivered.
[3] Includes GSA as follows: 1,539 tons end of December 1966, sold but not delivered.
[4] Includes GSA as follows: 428 tons end of December 1967, sold but not delivered.

PRICES

Quoted prices for tin in the world's metal markets are generally quite changeable, and this was particularly true as 1969 drew to a close and tin prices climbed to their highest levels since September 1964. Spot prices on the New York metal market for the first 10 months of 1969 averaged $1.62 per pound against a 1969 average of $1.48, a 1967 average of $1.53, and a 1966 average of $1.64. However, in late October and in November and December, New York spot averages ran between $1.76 and $1.81, and there were a few days during that period when the price hovered above $1.85. Prices finally peaked out at $1.88 on December 4, 1969. A number of reasons were publicly advanced for this unusual situation, which occurred in the presence of a world oversupply of tin and with export controls in effect for producing member countries of the ITC. Among these explanations were that steel company tin buyers had allowed their inventories to decline and then were obliged to buy at spot prices; that Japanese purchasers had bought heavily since July in order to build their inventories as a hedge against higher prices; that a heavy offtake by the Soviet Union and Eastern Europe continued; that unrest in Malaysia was expected to cause curtailment in output, which did not take place; that a Malaysian tin smelter was to be shut down indefinitely because of technical difficulties thereby creating a shortage of Malaysian tin for export and that speculative pressures existed against the ITC's buffer stock. A discussion of the effect of this latter activity will be found in the section devoted to the ITC in the "World Review" section. The ITC advanced its regular December 14 meeting date to December 2 and while assembled, eliminated all export restrictions. Tin prices began to retreat slowly.

The London Metal Exchange quoted tin prices in long tons of 2,240 pounds for the last time in 1969. Beginning with the first business day of 1970, prices were to be quoted in metric tons of 2,204.6 pounds. This made a minor change necessary in the ITC's floor and ceiling-price system. Before conversion to the metric system, the floor had been £1,280 per long ton of tin and the ceiling had been £1,630. After the changeover the floor was to be £1,260 and the ceiling was to be £1,605.

Table 11.—Monthly prices of Straits tin for prompt delivery in New York

(Cents per pound)

Month	1968			1969		
	High	Low	Average	High	Low	Average
January	150.750	144.750	147.875	165.000	160.000	162.500
February	145.750	145.000	145.632	167.500	164.000	165.184
March	147.000	145.250	145.625	162.500	152.500	155.524
April	145.750	144.500	145.214	159.250	154.250	156.810
May	144.500	142.750	143.295	158.000	155.500	156.666
June	142.250	141.250	141.650	160.000	157.500	159.000
July	142.250	141.000	141.477	166.000	159.250	162.000
August	142.500	141.500	141.852	167.250	163.000	165.905
September	152.000	142.500	148.038	167.000	163.750	165.643
October	157.250	148.250	151.071	168.250	163.000	166.707
November	167.250	157.750	162.139	186.750	168.500	175.956
December	167.750	159.000	163.464	187.500	179.500	181.321
Average	167.750	141.000	148.111	187.500	152.500	164.435

Source: American Metal Market.

FOREIGN TRADE

Participation by the United States in the world's tin commerce leans heavily toward imports. Very little tin is mined in this country, and in 1969 there were no tin concentrates imported for smelting because the Nation's only tin smelter suspended its primary tin-smelting activities. Therefore, U.S. needs for tin in 1969 were supplied by imports, mostly as bars and blocks and pigs, and mostly through the Port of New York. Total tin imports for consumption were off 4 percent from the 1968 high. The export controls on the producing member nations of ITC, which were in

Table 12.—U.S. exports and imports for consumption of tin, tinplate, and terneplate in various forms

Year	Ingots, pigs, and bars				Tinplate and terneplate				Tinplate circles, strips, and cobbles		Tinplate scrap	
	Exports		Reexports		Exports		Imports		Exports		Imports	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)
1967	2,050	$6,962	429	$1,412	241,873	$39,781	139,598	$27,112	13,732	$1,485	12,078	$381
1968	3,813	12,734	682	2,267	249,392	41,898	203,269	39,156	13,631	1,405	15,827	541
1969	2,362	8,459	541	1,927	289,852	49,160	268,450	51,339	23,285	2,577	21,293	917

effect throughout the year, appear to have been an important factor in the reduced imports. Malaysia continued to be the prime supplier and furnished 69 percent of all tin imported by the United States. Thailand held second place with 25 percent of U.S. imports and increased shipments during 1969 by 13 percent. Although the United Kingdom does not supply a large amount of U.S. tin requirements, shipments increased 31 percent in 1969. There were two returnees to the U.S. tin market after long absences: South Vietnam and Australia.

Table 13.—U.S. imports for consumption and exports of miscellaneous tin, tin manufactures, and tin compounds

Year	Miscellaneous tin and manufactures				Tin compounds	
	Imports			Exports	Imports	
	Tinfoil, tin powder, flitters, metallics, tin, and manufactures, n.s.p.f.	Dross, skimmings, scrap, residues, and tin alloys, n.s.p.f.		Tin scrap and other tin-bearing material, except tinplate scrap		
	Value (thousands)	Long tons	Value (thousands)	Value (thousands)	Long tons	Value (thousands)
1967	$355	449	$462	$1,490	81	$208
1968	2,742	487	532	2,676	39	81
1969	3,458	948	1,052	4,825	22	71

In the past 5 years consumption of primary tin in the United States has been as much as 25 percent greater than imports. However, by 1969 the spread had narrowed to 2,780 long tons, and consumption was only 5 percent more than imports. A drawdown of stocks in the hands of consumers was an indicated explanation.

Trade was brisk in various tin semimanufactures during the year, and while exports exceeded imports by 8 percent, the value of imported tin semimanufactures (tinplate and terneplate) was higher by about 4 percent. That tin which is a constituent alloy in imports and exports of babbitt, solder, type metal, and bronze is shown in the Yearbook chapters on "Copper" and "Lead". Ferrous scrap exports, including tinplate and terneplate scrap, are not classified separately.

Table 14.—U.S. imports for consumption of tin [1], by countries

Country	1968		1969	
	Long tons	Value (thousands)	Long tons	Value (thousands)
Australia	---	---	330	$1,346
Belgium-Luxembourg	12	$37	31	106
Bolivia	38	100	---	---
Canada	1	11	43	162
India	---	---	25	80
Indonesia	350	1,134	205	745
Malaysia	41,324	131,738	37,926	127,784
Netherlands	871	2,652	267	901
Nigeria	606	1,933	170	590
Portugal	240	776	40	132
Singapore	80	246	20	68
South Africa, Republic of	50	158	---	---
South Vietnam	---	---	50	159
Spain	30	94	24	89
Thailand	12,326	38,199	13,946	46,206
United Kingdom	1,430	4,862	1,873	6,669
Total	57,358	181,940	54,950	185,037

[1] Bars, blocks, pigs, grain, or granulated.

Table 15.—U.S. imports for consumption of tin concentrate, by countries

Country	1967 Long tons (tin content)	1967 Value (thousands)	1968[1] Long tons (tin content)	1968[1] Value (thousands)
Australia	---	---	96	$36
Bolivia	3,254	$7,632	r 2,337	r 5,661
Congo (Kinshasa)	---	---	6	17
United Kingdom	1	3	---	---
Total	3,255	7,635	r 2,439	r 5,714

r Revised.
[1] No transactions in 1969.

WORLD REVIEW

As anticipated under the restraints of the export controls declared by the ITC, world production of tin-in-concentrates was down in 1969, but only by slightly more than 2 percent. Total world output was 222,700 long tons and was still about 2.5 percent above the 1967 level. Malaysia continued to lead all other nations with 32.3 percent of the total mine production. Other major free world producers were Bolivia, 13.5 percent; Thailand, 9.3 percent; Indonesia, 7.7 percent; Nigeria, 3.9 percent; and Australia, 3.5 percent. The estimated mine output of the centrally planned countries constituted about 21.6 percent of the world supply.

Many tin-producing nations have smelting facilities within their borders. Again, Malaysia was the foremost smelter of tin, with 38.6 percent. Thailand, the United Kingdom, Nigeria, Indonesia, and Australia in the free world followed in descending order. Other important smelting countries were the Netherlands and Belgium. The centrally planned countries' total smelter output was estimated to be about 25 percent of the world total.

INTERNATIONAL TIN COUNCIL

Under the terms of the Third International Tin Agreement, the International Tin Council (ITC) held four meetings in 1969, all in the headquarters city of London, England. As is customary, decisions of the Council concerning the first calendar quarter are made at a meeting held toward the end of the preceding year. At such a meeting, held on December 17–19, 1968, the Council declared the first quarter of 1969 to be a continuing period of export control, and the overall amount of tin which could be exported during the period by the six producing member nations was set at 38,000 long tons. The meeting of March 11–13 continued export controls at 38,750 long tons because of the 91-day period involved, invited Australia (not a producing member) to continue to limit its exports, and authorized the Buffer Stock Manager to operate within the so-called middle range, £1,400 to £1,515. There were no new factors injected into the meeting of July 17–19, 1969, but a slightly improved market position influenced a decision to allow an overall export quota for the third quarter of 39,500 long tons. Poland was welcomed into the Council as a consuming member, and the 1,000 consumer-nation votes were adjusted among the member nations accordingly. The year's third meeting, September 16–18, again increased the amount to be produced under a continuing export control, to 41,500 long tons. Although scheduled later, the fourth meeting was held December 2–4. This was done because of the rapidly rising prices for tin in world markets. At this meeting all export controls were lifted effective January 1, 1970. After reviewing the conditions that caused the sudden increase in consumption and apparent shortfall in exports, the ITC also decided that no country exporting more than its permissible amount for the fourth quarter of the year should be penalized. Operations of the Buffer Stock Manager were restricted, and the floor, ceiling, and middle sector prices under which he operated were adjusted to take into account eminent action by the London Metal Exchange to quote tin prices in metric tons. The metric ton quotation price ranges thus established were as follows:

	Pounds sterling per metric ton
Floor price	1,260
Lower sector	1,260 to 1,380
Middle sector	1,380 to 1,490
Upper sector	1,490 to 1,605
Ceiling price	1,605

The Council welcomed Hungary as a consuming member and again adjusted the 1,000 votes allocated to consumer nation members to take this addition into account. At this point there were 20 consuming nations in the Council.

The Council also requested the United Nations to set up a conference to discuss a Fourth International Tin Agreement, and subsequently, the meeting was set for Geneva, Switzerland, to begin on April 13, 1970. The Third Agreement expires June 30, 1971.

In November 1969 the ITC, in cooperation with the Department of Mineral Resources of the Government of Thailand, held the Second Technical Conference on Tin in Bangkok. For further discussion, see the section in this chapter headed "Technology."

Table 16.—World mine production of tin (content of ore), by countries [1]

(Long tons)

Country [2]	1967	1968	1969 p
North America:			
Canada	r 195	160	120
Mexico	588	519	280
United States	W	W	W
South America:			
Argentina	802	701	e 700
Bolivia [3]	26,890	28,945	29,489
Brazil e	r 1,733	1,837	2,560
Peru (recoverable)	r 65	99	82
Europe:			
Czechoslovakia	150	162	140
France	r 461	343	263
Germany, East [4]	1,000	1,000	1,000
Portugal [5]	645	668	440
Spain	r 160	140	121
U.S.S.R. [6] [7]	25,000	26,000	27,000
United Kingdom	1,475	1,798	1,622
Africa: [2]			
Burundi	45	116	83
Cameroon	50	41	29
Congo (Brazzaville)	r 71	24	20
Congo (Kinshasa)	4,664	6,895	6,718
Morocco	10	19	10
Niger	r 55	70	73
Nigeria	9,340	9,644	8,606
Rhodesia, Southern e	r 500	600	500
Rwanda e	r 1,393	1,272	1,150
South Africa, Republic of	1,761	1,837	1,847
South-West Africa, Territory of e	720	730	730
Tanzania	341	286	178
Uganda	111	228	146
Asia:			
Burma [5]	r 475	385	340
China, mainland [6]	20,000	20,000	20,000
Indonesia	13,597	16,563	17,146
Japan	1,166	930	729
Korea, South	40	44	e 40
Laos	533	482	621
Malaysia	72,121	75,069	72,167
Thailand	22,490	23,678	20,786
Oceania: Australia	r 5,586	6,650	7,873
Total [8]	r 214,233	227,935	223,609

e Estimate. p Preliminary. r Revised. W Withheld to avoid disclosing individual company confidential data.
[1] Data derived in part from the Statistical Bulletin of the International Tin Council, London, England.
[2] Tin was also produced in Mozambique during 1967.
[3] COMIBOL production plus exports by small and medium mines and smelters.
[4] Estimate, according to the 56th annual issue of Metal Statistics (Metallgesellschaft) through 1968.
[5] Includes tin content of mixed concentrates.
[6] Estimated smelter production.
[7] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.
[8] Totals are of listed figures only.

Table 17.—World smelter production of tin, by countries [1]

(Long tons)

Country	1967	1968	1969 p
North America:			
Mexico	607	317	139
United States [2]	[3] 3,048	[3] 3,453	345
South America:			
Bolivia	800	-----	48
Brazil	1,415	1,251	2,200
Europe:			
Belgium	4,193	4,799	4,444
Germany:			
East [4]	1,200	1,200	1,200
West	1,622	1,502	2,415
Netherlands	13,739	7,982	5,298
Portugal	592	619	496
Spain	1,823	2,323	2,065
U.S.S.R. e [5]	25,000	26,000	27,000
United Kingdom	23,317	24,933	25,982
Africa:			
Congo (Kinshasa)	1,815	1,892	1,882
Morocco e	12	15	12
Nigeria [6]	9,131	9,778	8,740
Rhodesia, Southern e	r 500	600	500
South Africa, Republic of	r 658	686	738
Asia:			
China, mainland e	20,000	20,000	20,000
Indonesia	1,481	4,885	5,898
Japan	1,666	1,861	1,377
Malaysia	76,328	88,318	88,482
Thailand	26,634	24,662	22,049
Oceania: Australia	3,594	3,692	4,156
Total [7]	r 219,175	230,768	225,466

e Estimate. p Preliminary. r Revised.
[1] Data derived in part from the Statistical Bulletin of the International Tin Council, London, England.
[2] Includes tin content of alloys made directly from ores.
[3] Imports into the United States of tin concentrates (tin content).
[4] Estimate, according to the 56th annual issue of Metal Statistics (Metallgesellschaft) through 1968.
[5] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.
[6] Including a small amount smelted from imported concentrates.
[7] Totals are of listed figures only.

Australia.—Annual production of tin as concentrates doubled in the 6-year period ending with 1969. Increases averaging almost 20 percent per year have been the rule since 1966, and only Australia's cooperation in 1969 with the ITC (of which it was a consumer member but not a producer member) on voluntary restriction of its exports at 4,400 long tons kept output slightly below the average increase. In 1969 Australia produced 7,873 long tons of tin as concentrates, an increase over 1968 production of 18.4 percent. The country's two smelters turned out 4,156 tons of metal during 1969, which amounted to a 12.6-percent annual increase. Japan, the United Kingdom and the Netherlands buy much of Australia's excess tin concentrates and tin metal. Most of the metal, however, is consumed within the country.

To advise the Government and industry on matters relating to tin export, the seven-member Australian Tin Advisory Committee was established late in 1968. At the same time that production began to rise so rapidly, domestic consumption by Australia's major tinplate producer also began to drop, particularly in 1969, as demand for Australian tinplate diminished, in part owing to the competition from aluminum, glass, plastic, etc. The committee was faced with recommending the various mines' shares of the export quota and with finding solutions to Australia's potential tin oversupply problem. By the nature of Australia's smelter capabilities and the complexity of some of her ores, there were vexing problems to be solved.

Plans have been made by Renison Ltd., Australia's largest tin-mining company, to increase ore throughput from 1,000 to 3,000 tons per day. Troubles with complex ores and startup problems in the company's new $9 million plant were solved during the year, and milling recoveries were improved.

Other tin-mining firms were busy in 1969 developing properties, increasing output, consolidating holdings, or seeking diversification into other metals or minerals, especially fluorspar, gold, and rutile. Australia's tin-mining industry was widely spread across the nation but was concentrated in Tasmania, Queensland, and New South Wales.

Bolivia.—Bolivia retained second place among world tin producers in 1969. Production of tin-in-concentrates rose about 2 percent, continuing a 6-year trend.

Corporación Minera de Bolivia (COMIBOL), the State-owned mining company, continued to hold an important position in Bolivia's tin-mining structure. On July 1, 1969, COMIBOL had nearly 21,000 workers in underground mines and in mill and other surface operations, plus educational and medical personnel.

At the Catavi tin mine, where a United Nations Development Program in cooperation with the Mining and Metallurgical Research Institute has developed a flotation process for recovering tin ore from colloidally suspended tailings, further work was underway to improve a volatilization process for treating low-grade tin concentrates. Encouraged by the results, COMIBOL planned to move ahead with a central treatment plant for these fines.

At midyear Bolivia sought a $17 million loan from the Inter-American Development Bank to finance a $20 million volatilization plant. The project called for a cassiterite flotation plant near the Vinto tin-smelting complex, which was under construction.

Burma.—Tin and tungsten are exploited together in Burma, and until the late 1950's production was between 2,000 and 3,000 tons of tin metal annually. In 1968 it was 924 tons; in 1969 it was at a new low, 626 tons. All mining was done by very small interests, and it was required that ore be sold to the Government. In December the Burmese Mineral Development Corporation signed a contract with a Soviet firm, Tyazhpromexport, for the survey and rehabilitation of the once highly productive Mawchi mines, destroyed during World War II. At one time this was the second largest tin-tungsten operation in the world. Plans call for operating as soon as possible at about two-thirds the output of 1940–41, or about 100 tons of concentrated ore per month.

Malaysia.—Tin mining is Malaysia's second most important industry. The rising tide of Malaysia's tin output was reversed in 1969, ending a trend which had begun in 1961. The setback was neither severe nor unexpected in light of the full year's imposition of export controls by ITC. At 72,167 long tons of tin in concentrates, the production was about the same as that of 1967, after peaking at 75,069 long tons in 1968. There were 955 gravel pumps in operation at yearend 1969 against 994 one year earlier. Sixty-five dredges, the same number as in 1968, were working as 1969 came to a close. Gravel-pump mines produced 54.82 percent of the ore (down from 57.82 percent in 1968), while dredging produced 33.15 percent in 1969 against 30.84 percent in 1968. Malaysian gravel-pump operations are generally small and very sensitive to the price of tin, while dredging is less affected by short-term price fluctuations. Marginal mines also closed during the periods of export controls. The number of dredges, on the other hand, has not changed much in about 6 years, but the newer dredges are capable of handling larger volumes of gravel, leaner pay, and deeper digging depths. Four such plants have gone into production in recent years, and two more are nearing completion. The amount of capital required for these huge dredges necessitates substantially good long term prices for the tin. Large open pit operations employing heavy earthmoving equipment also require high capital outlay and can continue only when long term prices remain favorable.

It was reported that richer Malaysian tin reserves are being progressively exhausted and that lower grade deposits, while extensive, require greater capital outlay. Exploration, using highly complex geophysical and geochemical methods, continued to turn up new and sometimes deeper reserves.

In May and June there were civil disturbances in Malaysia which were most active in the vicinity of Kuala Lumpur and curfews were imposed. The violence was of sufficient magnitude that all Malaysian tin miners were idle for about 2 weeks. The Penang tin market closed briefly. Severe effects upon tin mining were expected, but curfew passes were issued to tin workers in the vicinity of Kuala Lumpur, and the feared shortfall failed to materialize by yearend.

High-grade pockets of cassiterite were being mined with increasing frequency in Malaysia during the year. Most of these are found beneath old placer mine locations and can be mined by open pit methods. Most of the deposits were found with modern diamond-drilling methods. Rubber-tired front-end loading tractors are used to move broken rock. For many years no attempts were made even to sample these bedrock deposits.

Malaysia's tin is exported as metal smelted in the region. Forty-two percent went to the United States in 1969, and 28 percent went to Japan. Canada, Italy, and the Netherlands were other important customers. The U.S.S.R. took 3,360 long tons, about 3.7 percent of Malaysia's total tin exports.

Nigeria.—Nigerian tin production declined in 1969, and many were of the opinion that output would never again equal the 9,700 tons produced in 1968. A shortage of labor was considered to be a minor contributing factor, but depletion of known shallow ore deposits and the lack of investor funds to buy more sophisticated equipment to mine deeper ores were the major impediments. During the summer Nigeria announced an underage in her allowable tin exports under ITC export controls of 600 tons, and the Council thereupon reallocated this underage to Indonesia (400 long tons), Thailand (100 tons), and Bolivia (100 tons).

South Africa, Republic of.—The Minister of Economics Affairs officially opened a new electrolytic tinning line at the Vanderbijlpark plant of Iscor on May 22, 1969. The line will eventually have a capacity of 300,000 tons per year of tinplate, which will supply all South African requirements well into the 1970's. The nation consistently produces between 1,600 and 1,850 long tons of tin metal annually.

U.S.S.R.—The U.S.S.R. contracted with Head Wrightson & Co., Ltd. a British firm, to build an electrolytic tinplate plant at Magnitogorsk in the Southern Ural Mountains. The value of the contract was reported to be $10 million. The cost included design, supply and supervision of erection, and commissioning of the plant. The equipment will be fabricated at Head Wrightson's Middlesborough, England, plant. The thoroughly modern electrolytic plant will be able to put a coating of tin on both sides of a strip of steel at a rate of up to 1,750 feet per minute. The tin thickness can be the same or different on opposite sides of the tinplate stock.

According to London sources, a third tin deposit has been found in the Soviet Far East in the general vicinity of Amur Oblast. Although nothing has been released on reserves, the deposit is reported to be "very promising" with ores of "high grade." It is located fairly close to an existing rail line. Other nearby tin operations are at Khingan, Jewish Autonomous Region Oblast' of Khabarovsk Kray close to the Amur Oblast' border and the recently activated Solnechnyy mining and concentrating combine, also in Khabarovsk Kray. All three operations are open pit mines.

United Kingdom.—Two old mines, which have survived from the days when Cornwall tin mines were turning out as much as 11,000 tons of metal per year, were focal points for a resurgence of tin-mining activities in 1969.[3] South Crofty, near Camborne, produced 1,148 tons of 70 percent tin concentrates in 1968. A $1.6 million expansion and modernization program was underway during 1969 which was aimed at a considerable increase in production within 2 years. At Pendeen, on Cornwall's Atlantic coast, the Geevor mine, which was active in the 19th century, was flooded out in 1932 by sea water in a working 2,000 feet out beneath the sea. The breach was recently sealed,[4] and new underground exploration and development has begun. Provisionally, the Geevor's owners hoped to market 970 tons of tin in concentrates in 1969. Dried and bagged concentrates from both mines are shipped by truck to the Bootle, Lancashire, smelters of Williams, Harvey Ltd.

More prospecting was proceeding in 1969 around other old operations such as near Truro. Mill tailings, even in estuaries, were being seriously evaluated.

Consolidated Gold Fields of South Africa Ltd. announced during the spring that it would open a new tin mine called The Janes about 3 miles from Truro.[5] A concentrator, especially designed to allow for future expansion, was also contracted for at Truro.

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[3] Engineering and Mining Journal. Rebuilding Cornwall's Tin Industry. V. 170, No. 11, November 1969, pp. 82–87.

[4] Institution of Mining and Metallurgy. Sealing of the Undersea Breach Into Levant Tin Mine, Cornwall. Transactions, v. 78, Sec. A, No. 752, July 1969, pp. A65–A89.

[5] South African Mining Engineering Journal. Consolidated Gold Fields' R 10—Million Cornish Tin Mine. V. 80, No. 3990, July 25, 1969, pp. 183–187.

TECHNOLOGY

The Second Technical Conference on Tin, under the auspices of the ITC and the host Government of Thailand and its Department of Mineral Resources, was held in Bangkok from November 18 through 22, 1969. Over 60 papers were delivered. Many discussed technical problems in Malaysia, Thailand, and Indonesia. Geology and prospecting for tin in Brazil, England, Czechoslovakia, Australia, and Nigeria were covered. A major group of papers dealt with mining and recovery. Finally, the work of the various geological surveys department of mines, and of ITC itself were treated and headlined by a discussion of the role of research and development in the field of tin consumption by Dr. W. E. Hoare, Director, Tin Research Institute, London. The meeting was followed by a week-long field trip to Southern Thailand to see tin mining and smelting and to study the geology of the area.

In June 1969 the Japan Tin Centre, a cooperative effort of the International Tin Research Council and the Japanese Mining Industry Association was opened in Tokyo. As in many other developed countries, Japan uses tin for cans, solder, and organotin compounds. The new Tin Centre's broad technical services will be available to all and are backed by the resources of the Tin Research Institute and the Tin Council's offices around the World.

Tin additions to both flake and nodular graphite irons were said to have a useful place in contemporary foundry technology. The practice of adding tin to control the structure of cast iron has rapidly expanded, and certain foundries have been able to make castings that were impossible without tin additions.[6]

Investigations aimed at developing an economical, heat-treatable, copper-and-tin-based bronze alloy with commercially attractive properties were reported. The new tin-bronze age-hardening alloy contains 94 percent copper, 5 percent tin, and 1 percent magnesium.[7]

Several publications by the Bureau of Mines with respect to the technical aspects of tin were released during the year.[8]

In the rapidly developing field of powder metallurgy, the use of tin was under constant investigation and application. The addition of tin in the sintering of iron powder, in combination with copper, and the effective results obtained were reported in September 1969.[9]

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[6] Thwaites, C. J. Tin in Cast Iron. Foundry, v. 97, No. 10, October 1969, pp. 58–61.
———. The Development of the Use of Tin to Improve the Quality of Iron Castings. Iron and Steel, v. 42, No. 3, June 1969, pp. 201–208.

[7] Phillips, D. L., and P. A. Ainsworth. An Age-Hardening Tin-Magnesium Bronze. Metall (Germany), v. 8, August 1969, pp. 804–807. Available in English from Tin Research Institute, Inc., 483 West 6th Ave., Columbus, Ohio 43201.

[8] Chambers, D. H., and A. W. Maynard. High-Purity Zinc and Tin by Amalgam Electrorefining. BuMines Rept. of Inv. 7313, 1969, 10 pp.
Higley, L. W., J. L. Holman, E. R. Cole, and H. Kenworthy. Effect of Lowering the Tin Content of Secondary Red Brass. BuMines Tech. Prog. Rept. 18, 1969, 11 pp.
Schwanke, Alfred E., and Wilber L. Falke. Surface Tension and Density of Liquid Tin. BuMines Rept. of Inv. 7372, 1969, 9 pp.

[9] Barua, S. K., P. A. Ainsworth, and D. A. Robins. Sintering of Iron Powder Compacts With the Simultaneous Additions of Tin and Copper. Metallurgia, v. 80, No. 479, September 1969, pp. 87–91. Also available from Tin Research Institute, 483 West 6th Ave., Columbus, Ohio 43201.

Titanium

By John W. Cole [1]

Strong demand for metal and nonmetal titanium products caused record consumption of rutile and ilmenite concentrates. Use of metal-mill products increased in both the aerospace and nonaerospace industries, but the aerospace industries continued to use 90 percent of the total. The titanium pigments produced contained a record 652,000 tons of titanium dioxide. A total of 256,000 tons of welding rods, containing titaniferous materials in the coatings, was produced, down from 272,000 tons in 1968.

Legislation and Government Programs.—There were no sales of titanium sponge metal or of rutile concentrates by the General Services Administration (GSA) from the Defense Production Act (DPA) inventories. However, 326 tons of nonspecification-grade sponge metal was released to a contractor, who will return a like quantity of specification-grade material. The quantity of rutile in the stockpile was increased 3,310 tons through barter of excess stockpile materials.

Total stockpile inventories of sponge metal increased 1,006 tons to 30,738 tons at yearend. The objective was lowered from 37,500 to 33,500 tons in December. Total stockpile inventories of rutile at yearend were 50,927 tons. The objective was lowered from 200,000 to 100,000 tons in December.

Government exploration assistance for rutile, available through the Office of Minerals Exploration, U.S. Geological Survey, remained at 75 percent of the approved cost of exploration. The Department of the Interior, acting under authorization by the Office of Emergency Preparedness (OEP), continued its investigation of potential domestic sources of rutile. The Bureau of Mines continued investigating the technical and economic factors involved in the production of synthetic rutile.

[1] Physical scientist, Division of Nonferrous Metals.

Table 1.—Salient titanium statistics

	1965	1966	1967	1968	1969
United States:					
Ilmenite concentrate:					
Mine shipments........short tons..	948,832	868,436	882,414	960,118	893,034
Value..............thousands..	$18,058	$17,608	$18,519	$19,484	$18,636
Imports.............short tons..	166,315	186,539	207,906	246,109	316,574
Consumption..............do....	923,304	962,706	919,206	959,558	1,003,230
Titanium slag: Consumption.....do....	148,184	132,233	122,926	142,168	138,553
Rutile concentrate: [1]					
Imports....................do....	151,748	151,482	167,100	174,366	204,907
Consumption...............do....	117,376	135,883	153,457	160,273	185,702
Sponge metal:					
Imports for consumption....do....	3,134	5,225	7,144	3,443	6,332
Consumption...............do....	12,105	19,677	20,062	14,237	20,124
Price: Dec. 31, per pound..........	$1.32	$1.32	$1.32	$1.32	$1.32
World: Production:					
Ilmenite concentrate.......short tons..	2,705,425	2,886,937	3,036,517	3,261,684	3,530,745
Rutile concentrate..............do....	245,259	275,198	310,752	338,547	414,429

[1] Mine shipments withheld to avoid disclosing individual company confidential data.

DOMESTIC PRODUCTION

Concentrates.—Production of ilmenite concentrate was 931,000 tons, 5 percent less than that in 1968. Producers were E. I. du Pont de Nemours & Co., Inc., Starke and Highland, Fla.; Humphreys Mining Co., Folkston, Ga.; SCM Corporation, Glidden-Durkee Division, Lakehurst, N.J.; National Lead Co., Tahawus, N.Y.; and American Cyanamid Co., Piney River, Va. No domestic production of rutile concentrate was reported.

Metal.—Production of titanium sponge was 33 percent higher than that in 1968. The producing companies were Titanium Metals Corporation of America (TMCA), Henderson, Nev., owned by National Lead Co. and Allegheny Ludlum Steel Corp.; Reactive Metals, Inc., Ashtabula, Ohio, owned by National Distillers & Chemical Corp. and United States Steel Corp.; and Oregon Metallurgical Corp., Albany, Oreg., partly owned by Armco Steel Corp. and Ladish Co. The sponge-production capacity of the three plants was about 20,000 tons per year.

Production of titanium ingot, including alloys, was 28,500 tons, an increase of 48 percent over 1968 production. Nine companies that produced titanium ingot from sponge metal and scrap are as follows:

Company	*Plant location*
Crucible Steel Company of America	Midland, Pa.
G. O. Carlson, Inc	Niles, Ohio
Harvey Aluminum, Inc	Torrance, Calif.
Howmet Corp	Whitehall, Mich.
Oregon Metallurigal Corp	Albany, Oreg.
Reactive Metals, Inc	Ashtabula, Ohio
Teledyne Titanium, Inc	Monroe, N.C.
Titanium Metals Corporation of America	Henderson, Nev.
Titanium West, Inc	Reno, Nevada

Pigment.—The gross weight of titanium dioxide (TiO_2) pigment produced domestically was 1 percent greater than that of 1968, with the average TiO_2 content of the rutile-, anatase-, and composite-type pigments being slightly higher than in the previous year. Rutile-type pigment, produced by all eight pigment companies, again was about 60 percent of the total on a TiO_2 content basis. Most of the remainder was anatase-type pigment, produced by five companies, and composite-type produced by one company.

Companies producing titanium pigments and plant locations are as follows: American Cyanamid Co., Piney River, Va., and Savannah, Ga.; American Potash & Chemical Corp., a subsidiary of Kerr McGee Corp., Hamilton, Miss.; Cabot Titania, Inc., wholly owned subsidiary of Cabot Corp., Ashtabula, Ohio; E. I du Pont de Nemours & Co., Inc., Edge Moor, Del., Antioch, Calif., and New Johnsonville, Tenn.; National Lead Co., St. Louis, Mo., and Sayreville, N.J.; New Jersey Zinc Co., controlled by Gulf & Western Industries, Gloucester, N.J.; PPG Industries, Inc., Natrium, W. Va.; and SCM, Glidden-Durkee Division, Baltimore, Md.

Welding Rod Coating.—A total of 256,000 tons of welding rods, containing titaniferous materials in their coatings, was produced. Of the total output 51 percent contained rutile; 16 percent, ilmenite; 18 percent, a mixture of rutile and manufactured titanium dioxide; 9 percent, manufactured titanium dioxide; and 6 percent, miscellaneous mixtures and titanium slag.

Table 2.—Production and mine shipments of titanium concentrates[1] from domestic ores in the United States

Year	Production (short tons, gross weight)	Shipments: Short tons (gross weight)	Shipments: TiO_2 content (short tons)	Shipments: Value (thousands)
1965	969,459	948,832	494,353	$18,058
1966	965,378	868,436	451,132	17,608
1967	935,091	882,414	463,286	18,519
1968	978,509	960,118	506,260	19,484
1969	931,247	893,034	480,918	18,636

[1] Includes a mixed product containing rutile, leucoxene, and altered ilmenite. Production of rutile concentrate in the United States was discontinued in 1968; data for previous years are withheld to avoid disclosing individual company confidential data.

Table 3.—Titanium-metal data

(Short tons)

	1965	1966	1967	1968	1969
Sponge metal:					
Imports for consumption	3,134	5,225	7,144	3,443	6,332
Industry stocks	900	800	2,900	2,600	1,900
Government stocks (DPA inventories)	22,339	21,416	20,711	20,711	20,385
Consumption	12,105	19,677	20,062	14,237	20,124
Scrap-metal consumption	3,303	4,857	5,822	4,701	7,566
Ingot: [1]					
Production	15,294	24,253	25,960	19,234	28,490
Consumption	14,694	22,317	25,386	18,323	27,082
Net shipments of mill products [2]	9,358	13,996	13,634	11,900	15,940

[1] Includes alloy constituents.

[2] Bureau of the Census and Business and Defense Services Administration, Current Industrial Reports Series BDSAF-263. Net shipments are derived by subtracting the sum of producers' receipts of each mill shape from the industry's gross shipments of that shape.

Table 4.—Titanium-pigment data

(TiO_2 content)

Year	Production (short tons)	Shipments [1]	
		Quantity (short tons)	Value, f.o.b. (thousands)
1965	576,700	573,091	$298,368
1966	594,486	593,933	303,902
1967	589,449	582,325	297,283
1968	r 623,691	632,106	323,216
1969	p 651,628	NA	NA

p Preliminary. r Revised. NA Not available.

[1] Includes interplant transfers.

Source: Bureau of the Census.

CONSUMPTION AND USES

Metal.—Consumption of titanium sponge was 20,100 tons, up 41 percent from that of 1968. Shipments of titanium mill products were a record 16,000 tons, up 34 percent from 1968 shipments.

Although demand for titanium is increasing for nonaerospace uses, aerospace applications used approximately 90 percent of the metal consumed, and demand for use in the Boeing 747, Lockheed L–1011, and McDonnell-Douglas DC–10 consumed approximately 50 percent of mill products in 1969.

In nonaerospace applications, titanium was used in the chemical industry, where its strength and corrosion resistance are dominant characteristics. A new cathodic protection system developed by Engelhard Minerals and Chemical Corp. uses platinum-coated titanium electrodes to impress a current to inhibit corrosion of steel piping systems on oil tankers and other marine vessels.

Battelle Memorial Institute proposed a 2-year research program to investigate the engineering-design properties of Nitinol–55, a nickel-titanium alloy known as the "alloy with a memory." Although the unique characteristic of this material to return to an earlier configuration under a slight temperature change was discovered nearly 10 years ago, few uses have been found.

Table 5.—Consumption of titanium concentrates in the United States, by products

(Short tons)

Year and product	Ilmenite [1] Gross weight	Ilmenite [1] TiO_2 content (estimated)	Titanium slag Gross weight	Titanium slag TiO_2 content (estimated)	Rutile Gross weight	Rutile TiO_2 content (estimated)
1965	923,304	483,002	148,184	105,483	117,376	113,017
1966	962,706	507,379	132,233	93,683	135,883	130,191
1967	919,206	488,236	122,926	86,945	153,457	147,158
1968:						
Pigments	957,114	509,013	142,168	100,591	112,856	108,544
Titanium metal	-------	-------	-------	-------	(2)	(2)
Welding-rod coatings	(2)	(2)	-------	-------	21,414	20,409
Alloys and carbide	2,097	1,133	(3)	(3)	728	659
Ceramics	(2)	(2)	-------	-------	(4)	(4)
Glass fibers	-------	-------	-------	-------	(2)	(2)
Miscellaneous	347	207	-------	-------	25,275	23,988
Total	959,558	510,353	142,168	100,591	160,273	153,600
1969:						
Pigments	1,000,874	540,403	138,553	98,075	129,668	124,811
Titanium metal	-------	-------	-------	-------	(2)	(2)
Welding-rod coatings	343	208	(3)	(3)	22,001	20,987
Alloys and carbide	1,963	1,106	(3)	(3)	(3)	(3)
Ceramics	(2)	(2)	-------	-------	472	451
Glass fibers	-------	-------	-------	-------	(2)	(2)
Miscellaneous	50	30	-------	-------	33,561	31,934
Total	1,003,230	541,747	138,553	98,075	185,702	178,183

[1] Includes a mixed product containing rutile, leucoxene, and altered ilmenite.
[2] Included with "miscellaneous" to avoid disclosing individual company confidential data.
[3] Included with "pigments" to avoid disclosing individual company confidential data.
[4] Included with "alloys and carbide" to avoid disclosing individual company confidential data.

Table 6.—Distribution of titanium-pigment shipments, by industries

(Percent)

Industry	1965	1966	1967	1968	1969
Distribution by gross weight:					
Paints, varnishes and lacquers	62.9	61.6	61.9	60.7	58.5
Paper	12.6	13.9	14.6	14.9	17.0
Floor coverings	3.6	3.4	2.7	2.4	2.3
Rubber	4.2	4.2	2.8	2.9	2.6
Coated fabrics and textiles (oil cloth, shade cloth, artificial leather, etc.)	1.4	1.4	1.4	1.4	1.3
Printing ink	1.8	1.9	2.0	2.1	2.3
Roofing granules	1.3	1.2	1.1	.8	.9
Ceramics	1.5	1.7	1.9	2.1	2.0
Plastics (except floor covering and vinyl-coated fabrics and textiles)	3.6	3.8	5.1	6.0	6.2
Other (including export)	7.1	6.9	6.5	6.7	6.9
Total	100.0	100.0	100.0	100.0	100.0
Distribution by titanium dioxide content:					
Paints, varnishes, and lacquers	57.4	56.4	57.5	56.5	54.3
Paper	15.2	16.7	17.2	17.4	19.5
Floor coverings	4.3	3.9	3.1	2.7	2.6
Rubber	5.0	4.9	3.2	3.3	3.0
Coated fabrics and textiles (oil cloth, shade cloth, artificial leather, etc.)	1.6	1.6	1.6	1.6	1.4
Printing ink	2.1	2.2	2.3	2.4	2.6
Roofing granules	1.7	1.5	1.4	1.0	1.1
Ceramics	1.8	2.1	2.2	2.4	2.4
Plastics (except floor covering and vinyl-coated fabrics and textiles)	4.3	4.6	6.0	6.9	7.1
Other (including export)	6.6	6.1	5.5	5.8	6.0
Total	100.0	100.0	100.0	100.0	100.0

STOCKS

Industry stocks of rutile decreased 15 percent to 184,000 tons, equivalent to about 1 year's supply at the 1969 consumption rate. Ilmenite inventories decreased 5 percent, and stocks of titanium slag decreased 13 percent. Yearend sponge-metal stocks of producers and melters were 1,908 tons, 27 percent less than beginning stocks. Titanium scrap held by melters and fabricators was 4,727 tons compared with 4,434 tons at the end of 1968. Stocks of composite and pure titanium dioxide held by producers at yearend were 100,850 tons, up 7 percent from the first of the year.

Table 7.—Stocks of titanium concentrates in the United States, Dec. 31

(Short tons)

Year and stock	Ilmenite		Titanium slag		Rutile	
	Gross weight	TiO_2 content (estimated)	Gross weight	TiO_2 content (estimated)	Gross weight	TiO_2 content (estimated)
1968:						
Mine	(1)	(1)	-------	-------	(1)	(1)
Distributor	r 209,013	r 130,737	-------	-------	17,142	16,454
Consumer	682,000	373,350	119,746	84,743	201,375	193,388
Total	r 891,013	r 504,087	119,746	84,743	218,517	209,842
1969:						
Mine	(1)	(1)	-------	-------	-------	-------
Distributor	247,229	146,223	(2)	(2)	(2)	(2)
Consumer	600,010	330,515	103,733	73,550	184,086	177,243
Total	847,239	476,738	103,733	73,550	184,086	177,243

r Revised.
1 Included with "distributor" to avoid disclosing individual company confidential data.
2 Included with "consumer" to avoid disclosing individual company confidential data.

PRICES

Concentrates.—Prices for ilmenite remained the same as those in 1968. Domestic ilmenite with 60 percent titanium dioxide (TiO_2) content was quoted at $30 to $35 per short ton. Imported ilmenite containing 54 percent TiO_2, f.o.b. Atlantic ports, was quoted at $20 to $21 per long ton of contained TiO_2. The quoted price for imported rutile (96 percent TiO_2) rose in several steps from $125 to $160 in August, where it remained at yearend. Titanium slag (70 percent TiO_2) was raised to $45 per long ton.

Manufactured Titanium Dioxide.—The basic price of anatase grades of titanium dioxide pigment was raised 1 cent per pound. Quotations on other pigment grades remained the same. Yearend quotations from Oil, Paint and Drug Reporter were as follows:

	Price per pound
Anatase, chalk-resistant, regular and ceramic:	
Carlots, delivered	$0.265
Less than carlots, delivered	.270
Rutile, nonchalking, bags:	
Carlots, 20 tons, delivered East	.285
Less than carlots, delivered East	.295
Titanium pigment, calcium-rutile base:	
30 percent TiO_2, bags:	
Carlots, 20 tons, delivered	.09375
Less than carlots, delivered	.09875
50 percent TiO_2, bags:	
Carlots, 20 tons, delivered	.14375
Less than carlots, delivered	.14875

FOREIGN TRADE

Metal and alloy sponge and scrap exports increased slightly from those in 1968. Intermediate mill shapes and mill-product exports increased 44 percent in quantity and 22 percent in value. The United Kingdom received 64 percent of the metal and alloy sponge and scrap. Canada was the recipient of 52 percent of the intermediate mill shapes and wrought alloys; West Germany received 28 percent.

U.S. exports of ores and concentrates decreased from 4,200 tons in 1968 to 1,400 tons in 1969. Exports of dioxide and pigments decreased 19 percent.

U.S. imports for consumption of titanium metal increased 84 percent in quantity and 60 percent in value. Over 70 percent of imports originated in Japan, 13 percent came from the U.S.S.R., and 10 percent came from the United Kingdom. The value per pound of imports was $0.82 compared with $0.92 in 1968 and $0.89 per pound in 1967. Imports for consumption of wrought titanium were 273 tons, principally from Canada and Japan.

Imports of titanium slag from Canada increased 43 percent, and imports of ilmenite from Australia decreased 37 percent from those in 1968. Imports of rutile from Australia increased 3 percent. Imports of rutile from Sierra Leone were 26,400 tons, up from 1,300 tons in 1968, when dredging difficulties interfered with production.

Table 8.—U.S. exports of titanium products, by classes

Year	Ores and concentrates		Metal and alloy sponge and scrap		Intermediate mill shapes and mill products, n.e.c.		Dioxide and pigments	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1967	3,027	$167	1,429	$1,703	1,812	$13,366	25,852	$7,165
1968	4,238	276	2,756	1,748	1,228	7,575	30,188	8,227
1969	1,424	183	2,802	1,936	1,773	9,206	24,507	7,510

Table 9.—U.S. imports for consumption of titanium concentrates, by countries

Country	1967		1968		1969	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Ilmenite:						
Australia	60,689	$524	45,196	$380	28,524	$371
Canada [1]	147,216	4,621	200,913	4,787	288,050	3,536
Other countries	1	(2)	-------	------	-------	------
Total	207,906	5,145	246,109	5,167	316,574	3,907
Rutile:						
Australia	153,768	11,029	171,847	12,508	176,550	14,273
Sierra Leone	13,129	898	1,348	91	26,422	1,793
Other countries	203	16	1,171	54	1,935	141
Total	167,100	11,943	174,366	12,653	204,907	16,207

[1] Chiefly titanium slag averaging about 70 percent TiO_2.
[2] Less than ½ unit.

Table 10.—U.S. imports for consumption of unwrought titanium and waste and scrap

Country	1967		1968		1969	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Canada	168	$595	238	$675	214	$138
France	1	17	1	2	------	------
Germany, West	3	27	(1)	3	13	9
Italy	15	23	------	------	------	------
Japan	4,585	8,309	2,466	4,574	4,591	7,611
Netherlands	26	53	------	------	23	6
Sweden	11	19	------	------	------	------
U.S.S.R.	1,313	1,862	421	550	836	1,317
United Kingdom	1,022	1,833	317	548	655	1,267
Total	7,144	12,738	3,443	6,352	6,332	10,348

[1] Less than ½ unit.

WORLD REVIEW

Australia.—Exploration and development activity continued at a high level in beach sand heavy mineral deposits on both the east and west coasts. Cable (1956) Ltd. was reported to have discovered a commercially viable deposit at Lake Logue about 200 miles north of Perth. Offshore work continued on subsea deposits adjacent to southern Queensland and northern New South Wales.

Consolidated Rutile Ltd. is believed to have increased its reserves of rutile to nearly 1 million tons on North Stadbroke Island and is planning to produce 38,000 tons of rutile and 32,000 tons of zircon annually.

Western Titanium N.L. and the Commonwealth Scientific and Industrial Organization (CSIRO) continued pilot plant production of synthetic rutile from ilmenite. Several thousand tons containing over 90 percent titanium dioxide has been produced and accepted by overseas pigment manufacturers accustomed to using rutile. Western Titanium plans to build an $8 to $10 million plant with a synthetic rutile capacity of 100,000 tons per year.

Table 11.—World production of titanium concentrates (ilmenite and rutile) by countries

(Short tons)

Country [1]	1967	1968	1969 [p]
Ilmenite:			
Australia (shipments) [2]	[r] 610,303	622,681	785,065
Brazil [3]	16,498	19,710	19,842
Canada (titanium slag) [4]	602,455	672,867	749,281
Ceylon	58,573	82,238	91,328
Finland	139,883	154,323	152,339
India	45,840	64,733	56,708
Japan (titanium slag)	6,293	4,624	5,617
Malagasy Republic	2,047	---------	---------
Malaysia (exports)	100,096	138,698	143,300
Norway	[r] 469,096	471,083	540,903
Portugal	590	610	220
Sierra Leone	7,716	8,025	10,803
Spain	[r] 40,865	43,583	44,092
United Arab Republic	1,171	NA	NA
United States [5]	935,091	978,509	931,247
Total [6]	[r] 3,036,517	3,261,684	3,530,745
Rutile: [7]			
Australia	[r] 297,376	323,608	396,080
Brazil	[r] 321	126	110
Ceylon	---------	1,270	1,213
India	2,798	2,961	2,751
Sierra Leone	[r] 10,251	10,582	14,275
United Arab Republic	6	NA	NA
Total [6]	[r] 310,752	338,547	414,429

[p] Preliminary. [r] Revised. NA Not available.
[1] Titanium concentrates are produced in U.S.S.R., but no reliable figures are available.
[2] Includes small quantities of leucoxene concentrates.
[3] Production—Comissao Nacional de Energia Nuclear only.
[4] Containing approximately 70–72 percent TiO_2.
[5] Includes a mixed product containing ilmenite, leucoxene, and rutile.
[6] Total is of listed figures only.
[7] Production for the United States withheld to avoid disclosing individual company confidential data.

Table 12.—Australia: Exports of ilmente and rutile concentrates, by countries

(Short tons)

Destination	1967	1968	1969 p
ILMENITE			
France	90,674	134,635	123,895
Germany, West	(1)	2,852	56,741
Japan	69,272	75,501	127,369
Spain	67	11,421	(1)
United Kingdom	186,704	173,144	258,665
United States	54,451	33,599	41,091
Other countries	29,248	12,268	26,741
Total	430,416	443,420	634,502
RUTILE			
Canada	5,419	26,649	2,993
France	8,732	9,668	6,061
Germany, West	11,443	7,865	10,995
Japan	32,913	34,287	32,331
Netherlands	21,034	18,325	24,363
United Kingdom	17,862	18,572	34,773
United States	146,021	164,528	168,386
Other countries	46,422	39,300	55,105
Total	289,846	319,194	335,007

p Preliminary.
1 Included with "Other countries."

France.—Sociètè des Fabriques de Produits Chimiques de Thann et Mulhouse announced plans to increase production capacity at its titanium dioxide plants at Thann and Le Havre. The capacity of the plant at Thann will be increased from 14,000 to 18,000 tons per year, and the Le Havre plant will be increased from 36,000 to 56,000 tons per year. Both plants will continue to employ the sulfate process.

British Titan Product's wholly owned French subsidiary Trioxide S.A. announced plans to double the capacity of its sulfate-process titanium dioxide plant at Calais to 60,000 tons per year in 1971.

Germany, West.—The new titanium dioxide plant at Nordenham on the left bank of the Weser estuary was inaugurated in July. The plant was erected by Titangesellschaft m.b.H. of Leverkusen, a wholly owned subsidiary of National Lead Company. The plant will produce 36,000 metric tons of titanium dioxide annually. Investment in the plant was reported to be $27.5 million.

India.—A Calcutta company in cooperation with American, Canadian, French, and Japanese interests announced that recently discovered "unlimited quantities" of ilmenite sands in Kerala will be exploited. Operations will begin within a year. The present production of about 40,000 tons per year of ilmenite will be enhanced by construction of a new "dry" plant to produce 100,000 tons per year of ilmenite.

Italy.—Italy's requirements of ilmenite for titanium dioxide pigment production will rise to 250,000 tons per year in the early 1970's from the present consumption of 100,000 tons per year. The only present pigment producer is Montecatini-Edison SpA whose two plants have a combined capacity of 60,000 tons of titanium dioxide per year. The company's capacity will be almost doubled when the new 55,000-ton-per-year plant at Searlino, Grosseta Province, is completed before the end of 1971. Società Italiana Resine (SIR) is building a 20,000-ton-per-year titanium dioxide plant at Porto Torres, Sardinia, which is expected to start production in 1973.

Japan.—Japan's total production of titanium sponge by two producers, Osaka Titanium Co. Ltd. and Toho Titanium Co., Ltd., was 7,100 short tons. Titanium slag production by Hokuetsu Metal Co., the only producer now operating, was 5,600 short tons. The major producer of titanium dioxide pigments, Ishihara Sangyo Kaisha, expects to be able to produce 90,000 tons of titanium dioxide annually by mid-1970 via the sulfate process. It is considering construction of a 36,000-ton-per-year unit using the American Potash process. Sakai Chemical Co. is increasing capacity 30 percent and expects to be producing 36,000 tons per year by mid-1971.

Nippon Soda Co. (NISO) and Tejjin announced a joint venture to produce titanium sponge by a proprietary, one-step, sodium-reduction process. The project, which is expected to cost about $5.6 million, is expected to start production in late 1970 with a capacity of 2, 500 tons per year.

Table 13.—Malaysia: Exports of ilmente by countries

(Short tons)

Destination	1967	1968	1969
Japan	r 100,038	138,472	e 144,200
Netherlands	-------	223	NA
Singapore	2	3	NA
United Kingdom	56	-------	NA
Total	r 100,096	138,698	146,153

e Estimate. r Revised. NA Not available.

New Zealand.—Interest continued in developing projects to produce ilmenite from beach sand deposits. Adaras Developments investigated deposits north of Wanganui, North Island, on behalf of Marcona Developments, Ltd., a subsidiary of Marcona Corp.

Norway.—National Lead's Norwegian mining subsidiary, A/S Titania announced the installation of new crushing and beneficiation facilities at its underground mine at Tellnes, near Hauge i Dalane, to increase production of ilmenite concentrates to 500,000 tons per year. The mine has been operating at capacity to meet the demand from National Lead's West German subsidiary Titangesellschaft m.b.H. About 50,000 tons of ilmenite are consumed annually by Titan Co. A/S, another National Lead subsidiary, which operates a 15,000-ton-per-year sulfate-titanium dioxide pigment plant at Fredrikstad.

Sierra Leone.—Sherbro Minerals, Ltd., owned 80 percent by PPG Industries Inc. and 20 percent by British Titan Products Co., Ltd. is modifying its operations to bring production up to a capacity of 100,000 tons of rutile per year. A surface mining operation to supplement dredge production has been started.

South Africa, Republic of.—Additions to the titanium dioxide plant of South African Titan Products (Pty) Ltd. at Umbogintwini in Natal have increased capacity by about 50 percent to 21,000 tons per year of titanium dioxide. The only producer in South Africa, the company is controlled by British Titan Products Co., Ltd., which owns 60 percent.

United Kingdom.—Construction was completed at Laporte Industries Ltd. (LIL) titanium dioxide plant, which uses the chloride process to produce at a capacity of 40,000 tons per year. Present capacities of titanium dioxide plants in the United Kingdom are as follows:

Company and plant location	Process and capacity (tons per year)	
	Sulfate	Chloride
British Titan Products Co. Ltd.:		
Billingham	25,000	2,000
Greatham	------	30,000
Grimsby	85,000	------
Laporte Industries Ltd.:		
Stallingborough	55,000	40,000

Yugoslavia.—The Yugoslav zinc producer "CINKARNA" reportedly started construction on the country's first titanium dioxide pigment plant. The sulfate-process plant will have a capacity of 20,000 tons per year of titanium dioxide. Ilmenite requirements may be imported from the United Arab Republic. The new plant should start producing during the latter half of 1970.

TECHNOLOGY

In view of the worldwide shortage of rutile reserves compared to the abundance of other titanium minerals (principally ilmenite) and the resulting difference in value between rutile and ilmenite, the principal research and development efforts were directed toward beneficiation of ilmenite to produce synthetic rutile.

Murphyores Inc. Pty. Ltd. and the Commonwealth Scientific Industrial Research Organization (CSIRO), Division of Mineral Chemistry, Port Melbourne, Australia, demonstrated the feasibility of upgrading ilmenite to produce synthetic rutile in a pilot plant.[2] The iron oxide in the ilmenite is reduced to a lower oxide by hydrogen and leached with hydrochloric acid to leave a residue containing 96 or 97 percent titanium dioxide. The synthetic rutile is stated to be equal or superior to natural rutile. A similar process was described by Egyptian scientists[3] using ilimenite from Nile River deposits.

Three U.S. patents covering methods of upgrading ilmenite were issued and assigned to National Lead Co. The first[4] describes a process in which the ore concentrate is reduced with hydrogen gas at a relatively low temperature. The reduced material is cooled and separated into magnetic and nonmagnetic fractions. The magnetic fraction is leached with dilute sulfuric acid to dissolve the iron and generate hydrogen gas, which is recirculated to the reduction step. The leached concentrate is washed to remove the bulk of the iron impurty. The second[5] describes a process in which the ilmenite ore is first roasted to a ferric-ferrous iron ratio of up to 20. The roasted ore is reduced with hydrogen, the

[2] Steel. Ilmenite Converts to Synthetic Rutile. V. 164, No. 10, Mar. 10, 1969, p. 52g.

[3] Zein, F. M., and M. A. Mandil. Upgrading of Egyptian Ilmenite. Min. and Miner. Eng., v. 5, No. 4, July 1969, pp. 43–46.

[4] Michal, E. J., and A. E. Nilsen. Processing Ore of the Beach Sand Type To Obtain a Chlorination Feed Material. U.S. Pat. 3,446,590, May 27, 1969.

[5] Aramendia, M. M., and D. L. Armant. Production of Titanium Dioxide Concentrate From Massive Ilmenite Ore of the MacIntyre Type To Produce a Chlorination Feed Material. U.S. Pat. 3,457,037, July 22, 1969.

gangue is removed from the metalized concentrate, the metalized concentrate is leached with a mineral acid, the leached concentrate is washed free of solubilized iron and magnesium, and the resulting titanium dioxide concentrate is heated to drive off water and residual acid. The third patent[6] describes a leaching method in which metalized ore is fed into the top of a leaching tower. Acid is introduced at the bottom. The leached ore is claimed to be suitable for use in the production of titanium tetrachloride.

The Bureau of Mines continued research on recovery of rutile from phosphate flotation tailings and sand and gravel washing operations in the southeastern States. Bureau of Mines researchers described a method for recovering metal values from wastes generated by commercial titanium chlorination operations[7] and a method for induction-melting of titanium in a water-cooled split copper crucible.[8] Bureau of Mines researchers authored two chapters on titanium metallurgy in a major reference publication.[9]

Kobe Steel, one of Japan's leading titanium-milling companies, announced development of two new automotive alloys[10] The first is designed for use in valves. It is designated Ks 155 ASZ and contains 82 percent titanium, 5 percent aluminum, 5 percent tin, 5 percent zirconium, and 1 percent iron. The second, for use in other parts such as valve lifters and connecting rods, is designated Ks 130 ACF and contains 92 percent titanium, 5 percent aluminum, 2 percent chromium, and 1 percent iron.

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[6] Honchar, A. P. Process and Apparatus for Leaching Metalized Ilmenite Ore With Sulfuric Acid in an Upright Leaching Tower Having a Distinct Upper Rough-Leaching Section. U.S. Pat. 3,468,633, Sept. 23, 1969.

[7] Merrill, C. W., M. M. Wong, and D. D. Blue. Beneficiation of Titanium Chlorination Residues; Preliminary Study. BuMines Inf. Circ. 7221, 1969, 7 pp.

[8] Clites, P. G., and R. A. Beall. Inductoslag Melting of Titanium. BuMines Inf. Circ. 7268, 1969, 20 pp.

[9] Baker, Don H. Titanium Electrorefining. Ch. in High Temperature Refractory Metals. Gordon and Breach Science Publishers, Ltd., London, v. 1, 1969, pp. 223–233.

Henrie, T. A. Extractive Metallurgy of Titanium. Ch. in work cited above, pp. 134–154.

[10] Metals Week. V. 41, No. 4, Jan. 26, 1970. p. 51.

Tungsten

By Richard F. Stevens, Jr.[1]

The tungsten industry saw considerable activity during 1969 when over 38 million pounds of contained tungsten were released from the General Services Administration (GSA) stockpile. Although the domestic price of tungsten remained stabilized during the year as a result of the GSA fixed-price disposal program, the quoted European price rose to almost $70 per short-ton unit at yearend as exports from China (mainland) were discontinued. Substantial amounts of the tungsten purchased from GSA by traders were exported to Western and Eastern European countries to fill the supply deficit caused by the withdrawal of shipments of Chinese tungsten. This resulted in the United States becoming for the first time, a net exporter of tungsten concentrate instead of being as before, a net importer. The position of the U.S. as a net exporter is expected to continue for a few years. Although the resumption of Chinese tungsten exports could cause a situation of oversupply, it is not thought that this temporary supply imbalance would be serious enough to cause a significant and prolonged price decrease.

Domestic demand for tungsten in 1969 rose 18 percent while mine production, as measured by mine shipments, decreased 8 percent. As a result of the stabilized tungsten market, the growing demand, and the favorable price, both domestic and foreign, several mines were opened or reopened. Reportedly, most of the first year's output of these mines was already committed.

[1] Metallurgical engineer, Division of Ferrous Metals.

Table 1.—Salient tungsten statistics

(Thousand pounds of contained tungsten)

	1965	1966	1967	1968	1969
United States:					
Mine production	W	W	r 8,167	r 8,397	7,439
Mine shipments	7,566	r 8,482	8,649	10,188	9,405
Releases from Government stocks	926	8,273	6,393	3,225	38,314
Exports [1]	11	101	974	623	7,152
Imports, general	3,495	4,203	2,004	1,824	1,534
Imports for consumption	3,618	4,298	1,699	1,743	1,503
Consumption of concentrate	13,868	18,058	13,860	11,038	13,053
Stocks:					
Producer	411	358	975	603	503
Consumer and dealer	1,434	1,582	1,134	574	1,066
World:					
Production	r 59,632	r 63,085	62,725	70,425	72,060
Consumption	60,634	65,441	62,628	64,778	77,227

r Revised.
W Withheld to avoid disclosing individual company confidential data.
[1] Estimated tungsten content.

Legislation and Government Programs.—During the first 11 months of the year, GSA continued its tungsten concentrate disposal program and offered the concentrate in the Defense Production Act (DPA) inventory, all of which had been declared to be excess, for sale as a "shelf" item on a unrestricted "first-come, first-serve" basis. Sales continued to be made at $43 per short-ton unit, adjusted for premiums and penalties, and some 37½ million pounds of contained tungsten were released through November. Most of this material was sold to traders who, taking advantage of the price differential between the U.S. and Western Europe, exported a significant amount. Since the traders hold ownership of about an additional 25 million pounds, tungsten content, it is expected that the U.S. will be a net exporter for the next few years.

On December 5, 1969, the stockpile sales policy was amended to restrict the material sold for domestic consumption only. Subsequently about 0.8 million pounds of wolframite was sold to domestic processors at the "shelf" price, as adjusted. Late in December, GSA announced the offering of an additional 2.4 million pounds, tungsten content, for domestic consumption. This material was sold at the $43 "shelf" price to domestic consumers in early January 1970. Also in January, GSA announced that it would sell some 17 million pounds of tungsten contained in concentrate on a sealed bid basis later in the year. This material was believed to represent the last of the tungsten material in the DPA inventory.

Although bills had been introduced in February to provide the necessary congressional authorization for disposal of the 100 million pounds of excess tungsten in the other Government stockpiles, very little action was taken by the Congress during 1969 and the outlook for clearance of a disposal bill in 1970 appeared questionable. The companies which purchased the 38.3 million pounds of excess tungsten during the year, all from the DPA inventory are listed below:

Table 2.—U.S. Government tungsten stockpile releases in 1969, by company

Company	Amount short-ton unit	Dollar value	Average price per short-ton unit
Associated Metals & Minerals	1,861	$76,237	$40.97
Baldwin-Lima-Hamilton Corp., Standard Steel Division	734	29,679	40.43
Brandeis Goldschmidt Co., Inc	153,261	6,319,690	41.23
Columbia Tool Steel Co	9,358	380,665	40.68
CONMETALS Inc	124,754	5,137,685	41.18
Continental Copper & Steel Corp., Braeburn Div	1,100	44,556	40.51
Engelhard Minerals & Chemicals	8,657	347,313	40.12
Fansteel Inc	13,367	568,894	42.56
Firth Sterling—A Teledyne Co	2,783	109,840	39.47
General Electric Co	113,595	4,849,756	42.69
Kennametal, Inc	41,367	1,743,761	42.15
Latrobe Steel Co	9,184	380,963	41.48
Mercer Alloys	3,363	140,001	41.63
Metal Traders, Inc	500,243	20,908,808	41.80
Molybdenum Corporation of America, (Molycorp)	61,633	2,537,999	41.18
NORORE Corp	19,322	805,102	41.67
The Ore & Chemical Corp	3,100	128,429	41.43
Philipp Brothers	809,607	33,956,198	41.94
Reactive Metals, Inc	13,719	575,443	41.94
Reactive Metals, Inc.—represented by agent:			
Associated Metals & Minerals	124,498	5,118,098	41.11
Said Dass Kishen Chand Mera, Amripsar, India (AID contract)	570	24,137	42.35
R. Sen & Co., Calcutta, India (AID contract)	2,715	114,220	42.06
STALCO International	16,912	714,247	42.23
Sylvania Electric Products, Inc	39,780	1,708,613	42.95
C. Tennant Sons & Co	154,983	6,471,319	41.76
Titanium Metals Corporation of America—represented by agent:			
C. Tennant Sons & Co	83,017	3,486,493	42.00
Union Carbide Corp	43,849	1,751,173	39.94
Universal Cyclops Corp., Specialty Steel Division	7,629	322,092	42.22
VASCO (Vanadium Alloy Steel Co.)—A Teledyne Company	4,013	172,423	42.97
Wah Chang—A Teledyne Company	46,488	1,926,003	41.43
Total and average	2,415,462	100,849,837	$41.75

Table 3.—U.S. Government tungsten stockpile materials inventories and objectives

(Thousand pounds, tungsten content)

Material	Objective	Inventory by program Dec. 31, 1969			
		National (strategic) stockpile	DPA inventory [1]	Supplemental stockpile	Total
Tungsten ore and concentrate:					
Stockpile grade	35,785	73,750	34,945	3,304	111,999
Nonstockpile grade	-------	40,485	8,569	1,153	50,207
Total inventory	-------	114,235	43,514	4,457	162,206
Ferrotungsten:					
Stockpile grade	1,800	938	-------	-------	938
Nonstockpile grade	-------	1,203	-------	-------	1,203
Total inventory	-------	2,141	-------	-------	2,141
Tungsten metal powder, hydrogen reduced:					
Stockpile grade	1,600	1,196	-------	-------	1,196
Nonstockpile grade	-------	102	-------	-------	102
Total inventory	-------	1,298	-------	-------	1,298
Tungsten metal powder, carbon reduced:					
Stockpile grade	500	547	-------	-------	547
Nonstockpile grade	-------	171	-------	-------	171
Total inventory	-------	718	-------	-------	718
Tungsten carbide powder:					
Stockpile grade	2,000	842	-------	1,080	1,922
Nonstockpile grade	-------	113	-------	-------	113
Total inventory	-------	955	-------	1,080	2,035
Tungsten carbide, crystalline:					
Stockpile grade	1,100	-------	-------	-------	-------

[1] Over 61 percent of this material represents tungsten sold by GSA in 1969 but not physically transferred from Government storage sites at yearend.

DOMESTIC PRODUCTION

Ore and Concentrate.—In 1969 tungsten mine production continued to be stimulated by the relatively high and stabilized prices which resulted from the Government's continuing fixed-price stockpile disposal program. During the year, domestic production, as measured by mine shipments, decreased 8 percent. While 42 mines reported production and/or shipments of tungsten concentate in 1969, only two mines operated throughout the year: the Pine Creek mine and mill of the Mining and Metals Division, Union Carbide Corp., near Bishop, Calif.; and the Climax mine and mill of the Climax Molybdenum Co., a division of America Metal Climax, Inc., (AMAX), near Leadville, Colo. Both of these mines obtained tungsten as a coproduct or byproduct. Tungsten was the major mineral value recovered at Pine Creek along with minor amounts of molybdenum, copper, and gold. At Climax, the major mineral value recovered was molybdenum. Tungsten, tin, pyrite, and monazite were recovered as byproducts and were entirely dependent upon the rate of molybdenum production.

Since the Pine Creek facility was closed for about 6 weeks early in the year as a result of a severe avalanche and a short strike, its total annual production decreased about 10 to 12 percent.

Additional intermittent tungsten production and/or shipments were also reported from Mohave, Santa Cruz, and Yavapai Counties, Ariz.; Fresno, Inyo, Madera, and San Bernardino Counties, Calif.; Boulder, Lake, and San Juan Counties, Colo.; Custer County, Idaho; Beaverhead County, Mont.; Churchill, Mineral, Ormsby, and Pershing Counties, Nev.; and Box Elder, Millard, Salt Lake, and Tooele Counties, Utah. Some of these mines, because of their high elevation, were able to operate for only about half of the year when the area was relatively clear of snow.

The former Hamme tungsten mine near Henderson, N.C. was purchased from the Howemet Corp., by Ranchers Exploration & Development Corp., Albuquerque, N. Mex., late in 1968. Ranchers indicated that it had completed pumping the water that had been allowed to fill the mine following its closing on February 14, 1963. A

Table 4.—Tungsten concentrate shipped from mines in the United States

Year	Quantity			Reported value f.o.b. mines [1]		
	Short tons 60 percent WO_3 basis	Short-ton units WO_3[2]	Tungsten content (thousand pounds)	Total (thousands)	Average per unit of WO_3	Average per pound of tungsten
1965	7,949	476,979	7,566	$13,028	$27.32	$1.72
1966	8,912	534,727	8,482	17,620	32.95	2.08
1967	9,088	545,269	8,649	20,895	38.32	2.42
1968	10,704	642,263	10,188	25,197	39.23	2.47
1969	9,883	592,915	9,405	24,625	41.53	2.62

[1] Values apply to finished concentrate and are in some instances f.o.b. custom mill.
[2] A short-ton unit equals 20 pounds of tungsten trioxide (WO_3) and contains 15.862 pounds of tungsten.

main shaft was sunk, and the company reviewed extrative metallurigical techniques to determine the most economic recovery methods to use for the mine's huebnerite and scheelite ores.

During 1969, equipment was obtained to replace that which had been sold at auction following closure of the Hamme mine, and construction of a processing mill adjacent to the mine site was begun. Early in 1970 this mine began start-up production operations and was scheduled to come onstream in the fall of 1970 with an initial annual full-scale production capacity of about 1.4 to 1.5 million pounds, tungsten content. This would rank Ranchers as the third major domestic tungsten producer behind Union Carbide and Climax. With anticipated expansion, Ranchers could be expected to rise to second since Climax's production is as a byproduct of molybdenum mining and remains relatively constant.

Although subjected to heavy snows, the Eureka tungsten mine of Canyon Mining Corp., near Boulder, Colo., was able to operate throughout much of the year due to its proximity to an all-weather highway.

Although considerable interest remains in the Calvert Creek open-pit tungsten mine in Montana, the joint Minerals Engineering Co.—General Electric Co. (GE) program to reopen this property was terminated in mid-year when GE cancelled its financial backing of the project. It is believed that Minerals Engineering was unable to satisfactorily solve the corrosion and related problems in the solvent extraction circuits associated with the ammonium paratungstate (APT) plant at Glen, Montana.

Mines Exploration Co. produced a high-grade scheelite concentrate in the Atolia District of San Bernardino County, Calif. Ore was obtained from four underground mines and transported to a 25-ton-per-day gravity mill where a 60 percent WO_3 concentrate was dried and sacked.

Mining and milling operations at the Silver Star—Queens Mines' Yellow Hammer tungsten-copper property in western Utah began in early October. The tungsten ore was shipped to the newly rehabilitated tungsten mill at Gold Hill, Utah, which has a current capacity of 40 tons of tungsten ore per day. Plans are underway to substantially increase the milling capacity and to add a copper recovery circuit. It is believed that the tungsten concentrates are sold to Union Carbide Corp. where they are upgraded in the company's processing facilities to synthetic scheelite.

During the year a large low-grade tungsten deposit was discovered on the Gamble ranch of the Arizona—Colorado Land and Cattle Co. in northeastern Nevada. Some 25 million tons of ore averaging 0.19 percent WO_3 have been proven, and the existance of further reserves totaling 17.4 million tons of similar grade material appear probable.

Metal, Alloys, and Compounds.—The Chemical & Metallurgical Division of Sylvania Electric Products Inc. (a subsidiary of General Telephone & Electronics Corp.) announced that it would build a new 40,000-square-foot laboratory in Towanda, Pa., to expand its research and engineering operations related to tungsten and other refractory metals. This two-story structure is scheduled to be completed by mid-1970.

The Nevada Scheelite Division of Kennametal, Inc., began building a new mill to reprocess crude tungsten carbide made by the thermite process about 10 miles north of Fallon, Nev. The new mill will replace the present plant located 45 northeast of Hawthorne, Nev.

Gulf Chemical & Metallurgical Corp. became the new owner-operator of the Texas City tin smelter in Texas City, Texas in the spring of 1969. This smelter, which was previously owned and operated by the Lenway Chemical and Metallurgical Co. and before that, by Wah Chang (A Teledyne Co.), is currently producing a number of chemical and metallurgical products including tungsten. Another venture of this company includes a plant at Ironton, Ohio, which produces calcium tungstate.

CONSUMPTION AND USES

Although decreasing slightly in overall relative percentage, tungsten carbide (WC) continued to represent the major individual form of tungsten used during 1969, accounting for 39 percent of the total consumption which increased by 22 percent to over 16 million pounds of contained tungsten, during the year. Consumption of other tungsten products, except ferrotungsten, increased substantially and provided the following percentages of total consumption: Tungsten carbide powder (32), ferrotungsten (10), and scheelite and scrap (17). In addition, slightly more than 2

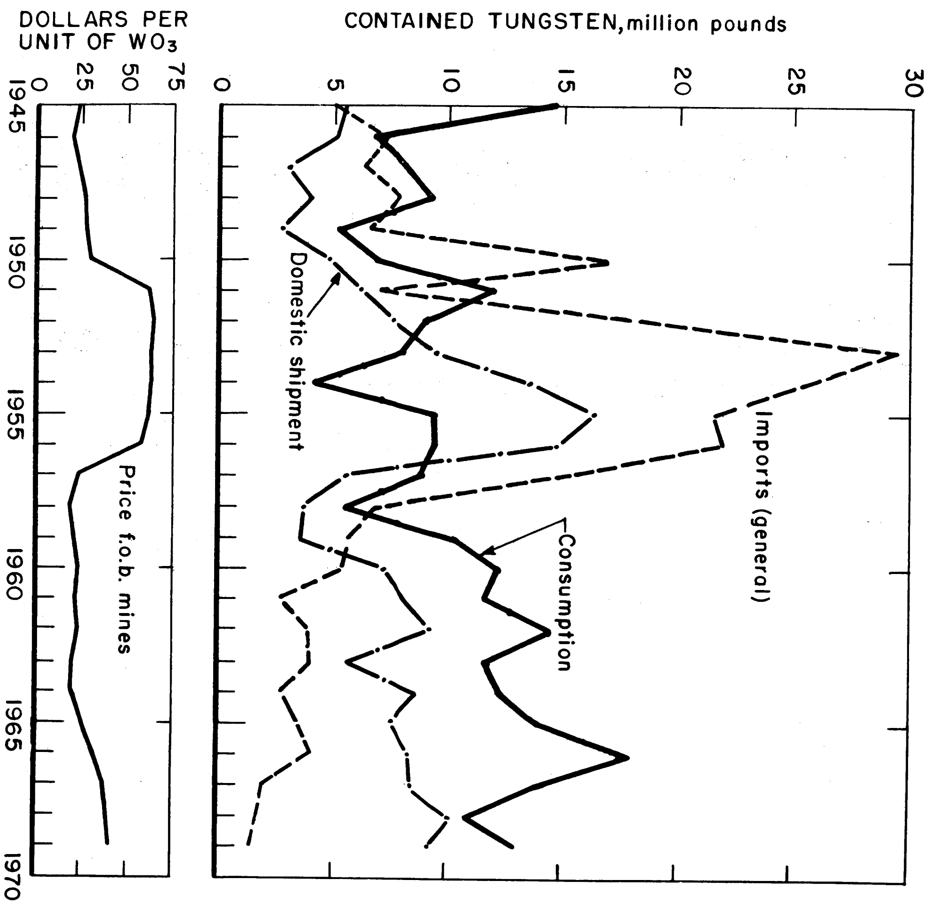

Figure 1.—Domestic shipments, imports, consumption, and average price of tungsten ore and concentrate.

percent was used in the form of tungsten chemicals. Tungsten carbide was produced from tungsten metal powder and from tungsten scrap. Both natural and synthetic scheelite and ferrotungsten were used as additives in steelmaking and high-purity tungsten carbide, tungsten wire, and wrought mill products were produced from hydrogen-reduced tungsten metal powder having low impurity content.

Two new grades of fine grained tungsten carbides have been commercially developed by the Carmet Division of Carmet Co., a subsidiary of Allegheny Ludlum Steel Corp. The use of these grades, designated CA-310 and CA315, enables production of cutting tools having unusually high strength, hardness, and wear resistance, all of which promote longer tool life. The fine grained carbide structure, which exhibit these properties is produced by dispersing microparticles of tungsten carbides in the matrix of the cutting tool microstructure.

Tungsten carbide hard facing continued to be used extensively to provide maximum abrasion resistance for drill bits,

Table 5.—Production, shipments, and stocks of tungsten products in the United States

(Thousand pounds of contained tungsten)

	Hydrogen and carbon reduced metal powder	Tungsten carbide powder: Made from metal powder	Tungsten carbide powder: Crushed and crystalline	Chemicals	Other [1]	Total [2]
1968						
Gross production during year	7,702	4,458	2,472	10,542	2,423	27,597
Used to make other products listed here	5,349	------	------	9,934	1,776	17,059
Net production	2,353	4,458	2,472	608	646	10,538
Shipments [3]	7,191	4,457	2,712	6,313	2,452	23,125
Producer stocks, December 31	1,812	223	776	1,621	314	4,747
1969						
Gross production during year	9,205	5,531	2,831	11,556	2,599	31,722
Used to make other products listed here	6,517	------	------	10,418	1,452	18,387
Net production	2,688	5,531	2,831	1,138	1,147	13,334
Shipments [3]	8,756	5,571	3,414	7,019	2,640	27,400
Producer stocks, December 31	1,369	216	408	1,180	220	3,392

[1] Includes ferrotungsten, scheelite (produced from scrap), nickel-tungsten, self-reducing oxide, pellets, and scrap.
[2] Data may not add to totals shown because of independent rounding.
[3] Includes quantities consumed by producing firms for manufacture of products not listed here.

Table 6.—Consumption, by end uses, and stocks of tungsten products in the United States in 1969

(Thousand pounds, contained tungsten)

	Ferrotungsten [1]	Tungsten metal powder [2]	Tungsten carbide powder	Other tungsten materials [3]	Total [4]
Steel:					
Stainless and heat resisting	177	(5)	------	168	345
Alloy (excludes stainless and heat resisting)	294	W	W	300	594
Tool	930	(5)	------	1,021	1,951
Cast irons	W	------	------	W	W
Superalloys	75	W	W	306	381
Alloys (exclude alloy steels and superalloys):					
Cutting and wear resistant materials	W	1,194	5,723	358	7,275
Other alloys [6]	35	728	W	265	1,028
Mill products made from metal powder	------	2,898	------	W	2,898
Chemical and ceramic uses	------	------	------	406	406
Miscellaneous and unspecified	64	307	523	281	1,175
Total [4]	1,577	5,127	6,246	3,106	16,056
Consumer stocks Dec. 31, 1969	293	562	431	492	1,778

W Withheld to avoid disclosing individual company confidential data, included in "Miscellaneous and unspecified."
[1] Includes melting base self-reducing tungsten.
[2] Includes both carbon-reduced and hydrogen-reduced tungsten metal powder.
[3] Includes tungsten chemicals, natural and synthetic scheelite, tungsten scrap, and other.
[4] Data may not add to totals shown because of independent rounding.
[5] Less than ½ unit.
[6] Includes welding and hard-facing rods and materials and nonferrous alloys.

plows, shovel and bucket teeth, and tool joints without requiring fusion welding techniques.

Adamas Carbide Corp. began construction of a new branch plant in Livonia, Mich., to meet the rapidly growing demand for tungsten carbide in tire studs. Adamas stated that the new facility was being built because the main plant at Deaborn Heights, Mich., was not large enough to keep pace with the increased growth in the tungsten carbide market. At the new plant tungsten carbide will be produced in flats, rounds, and special shapes by hydrostatic pressing and vacuum sintering.

A commercial extrusion method has been developed by Thermo Electron Corp., Walthan, Mass., for the production of extruded heavy walled tubing using naturally forming tungsten oxide (WO_3) as lubricant at elevated temperatures. Under certain conditions, tungsten forms its own lubricant and no further extrusion lubricant is required.

A tungsten carbide titanium carbide combination has been developed by Sandvik Coroment, Stockholm, Sweden, in which a 0.002-inch coating of titanium carbide is placed on a cemented tungsten-carbide core. This combination combines the wear-resistance of titanium carbide with the toughness of tungsten carbide.

The relatively old metallurgical process of chemical vapor deposition (CVD) is now being successfully used by Fansteel Inc. to produce high-purity, high-density tungsten metal crucibles for use in the growing of single crystals. These CVD-formed crucibles have all the desirable properties of tungsten metal without being as difficult to work as is wrought tungsten metal; they can be produced at a fraction of the costs of conventional fabrication techniques.

PRICES AND SPECIFICATIONS

Throughout 1969 the price of imported tungsten ore and concentrate was quoted at $43 (nominal) per short-ton unit reflecting the continued stabilizing influence of the GSA sales policy. As quoted in Metals Week and in the Metal Bulletin (London), the world price remained near the GSA sales price during the first half of the year. However, during the second half of 1969, the world tungsten price rose and remained above the GSA price. At yearend the world price was quoted at a high of 645 shillings per long-ton unit ($69.13 per short-ton-unit). This rise continued into early 1970 when a high of 760 shillings per long-ton unit ($81.46 per short-ton-unit) was reached. The cause of this significant price increase was reported to be due almost entirely to the suspension of tungsten shipments from mainland China. It is believed that this action forced the industralized Eastern and some Western European countries which had previously received all or a significant amount of their supply from mainland China to seek their requirements from free world sources.

The price of ammonium paratungstate (APT), an intermediate tungsten com-

Table 7.—Monthly price quotations of tungsten concentrate in 1969

Month	Wolfram and scheelite: London market, shillings per long-ton unit of WO_3, 60 percent basis:		Equivalent quotations, dollars per short-ton unit of WO_3, 60 percent basis		
	Low	High	Low	High	Average [1]
January	430	450	$46.09	$48.23	$47.33
February	397½	430	42.60	46.09	43.94
March	395	412½	42.23	44.21	43.34
April	365	405	39.12	43.41	41.26
May	345	422½	36.98	45.28	41.70
June	417½	440	44.75	47.16	45.87
July	420	440	45.02	47.16	46.22
August	425	440	45.55	47.16	46.35
September	425	440	45.55	47.16	46.35
October	425	440	45.55	47.16	46.35
November	430	470	46.09	50.38	47.48
December	455	645	48.77	69.13	60.24

[1] Arithmetic average of weekly quotations. Equivalent 1969 average price $46.37; duty $6.34, equivalent average price, duty paid, $52.71 per short ton unit.

pound which can be readily converted to tungsten metal powder by hydrogen reduction, processed from domestic ore and delivered to contract customers, reportedly range from $40 to $44 per short-ton-unit. APT processed from GSA concentrates was believed to be sold in the range from $48 to $51 per short-ton-unit.

The quoted prices of both carbon and hydrogen-reduced tungsten metal powder increased during the year. At yearend, carbon-reduced tungsten metal powder (99.8 percent in 1,000 pound lots) was quoted by Metals Week at $3.06 per pound of contained tungsten compared with the 1968 quotation of $2.75 per pound. The quoted price of hydrogen-reduced tungsten metal powder (99.99 percent purity) rose and ranged from $4.91 to $5.75 per pound of contained tungsten at yearend 1969 compared with a range of $4.60 to $5.44 in 1968.

In Metals Week, the quoted price of the various grades of ferrotungsten in lots of 5,000 pounds or more, ¼-inch lump, packed, f.o.b. destination, continental United States, 70 to 80 percent tungsten, increased from a range of $3.20 to $3.71 per pound, tungsten content, at the beginning of the year to a range of $3.25 to $3.86 per pound, tungsten content at yearend 1969. The price of UCAR, Union Carbides's special high grade ferrotungsten was increased from $3.71 to $3.86 per pound, tungsten content, effective July 1, 1969.

While not quoted, the price of scheelite concentrate for direct addition to steel melts was believed to be in the range from about $39 to $42 per short-ton-unit, equivalent to about $2.46 to $2.64 per pound of contined tungsten.

FOREIGN TRADE

Exports of tungsten concentrate (table 8) jumped by a factory of 11½ in 1969 and represented material purchased from the GSA stockpile and shipped by traders to Europe to take advantage of the higher price there. While there were no reexports of tungsten concentrate during the year, reexports of tungsten products are listed in table 9.

Exports unwrought tungsten metal and alloys in crude form, waste and scrap, primarily to West Germany (49 percent), Japan (29 percent), Canada (6 percent), the Netherlands and the United Kingdom (5 percent each), Austria (3 percent), and Italy (2 percent), rose 50 percent to 893,474 pounds, gross weight, valued at $1,248,963 in 1969. Tungsten and tungsten alloy powder exports increased 36 percent during the year to 63,897 pounds, gross

Table 8.—U.S. exports of tungsten ore and concentrates, by countries

(Thousand pounds and thousand dollars)

Country	1968			1969		
	Gross weight	Tungsten content [1]	Value	Gross weight	Tungsten content [1]	Value
Austria	106	55	$141	86	44	$104
Belgium-Luxembourg	------	------	------	618	319	824
Canada	90	47	133	457	236	713
France	83	43	111	649	335	1,004
Germany:						
East	------	------	------	1,452	749	2,234
West	485	250	687	3,913	2,019	5,344
India	------	------	------	93	48	144
Italy	------	------	------	26	14	44
Japan	119	61	169	2,156	1,112	2,917
Mexico	------	------	------	(2)	(2)	1
Netherlands	29	15	43	1,175	606	1,690
Poland	------	------	------	548	283	796
Sweden	------	------	------	246	127	424
U.S.S.R	------	------	------	228	118	366
United Kingdom	295	152	421	2,212	1,141	3,224
Total	1,207	623	1,705	13,859	7,151	19,829

[1] Tungsten content estimated by multiplying the gross weight by a factor of 0.516 equal to 0.65 (to convert from 65 to 100 percent WO_3 basis) times 0.7931 (to convert from WO_3 to W basis).
[2] Less than ½ unit.

weight, valued at $291,001 and were shipped primarily to Canada (41 percent), West Germany (25 percent), and Mexico (16 percent).

Tungsten and tungsten alloy wire exports, primarily to Canada (37 percent), Brazil (19 percent), and Italy (12 percent), rose 20 percent to 62,445 pounds,

Table 9.—Re-exports of tungsten products in 1969, by country

(Pounds, gross weight)

Country	Quantity	Value
Unwrought tungsten, waste and scrap:		
Japan	188	$284
Tungsten metal powder:		
Italy	NA	19,953
Tungsten wire:		
Netherlands	6,000	1,148
Tungsten, wrought:		
Belgium-Luxembourg	10	276
Austria	50	741
Total, wrought	60	1,017

gross weight, valued at $1,822,461 in 1969. Exports of wrought tungsten and tungsten alloys primarily to Japan (73 percent), and West Germany (15 percent), increased by a factor of more than five and totaled 380,160 pounds, gross weight, and valued at $1,530,250.

During the year, general imports of tungsten concentrate fell 16 percent and imports for consumption decreased 14 percent. In 1969, as in the previous 5 years, there were no duty-free imports of tungsten ore and concentrate for the U.S. Government.

Imports of tungsten carbide during the year decreased 8 percent to 13,761 pounds, tungsten content, valued at $95,351 and came primarily from the United Kingdom (74 percent), and West Germany (25 percent). There continued to be no imports of semifabricated tungsten in ingots and shot during the year.

Imports of tungsten waste and scrap containing over 50 percent tungsten rose 17 percent to 31,472 pounds, tungsten content, valued at $64,740 in 1969 and were primarily received from the Netherlands (55 percent). During the year, imports of unwrought tungsten in lump, grains, and powder increased by a factor of over two to 6,675 pounds, tungsten content, valued at $43,552 and were received primarily from Canada (65 percent), and West Germany (34 percent). In 1969, imports of wrought tungsten fell by 20 percent to 4,945 pounds valued at $401,434. This material came primarily from Austria (47 percent), and the Netherlands (44 percent).

Table 10.—U.S. imports [1] of tungsten ore and concentrates, by countries

(Thousand pounds and thousand dollars)

Country	1968			1969		
	Gross weight	Tungsten content	Value	Gross weight	Tungsten content	Value
Australia	266	145	$297	235	132	$348
Bolivia	109	55	73	-----	-----	-----
Burundi and Rwanda	11	4	11	-----	-----	-----
Canada	1,610	1,035	1,928	1,870	1,046	2,234
Chile	15	9	21	-----	-----	-----
Hong Kong	5	2	4	-----	-----	-----
Mexico	3	2	2	2	1	1
Peru	874	506	961	449	256	671
Portugal	67	40	91	168	99	273
United Kingdom [2]	45	26	56	-----	-----	-----
Total	3,005	1,824	3,444	2,724	1,534	3,527

[1] Data are "general imports", that is, they include tungsten imported for immediate consumption plus material entering warehouses.
[2] Represents transshipment, rather than country of origin.

Table 11.—U.S. imports for consumption of tungsten ore and concentrates, by countries

(Thousand pounds and thousand dollars)

Country	1968			1969		
	Gross weight	Tungsten content	Value	Gross weight	Tungsten content	Value
Australia	134	73	$146	179	101	$266
Bolivia	109	55	73	-----	-----	-----
Burundi and Rwanda	11	4	11	-----	-----	-----
Canada	1,610	1,035	1,928	1,870	1,046	2,234
Chile	(1)	(1)	(1)	-----	-----	-----
Hong Kong	5	2	4	-----	-----	-----
Mexico	3	2	2	2	1	1
Peru	874	506	961	449	256	671
Portugal	67	40	91	168	99	273
United Kingdom [2]	45	26	56	-----	-----	-----
Total	2,858	1,743	3,272	2,668	1,503	3,445

[1] Less than ½ unit.
[2] Represents transshipment, rather than country of origin.

Table 12.—U.S. imports for consumption of tungsten or tungsten carbide forms

(Thousand pounds and thousand dollars)

Year	Ingots, shot, bars, and scrap		Wire, sheets, or other forms, n.s.p.f.		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1967	138	$246	5	$277	143	$523
1968	44	51	6	316	50	367
1969	33	65	5	401	38	466

Table 13.—U.S. import duties on all forms of tungsten

(Tungsten content per pound of contained tungsten)

Tariff classification	Article	Rate of duty [1]	
		Effective Jan. 1, 1969	Effective Jan. 1, 1970
601.54	Tungsten ore	$0.40 per pound tungsten (W).	$0.35.
603.45	Other metal bearing materials in chief value tungsten	$0.335 plus 16 percent ad valorem.	$0.294 plus 14 percent ad valorem.
607.65	Ferrotungsten	$0.335 plus 10 percent ad valorem.	$0.294 plus 8.5 percent ad valorem.
629.25	Waste and scrap containing by weight not over 50 percent tungsten	$0.33 plus 10 percent ad valorem.	$0.29 plus 8.5 percent ad valorem.
629.26	Waste and scrap containing by weight over 50 percent tungsten	16.5 percent ad valorem	14.5 percent ad valorem.
629.28	Unwrought tungsten, except alloys in lump, grain and powder	$0.33 plus 20 percent ad valorem.	$0.29 plus 17.5 percent ad valorem.
629.29	Unwrought tungsten ingots and shot	16.5 percent ad valorem	14.5 percent ad valorem
629.30	Unwrought tungsten, n.e.c.[2]	20 percent ad valorem	17.5 percent ad valorem.
629.32	Tungsten alloys, unwrought, containing by weight not over 50 percent tungsten	$0.335 plus 10 percent ad valorem.	$0.294 plus 8.5 percent ad valorem.
629.33	Tungsten alloys, unwrought, containing by weight over 50 percent tungsten	20 percent ad valorem	17.5 percent ad valorem.
629.35	Wrought tungsten	do	Do.
416.40	Tungstic acid	$0.33 plus 16 percent ad valorem.	$0.29 plus 14 percent ad valorem.
417.40	Ammonium tungstate	do	Do.
418.30	Calcium tungstate	do	Do.
420.32	Potassium tungstate	do	Do.
421.56	Sodium tungstate	do	Do.
422.40	Tungsten carbide	$0.33 plus 20 percent ad valorem.	$0.294 plus 17 percent ad valorem.
422.42	Other tungsten compounds, n.e.c.[2]	$0.33 plus 16 percent ad valorem.	$0.29 plus 14 percent ad valorem.
423.92	Mixtures of two or more inorganic compounds in chief value tungsten	do	Do.

[1] Not applicable to Communist countries.
[2] Not elsewhere classified.

Imports of calcium tungsten during 1969, almost all from West Germany, totaled 20,744 pounds, tungsten content, valued at $144,501, a 65 percent rise over 1968 imports.

Imports of material classified as other metal-bearing materials in chief value tungsten increased 20 percent and totaled 5,953 pounds, tungsten content, valued at $10,162. This material, believed to primarily represent synthetic scheelite, was all received from Japan.

As in the previous 3 years there were no imports of foreign tungsten concentrate into the Virgin Islands or shipments of processed tungsten products from the Virgin Islands to the continental United States in 1969. This data indicates that Molybdenum Corporation of America's tungsten processing plant which was set up in 1965 has discontinued its operations which were originally established to avoid the duty on imported tungsten. There continued to be no imports of ferrotungsten during the year.

In accordance with the "Kennedy round" tariff negotiations of GATT, the U.S. import duties on all forms of tungsten were further reduced, effective January 1, 1970, as indicated in table 13.

WORLD REVIEW

Meetings of the United Nations Committee on Tungsten and two of its subsidiary bodies were held in October at the Palais des Nations, Geneva, Switzerland. The Committee's eight-member Working Group met first to prepare a review of the prevailing world tungsten situation. This group was composed of representatives from Australia, Austria, Bolivia, Portugal, South Korea, Sweden, The United States, and West Germany. Following the Working Group, a meeting of the Statistical Working Party, open to all member governments, was held to resolve problems associated with tungsten production and consumption statistics. Finally, a relatively short meeting of the full Committee was held but due primarily to the lack of major problems and the continuing high price of tungsten, some members of the Committee did not attend the latter two meetings.

The Committee on Tungsten, through its U.N. staff, continued the collection of statistical, scientific, technical, and economic data on tungsten. In addition to its regular quarterly report, "Tungsten Statistics" the Committee issued two supplements to the publication "Tungsten Bibliography." Copies of all these reports are available to anyone interested upon request from the United Nations Conference on Trade and Development (UNCTAD), Distribution Section, Palais des Nations, Geneva, Switzerland.

Table 14.—World production of tungsten ore and concentrate, by countries [1]

(Thousand pounds of contained tungsten) [2]

Country	1967	1968	1969 p
North America:			
Canada	e 220	2,860	3,222
Mexico	r 414	586	636
United States (shipments)	8,649	10,188	9,405
South America:			
Argentina	r 235	405	e 418
Bolivia (exports)	r 3,401	3,984	4,050
Brazil e	638	958	1,910
Peru	r 902	1,278	1,478
Europe:			
Austria	r 172	308	e 220
Portugal	2,416	2,889	e 2,706
Spain	r 176	273	e 154
U.S.S.R. e	13,600	13,600	14,300
Africa:			
Congo (Kinshasa)	116	86	143
Rwanda	611	708	374
Uganda	84	97	117
Asia:			
Burma	338	307	249
China, mainland e	17,600	17,600	17,600
Japan	862	1,175	1,335
Korea:			
North e	4,720	4,720	4,720
South	4,464	4,602	4,336
Malaysia	33	143	304
Thailand	956	1,093	1,437
Oceania:			
Australia	r 2,118	2,565	2,946
Total [3]	r 62,725	70,425	72,060

e Estimate. p Preliminary. r Revised.

[1] France, Sweden, and Yugoslavia are no longer tungsten producers. In addition, the following countries also produce tungsten: Guatemala, Hong Kong, India, Italy, Mongolia, New Zealand, Nigeria, Republic of South Africa, Southern Rhodesia, Territory of Southwest Africa, and Tanzania.

[2] Conversion factors: WO_3 to W equals 0.7931; in converting 60 percent WO_3 concentrate to W, multiply by 0.4758.

[3] Totals are of listed figures only.

Table 15.—World consumption of tungsten ore and concentrate, by countries [1]

(Thousand pounds, tungsten content)

	1967	1968	1969 p
Actual consumption:			
Australia e	110	110	110
Austria	3,140	2,820	3,390
Canada	405	e 440	e 450
Japan	5,740	4,990	7,286
Portugal	688	524	686
Sweden	1,350	2,565	3,364
United Kingdom	4,880	5,920	7,665
United States	13,860'	11,038	13,053
Apparent consumption, including stock variations:			
France	2,320	1,965	3,225
Apparent consumption, excluding stock variations:			
Argentina	110	119	100
Belgium-Luxembourg	55	167	175
Bulgaria [2]	70	75	80
China, mainland [2]	1,250	1,375	1,400
Czechoslovakia	2,319	3,775	3,016
Germany: East [2]	300	430	800
West	r 4,411	5,610	9,220
Hungary [2]	30	40	50
India e	480	540	390
Italy	22	62	75
Korea, North [2]	r 3,500	3,500	3,500
Netherlands	286	284	488
Poland	2,823	3,799	3,414
South Africa, Republic of [2]	600	620	630
Spain	r 169	e 150	e 150
U.S.S.R. [2]	13,600	13,750	14,400
Yugoslavia [2]	110	110	110
Total	r 62,628	64,778	77,227

e Estimate. p Preliminary. r Revised.

[1] In addition, the following countries are known or believed to consume tungsten concentrate but specific data are not available: Brazil, Chile, Denmark, Finland, Israel, Norway, Rumania, Switzerland.

[2] Estimated by author of chapter.

Australia.—Endurance Mining Corp., N.L. and Peko-Wallsend Ltd. formed a joint company to explore and develop Endurances' tungsten deposits at Attunga, near Tamworth, New South Wales. Preliminary drilling indicated that these deposits average about 0.8 percent wolfram. If development of the deposits is indicated to be commercially feasible, Peko-Wallsend will provide the financing necessary for an extraction plant.

Preliminary drill evaluations of Endurance Mining Corp.'s tungsten reserves on its Moonbi prospect near Tamworth, N.S.W., indicated the presence of at least 500,000 tons of scheelite containing 1.44 percent tungsten. Further drilling will be conducted to more accurately outline the ore body and to determine if sufficient material exists to warrant commerical development of this deposit.

Samples of the tungsten ore obtained from an 80-acre site at Mt. Horror near Winneleah, Tasmania, assayed 4.8 percent WO_3 and could be concentrated by jigging and tabling to 49.9 percent WO_3 with a recovery at 87.5 percent. Further concentration should produce a salable grade of concentrate (over 65 percent WO_3) with an overall recovery of about 80 percent.

Ownership of King Island Scheelite (1947) Ltd. was acquired by Peko-Wallsend Ltd. during the year and reserves were increased by extensive exploration activities to 6 million tons averaging 0.8 percent tungsten. Another ore body was defined during the year and was estimated to contain 1.8 million tons of ore averaging 1.1 percent tungsten.

Early in 1969, King Island Scheelite announced plans for a $10 million expansion program to start in April. This expansion will involve rebuilding of the present tungsten mining-processing complex to increase production capacity at present open-pit mining operations. In addition, a new concentrator having an initial capacity of 450,000 tons per year with provision for subsequent expansion to a capacity of 600,000 tons per year will be constructed. This new concentrator will be located about 1 mile north of the existing complex.

Bolivia.—To reduce the country's dependence on tin exports, a mineral industry diversification program was proposed by the Corporacíon Minera de Bolivia (COMIBOL) which would survey tungsten deposits in 19 areas to determine the economic feasibility of recovering this material.

Brazil.—Interesting scheelite deposits have been discovered near Lajes, Rio Grande do Norte. The output of these deposits by local residents-turned-prospectors is believed to approach or equal the commercial tungsten mining operation near Currais Novos.

Burma.—Because of the 1964 nationalization of the Burma Corporation Ltd. and the Government's refusal to renew expired mining licenses, the Tenasserim Districts of Tavoy and Mergui have recently declined as producers of tin-tungsten concentrate.[2]

The Government-owned Mineral Development Corporation (MDC), which operates most of the country's tin and tungsten mines, reportedly will sign a 4 year contract with the U.S.S.R to rehabilitate the Mawchi tin-tungsten mines destroyed in World War II and currently yielding only marginal production.

Exploitation of a newly discovered tin-tungsten deposit in the Karan Range east of Pyinmana was recently begun by MDC.

Canada.—Canada Tungsten Mining Corporation Ltd. (CTMC), the country's only tungsten producer, increased total production at its mine and mill at Tungsten (formerly Flat River), Northwest Territories, near the Yukon border and had the most successful year in the company's history. Mine production totaled 203,173 short-ton units of WO_3 (some 3.2 million pounds of contained tungsten), an increase of 13 percent over 1968, and the concentrator was operated at 95 percent efficiency averaging 482 dry tons of ore per day.[3] During the latter half of 1969 milling rates were increased to 550 to 600 tons per day. While the grade of ore milled during the year dropped from 1.98 percent to 1.54 percent WO_3 the overall scheelite recovery rose to 78.81 percent from 77.74 percent.

In addition to the scheelite, 466,113 pounds of byproduct copper was produced, and copper mill recovery averaged 66.12 percent during the year.

CTMC announced that due to the increased price of tungsten a program was scheduled for 1970 to evaluate possible ad-

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[2] Bureau of Mines. Mineral Trade Notes. V. 67, No. 2, February 1970, p. 30.

[3] Canada Tungsten Mining Corp. Ltd. Annual Report 1969. Toronto, Canada, Apr. 3, 1970, 9 pp.

ditional and previously uneconomical low-grade ore in the present pit area.

As of December 31, 1969, reserves of ore in place totaled 733,823 tons averaging 1.68 percent WO_3 while stockpiled ore awaiting concentration totaled 84,058 tons averaging 1.56 percent WO_3.

Although the control of air and water pollution at CTMC's Vancouver Leach plant in North Vancouver, British Columbia, presented some problems during the year these were overcome by the use of additional water scrubbing equipment and liquid caustic. In addition, certain equipment changes were made to improve recovery and overall efficiency of the leach-plant operation.

Canadian Exploration, a subsidiary of Placer Development, announced plans to bring the Invincible tungsten property near Salmo, British Columbia, into production at an initial rate of 10,000 tons of ore per month. Reserves in this orebody are estimated at 278,000 tons averaging 0.78 percent WO_3. Initial production is scheduled for late 1970 or early 1971.

Burnt Hill Tungsten & Metallurgical Ltd. continued evaluation and development of its tungsten property in York County, New Brunswick, as a three-compartment shaft was completed to the 160-foot level. Present indications show that in addition to tungsten this property will be able to economically produce byproduct bismuth, tin, and molybdenum.

Exploration and preliminary development of a large volume, low-grade tungsten deposit at the Grey River Settlement on Newfoundland's South Coast was continued. Metallurgical, engineering, and economic studies will be conducted during 1970 to determine the feasibility of bringing the property into production. This deposit may be a geological continuation of a reported tungsten deposit in the Recontre West Area just south of the Grey River site.

China, mainland.—Although no official statistics are available on the country's tungsten activities it is believed that tungsten production fell 50 percent between 1962 and 1968. In 1968, over half of the Chinese tungsten was exported to the free world, primarily certain Western European countries, (63 percent), and to Eastern European Bloc countries (37 percent). While data on trade with the U.S.S.R. in 1968 is not available, it is estimated to be insignificant and less than the 6 million pounds, tungsten content, reported as U.S.S.R. imports in 1967. It is thought probable that mainland China has increased domestic consumption and has been stockpiling tungsten as it has a wide range of other metals.

Czechoslovakia.—A new ferroalloy plant situated just outside of Prague which was due to become operational during the year has been delayed for about a year. This left the country with a surplus of tungsten at mid-year which they tried unsuccessfully to resell. However, by yearend, the absence of tungsten from mainland China reversed the situation and caused a shortage of supply. Most of this shortage will be made up by material purchased by traders from the GSA stockpile.

Germany, East.—Import-export data tend to confirm reports in the commercial trade literature that shipment of tungsten concentrate from mainland China to its traditional Eastern and Western European countries was effectively discontinued during the year. As a result substantial amounts of tungsten concentrates, purchased by traders from GSA were shipped to East Germany during the year. It was indicated in early fall that East Germany was in the market for some 1,000 tons of tungsten concentrate presumbly for its own consumption.

India.—A new tungsten deposit which, when developed, could contribute to a reduction in tungsten imports was discovered in the East Godavari District of Tamil Nadu State. Investigation and final exploitation will be conducted by the State Mining Corporation. Currently, India imports tungsten concentrate primarily for use in its tungsten carbide industry.

Israel.—One of the country's rapidly growing industries, Iscar Ltd. of Nahariya, just north of Haifa, produces tungsten carbide for export from imported .tungsten base material. Iscar intends to double tungsten carbide production by the end of 1970 or early 1971.

Mexico.—Tormex Mining Developers have taken a 2-year option to purchase a 49-percent interest in the Baviacora tungsten mine in the state of Sonora. This mine currently processes some 80 tons of ore per day and produces about 15 tons of scheelite per month. Tormex is investigating the possibility of sufficient ore to support a larger open-pit type of operation.

Peru.—Commercial tungsten deposits were recently discovered at Purhuay, near Huari. Upon completion of a road to the deposits a Japanese company will reportedly begin mining operations.

Poland.—Trade data indicates that much or all of the tungsten formerly supplied to Poland by mainland China is now being supplied by U.S. traders who obtained it from the GSA stockpile. Poland is reported to have contracted for about 1,650 tons of concentrate over a 6-month period.

Portugal.—The Beralt Tin and Wolfram Ltd. announced plans to increase production at its Panasqueira wolframite mine by 50 percent to 2,400 short tons of tungsten concentrate annually. The new production rate is expected to be reached in the latter part of 1970.

Sudan.—Tin-tungsten deposits on the west bank of the Nile River about 45 miles north of Khartoum are being investigated. If sufficient material can be outlined to justify commercial operations the ore will be mined and preconcentrated at the site prior to transportation by truck and rail to a site for further processing.

Uganda.—Early in the year a new tungsten deposit was located about 45 miles northeast of Mbarara in an area previously not known to be mineralized. During the first 6 weeks after the find was made, several tons of wolfram concentrate were recovered by mining operations using simple hand tools and panning methods. The possibility of finding other tungsten deposits in the general area is considered to be good.

U.S.S.R.—An exploration program is being conducted on the Ukrainian plateau in the general region of the Krivoi, Rog, and Dnepropetrovsk deposits to evaluate the economic potential of tungsten and other mineral ores located some 100 to 200 feet below the surface. The Soviet Union continued to be a net importer during the year, and it was believed that Soviet tungsten processing capacity exceeds the available supply of concentrate. Reportedly some of the GSA stockpile material sold to traders during the year would be shipped to the U.S.S.R. in early 1970. This could involve a barter-type of arrangement in which ferrotungsten would be supplied as payment for the tungsten concentrate.

Tungsten ore processing facilities at the Primorsky ore-milling complex in the far eastern region of the U.S.S.R. began experimental production of tungsten concentrate during the year from rich tungsten ore deposits of the Ussuri area in the north Primorye. This tungsten processing facility is scheduled to be commissioned in late 1971 or early 1972 at which time the plant will be operating at designed capacity.

United Kingdom.—During the year it became apparent to the tungsten trade that a regular "toll" processing of tungsten concentrate from Czechoslovakia was being conducted by U.K. processors to remove high tin impurties.

TECHNOLOGY

Studies conducted by Bureau of Mines' engineers indicated that both rhenium and tungsten metal powder could be reclaimed from scrap tungsten alloys containing about 25 percent rhenium by oxidation at 950° C to separate volatile rhenium heptoxide from tungsten trioxide.[4] The efficiency of this recovery technique was approximately 96 percent.

Bureau metallurgists investigating the preparation of tungsten carbide by molten-salt electrolysis found that optimum results were obtained with an electrolyte consisting of 87 mole-percent sodium chloride and 5.7 mole-percent each of sodium tungstate, sodium metaborate, and sodium hydroxide; a temperature of 1,000° to 1,025° C; an anode current density of 37 amp per decimeter^2 (dm^2) or less; and an initial cathode current density of 150 amp per dm^2.[5] Under these conditions the yield of friable electrolytic tungsten carbide was approximately 0.45 grams per amp hour (g/amp hr.).

Technical progress reviews of tungsten alloy development, irradiation effects, methods of fabrication, oxidation and corrosion resistance, and coating studies of tungsten were conducted for the U.S. Atomic Energy Commission (USAEC) with

[4] Ferrante, M. J., F. E. Block, A. D. Fugate, and F. A. Skirvin. Recovery of Rhenium From Tungsten-Rhenium Alloy. BuMines Rept. of Inv. 7254, April 1969, 11 pp.

[5] Gomes, John M., and M. M. Wong. Preparation of Tungsten Carbide by Electrodeposition. BuMines Rept. of Inv. 7247, April 1969, 13 pp.

special emphasis on high-temperature reactor-material applications.[6]

Extensive interest was shown in the use of the specialized nuclear and high-temperature properties of tungsten-based alloys for application in large nuclear aircraft systems.[7]

A new method of reclaiming tungsten and other refractory metal carbides was developed by Bureau metallurgists in which molten zinc is used to disintegrate the carbide mass by forming an alloy with the cobalt binder.[8] The advantages of these methods are simplicity and directness, efficiency and inexpensiveness, no solid waste products, high purity of reclaimed products, total use of reject scrap, and recyclable reagent (zinc).

During the year, the English language translation of a detailed Soviet technical publication became available which evaluated studies of the oxidation of tungsten, structural tungsten alloys, protective coatings for tungsten, and problems in the production of high-temperature tungsten-base structural materials.[9]

The mechanical behavior of commercial grades of tungsten carbide (WC) containing from 4 to 25 weight percent cobalt (Co) binder was evaluated and related to the material microstructure, including the interaction between WC and Co during sintering and subsequent cooling.[10]

X-ray stress-analysis studies of cemented tungsten carbide cermets were conducted to (1) evaluate the factors that influence stress measurement for the WC phase in WC-Co cermets and (2) to evaluate the effect of Co content on the temperature stress in WC-Co cermets.[11]

A highly successful method of cold machining refractory tungsten bar stock at $-40°$ F has been developed by Argonne National Laboratory using 25 percent trichlorethylene in mechanically refrigerated stoddard solvent as the coolent.[12] Examples of the success of this new technique are indicated by the reduction in machining time from 7 hours to 20 minutes and by the increase in tool life by a factor of four.

Continuing studies of the dispersion-hardening, grain growth, and preferred orientation effects of thorium oxide (ThO_2) additives to tungsten indicated that additions of 3.8 volume percent of thoria (ThO_2) enhanced the yield strength at temperatures in excess of 2,700° C.[13]

A method of obtaining fine-grain, noncolumnar tungsten by chemical vapor deposition (CVD) was developed which involves the partial nitriding of the tungsten to tungsten nitride (W_2N) during deposition and subsequent decomposition of the W_2N following deposition by heat

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[6] Simons, E. M., S. W. Porembka, Jr., and D. L. Keller. Reactor Materials. V. 12, Nos. 1–4, 1969, 275 pp.

U.S. Atomic Energy Commission. Fundamental Nuclear Energy Research—1969. January 1970, pp. 141–142, 214.

[7] Bridges, W. L. Materials for The Heat Transport System of an Aircraft Nuclear Powerplant. ER 9898, Lockheed-Georgia Co.—A Division of Lockheed Aircraft Corp., Marietta, Georgia, October 1968, 90 pp.

Gritton, E. C., and B. Pinkel. The Feasibility of the Gaseous-Core Nuclear Reactor for Electric Power Generation. Memorandum RM-5721-PR, The RAND Corp., Santa Monica, Calif. (Prepared for: U.S. Air Force Project RAND under Contract No. F44620-67C-0045), June 1969, 63 pp.

Leonard, Anthony. Out-of-Pile Thermionic Space Power Systems Using A Gaseous Heat-Transfer Fluid. Memorandum RM-4469-PR, The RAND Corp., Santa Monica, Calif. (Prepared for: U.S. Air Force Project RAND under Contract. No. AF-49(638)-700), September 1965, 42 pp.

Miller, M. M. The Nuclear Airplane Now! Industrial Research, v. 12, No. 3, March 1970, pp. 48–50.

Nuclear Aircraft. PDP-74, Lockheed-Georgia Co.—A Division of Lockheed Aircraft Corp., Marietta, Georgia, April 1969, 79 pp.

Pinkel, B. The Impact of the High Development Cost of Advanced Flight Propulsion Systems on Development Policy. Memorandum RM-4560-PR, The RAND Corp., Santa Monica, Calif., (Prepared for: U.S. Air Force Project RAND under Contract No. AF-49(638)-700), October 1965, 64 pp.

Romig, Mary F. The Influence of Electric and Magnetic Fields on Heat Transfer to Electrically Conducting Fluids. Memorandum RM-3336-1-PR, The RAND Corp., Santa Monica, Calif., (Prepared for: U.S. Air Force Project RAND under Contract AF-49(638)-700), September 1965, 147 pp.

[8] Barnard, Paul G., Aaron G. Starliper, and H. Kenworthy. Bureau of Mines Research: Reclaiming Refractory Carbides and Cobalt From Cemented-Carbide Scrap. Secondary Raw Materials, v. 7, No. 9, September 1969, pp. 19–21.

[9] Ivanov, V. Ye, Ye. P. Nechiporenko, L. N. Yefinmenko and M. I. Yurchenko. High-temperature Oxidation Protection of Tungsten. Clearinghouse for Federal Scientific and Technical Information, Springfield, Va., NASA Technical Translation TT-F-583, August 1969, 125, pp.

[10] French, David N. The Microstructure and Microproperties of WC-Co Alloys. International J. of Powder Metallurgy, v. 5, No. 3, July 1969, pp. 47–60.

[11] French, David N. X-Ray Stress Analysis of WC-Co Cermets: 1, Procedures, J. of the American Ceramic Soc., v. 52, No. 5, May 21, 1969, pp. 267–271.

———. X-Ray Stress Analysis of WC-Co Cermets: 11, Temperature Stresses. J. of the American Ceramic Soc., v. 52, No. 5 May 21, 1969, pp. 271–275.

[12] Matching the Exotics: Subzero Coolents Work for Argonne. Steel, v. 164, No. 10, Mar. 10, 1969, pp. 49–52.

[13] King, George W. An Investigation of the Yield Strength of a Dispersion-Hardened W-3.8 vol-pct ThO_2 Alloy. Trans. of Met. Soc. of AIME, v. 245, No. 1, January 1969, pp. 83–89.

Walter, J. L., and A. U. Seybolt. Effect of ThO_2 Particles on Grain Growth and Preferred Orientation in Tungsten Sheet. Trans. of Met. Soc. of AIME, v. 245, No. 5, May 1969, pp. 1093–1099.

treatment.[14] The presence of this second phase (W_2N) altered the growth pattern of the depositing tungsten and eliminated the columnar grain growth present in former CVD techniques.

In a study to determine the high-temperature formability and ductility of tungsten and other refractory metals a special forge was designed which operates at controlled temperatures in a protective atmosphere to predetermined amounts of deformation.[15] Since the maximum temperature of 1800° C can be attained very rapidly, in 2 to 3 minutes, grain growth is reduced to a minimum while the controlled atmosphere prevents oxidation.

Tungsten metal filaments have been developed which are reinforced by boron-carbide (B_4C) coatings applied by vapor deposition.[16] These coated filaments are stronger than the starting material and use of this technique may result in a more stable filament.

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[14] Landingham, R. L., and J. H. Austin. Fine-Grain Tungsten by Chemical Vapor Deposition. J. of Less Common Metals, Amsterdam, the Netherlands, v. 18, No. 3, July 1969, pp. 229–243.

[15] Habermann, C. E., A. L. Rafalski, and R. D. Hansen. A High-Temperature Forge for Refractory Metals. J. Less Common Metals, Amsterdam, the Netherlands, v. 18, No. 2, June 1969, pp. 105–109.

[16] McCreight, Louis R. Boron Carbide Resists Heat. Metal Progress, v. 95, No. 3, March 1969, pp. 110, 113–116.

Uranium

By John G. Parker [1]

Evidence for the continuing long-term need for uranium raw material was shown in the increasing amount of exploration and development work conducted in 1969. Drilling for these purposes reached 29.9 million feet during the year, a 25-percent increase over 1968, the previous record year. Procurement by the U.S. Atomic Energy Commission (AEC) decreased 16 percent as that agency started phasing out its role as the chief purchaser of uranium ore concentrates. Exports of enriched uranium increased and future shipments were assured as the AEC signed a multilease contract with the European Atomic Energy Community (Euratom).

Legislation and Government Regulations.—Hearings before the Joint Committee on Atomic Energy included those on amendments to the Atomic Energy Act, radiation standards for uranium mining, environmental effects of producing electric power, and future ownership of gaseous diffusion plants.[2] The report quoted President Nixon's announcement on November 10 that he was requesting AEC to continue operating the uranium enrichment plants for an indefinite period until they could be sold to industry. A separate AEC directorate, managing the enrichment facilities, will maintain separate accounting records and publish periodic financial reports similar to those of commercial enterprises.[3] Bills before Congress during the year included S. 1628 and H.R. 9304 requesting Congressional consent for the Western Interstate Nuclear Compact, an agreement between States to provide for regional cooperation in nuclear matters, and H.R. 12493, which would amend the Atomic Energy Act of 1954, permitting a State, with AEC agreement, to establish standards for the discharge of radioactive material from a nuclear powerplant. The latter bill would, if enacted, authorize imposition by the States of more restrictive standards than are now imposed by AEC.

In response to a request from AEC early in the year to reduce deliveries of U_3O_8 due in 1969 and 1970 under procurement contracts, six companies proposed to decrease shipments to AEC by a total of 4,000 tons.[4] When all purchase contracts are completed, the AEC estimated it would have a surplus of about 50,000 tons of U_3O_8 in concentrates. AEC rules and regulations, including new regulations or amendments put into effect or proposed in 1969, also were reported in the Commission's report.[5]

[1] Physical scientist, Intermountain Field Operation Center, Denver, Colo.

[2] Congressional Record. Activities and Accomplishments of the Joint Committee on Atomic Energy in the 91st Congress, First Session (1969). Dec. 19, 1969, pp. H 12826-H 12830.

[3] U.S. Atomic Energy Commission. Major Activities in the Atomic Energy Programs. January–December 1969. January 1970, p. 43.

[4] Page 35 of work cited in footnote 3.

[5] Pages 60-62, 307-311 of work cited in footnote 3.

Table 1.—Salient uranium statistics

(Short tons)

	1965	1966	1967	1968	1969
United States:					
Mine ore shipments	4,385,995	4,352,651	5,276,038	6,446,829	5,883,527
Concentrate (U_3O_8 content):					
AEC procurement	10,442	9,487	8,425	7,338	6,184
Private industry sales [e]	------	100	700	5,000	4,750
Imports: Concentrate (U_3O_8)	2,986	2,123	1,309	470	1,504
Free world: Production (U_3O_8)	20,589	19,520	19,098	22,772	[p] 21,632

[e] Estimate. [p] Preliminary.

Radiation standards for mining were amended, pursuant to sections 1 and 4 of the Walsh-Healey Public Contracts Act.[6] In anticipation of the time when private industry will own and not lease uranium for reactor use, a system of accounting for nuclear fuel and byproduct materials was proposed.[7]

Three more States—North Dakota, South Carolina, and Georgia—signed agreements with the AEC whereby they assumed regulatory authority over the use of byproduct material, source material, and less-than-critical quantities of special nuclear material within their borders.[8]

The depletion allowance for both domestic and foreign mining of uranium ores was lowered from 23 to 22 percent. The new rate was effective with taxable years beginning after October 9, 1969.

DOMESTIC PRODUCTION

Mine and Mill Production.—About 310 mining operations in 7 States produced 5.9 million tons of uranium ore in 1969, 9 percent less than was produced by 320 operations in the previous year. New Mexico again was the leader in output with 50 percent of the total recoverable uranium oxide, followed by Wyoming with 28 percent and Colorado with 12 percent. Following in order were Texas, Utah, Arizona, and South Dakota.

During the year, 15 mills processed uranium ores and 10 of them shipped 6,184 tons of U_3O_8 concentrate to the AEC. This compared with 7,338 tons shipped from 16 mills in 1968. The mills which supplied the AEC during 1969, those which proposed to reduce deliveries to the AEC, and the five which sold only to private companies in 1969 are shown in table 3 (Uranium ore-processing plants, December 31, 1969).

As of January 1, 1970, AEC estimated that domestic ore reserves, at $8 or less per pound, totaled 204,080 tons U_3O_8 in 96.6 million tons of ore with an average grade of 0.21 percent. Most of the reserves were in deposits of Jurassic and early Tertiary age, in coarse clastic rocks, and occur largely in New Mexico and Wyoming. About 58 percent of the output would come from open pit mines; practically all of the rest were from underground operations.[9]

As an index of uranium exploratory and developmental activities, 75,900 holes with an average depth of 390 feet were drilled compared with 50,000 holes averaging 410 feet in depth in 1968. The 29.9 million feet total in drilling—46 percent in Wyoming, 22 percent in Texas, 19 percent in New Mexico, and the rest in 11 other States—was more than 25 percent greater than 1968, the previous record year.[10] Exploratory drilling amounted to 20.5 million feet, nearly 70 percent of the total.

The uranium ore-processing plant being built by Susquehanna-Western, Inc., in the Ray Point area of Live Oak County, Tex., will be expandable to 2,000 tons per day and was scheduled for operation in 1970.[11] Atlas Corp. made arrangements with the AEC to deliver 360,700 pounds of U_3O_8 in concentrate in 1969–70 instead of the original contract 3.2 million pounds. To sell the additional 2,839,300 pounds at the low contract price to AEC would mean that the Moab, Utah, uranium processing plant either would have to be closed in 1969 and 1970 or operate at substantial losses during those years. It would be beneficial to sell the additional output on the commercial market or to mill uranium ores on a custom or toll basis, especially because of fire losses sustained by the processing plant in late 1968.[12] Western Nuclear, Inc. terminated deliveries of uranium concentrate to AEC as of June 30, 1969, delivering only under commercial contract after that date. The Petrotomics mill, half owned by Kerr-McGee Corp., completed an expansion early in 1970, with the extra capacity being scheduled for custom milling ore from the North Walker mine.[13]

[6] U.S. Department of Labor. Part 50–204—Safety and Health Standards for Federal Supply Contracts. Radiation Standards in Mining; Procedures for Variations. 41 F.R. 6779, Apr. 23, 1969.

[7] U.S. Federal Power Commission. Nuclear Fuel. Uniform System of Accounts for Public Utilities and Licensees (Classes A and B) and FPC Form 1. 18 F.R. 11382-11384, July 9, 1969.

[8] Page 150 of work cited in footnote 3.

[9] U.S. Atomic Energy Commission. Statistical Data of The Uranium Industry. Jan. 1, 1970, Grand Junction, Colo., pp. 26, 29–30, 32–33.

[10] U.S. Atomic Energy Commission. U.S. Uranium Mining Industry Sets New Drilling Record of 29,900,000 Feet in 1969. Press Release N–14, Feb. 6, 1970, 3 pp.

[11] Skillings' Mining Review. Uranium Extracting Mill to be Built by McKee. V. 58, No. 26, June 28, 1969, p. 6.

[12] Atlas Corp. Annual Report, Fiscal Year ended June 30, 1969, 15 pp.

[13] Kerr-McGee Corp. Annual Report 1969, 28 pp.

The Cimarron Uranium Fuels Plant, Kerr-McGee's operation north of Oklahoma City, Okla., began producing uranium dioxide pellets from uranium hexafluoride for the commercial fuel market in the third quarter of 1969.[14]

Refining and Enrichment.—During 1969 over 3 million pounds of enriched uranium were shipped from the gaseous diffusion plant, operated for AEC by Union Carbide Corp., at Oak Ridge, Tenn.[15] The other two gaseous diffusion enrichment plants are at Paducah, Ky., also operated by Union Carbide, and the Portsmouth Gaseous Diffusion Plant near Piketon, Ohio, operated by Goodyear Atomic Corp. As part of a planned reduction in power usage by these plants, total use of electricity was reduced finally to 2 million kilowatts, a level of operation which was scheduled to continue into 1970.[16] The ownership and management of such facilities were discussed.[17] During 1969, the AEC sold nearly $61 million worth of uranium toll enrichment services, more than $46 million of which were for enriched uranium delivered to domestic firms.[18]

The Allied Chemical Corp. plant at Metropolis, Ill., was the only commercial uranium hexafluoride (UF_6) operation in the United States; it converted over 5,000 tons of uranium to UF_6 in 1969. At yearend, construction was completed on the Kerr-McGee Sequoyah UF_6 conversion plant in eastern Oklahoma, and it was expected that commercial deliveries of the material would come from the 5,000 tons-per-year operation by May 1970.[19] The commercial charges were quoted in the AEC publication.

Kerr-McGee also was building the Cimarron plutonium plant north of Oklahoma City to process and fabricate plutonium nuclear fuels.[20] The plant will process plutonium and plutonium-uranium solutions into ceramic powders, which then will be pressed and sintered to form fuel pellets. Standard Oil Co. (N.J.), through a subsidiary named Jersey Enterprises, Inc., said it will work with Battelle-Northwest in a uranium and plutonium fuel elements developmental program in the Richland, Pasco, and Kennewick area of eastern Washington.[21]

Heavy Water.—Production in the Savannah River heavy water plant, near Aikin, S.C., decreased slightly in 1969. As in previous years, total sales exceeded output and succeeded in further reducing the AEC inventory.[22]

[14] Work cited in footnote 13.
[15] Union Carbide Corp. Annual Report 1970, 28 pp.
[16] Pages 46-47 of work cited in footnote 3.
[17] U.S. Atomic Energy Commission. Summary Report by AEC Staff on Future Ownership and Management of Uranium Enrichment Facilities in the United States. March 1969, 31 pp.
[18] U.S. Atomic Energy Commission. AEC Sells $60.8 Million Worth of Uranium Toll Enrichment Services in 1969. Press Release N–18, Feb. 12, 1970, 2 pp.
[19] U.S. Atomic Energy Commission. The Nuclear Industry 1969. Dec. 3, 1969, pp. 44–45. Page 11 of work cited in footnote 13.
[20] Kermac News. Plutonium. April 1969, pp. 2–3.
[21] Chemical Engineering. V. 76, No. 7, Apr. 7, 1969, p. 67. Chemical & Engineering News. V. 47, No. 14, Mar. 31, 1969, p. 19.
[22] Page 54 of work cited in footnote 3.

Table 2.—Uranium mine and mill production in 1969, by States

State	Ore shipped		Recoverable U_3O_8 content			Number of mills	Concentrate purchased by AEC	
	Short tons	Value (thousands)	Percent	Thousand pounds	Value (thousands)		U_3O_8 thousand pounds	Cost (thousands)
Colorado	620,641	$11,772	0.24	2,736	$16,935	1	[1] 1,929	[1] $11,283
New Mexico	3,057,592	45,659	.20	11,811	69,887	3	8,208	48,009
Utah	298,746	4,531	.20	1,140	6,824	1	(1)	(1)
Wyoming	1,536,546	26,753	.23	6,716	40,318	4	2,230	13,044
Other States [2]	370,002	5,525	.19	1,344	8,196	1	(1)	(1)
Total	5,883,527	94,240	0.21	23,747	142,160	10	12,367	72,336

[1] Colorado, Utah, and other States combined to avoid disclosing individual company confidential data.
[2] Ore shipments: Arizona, South Dakota, and Texas; Mills: South Dakota 1; Concentrates: South Dakota.

Table 3.—Uranium ore-processing plants, December 31, 1969

State and company	Plant location	Nominal capacity, tons ore per day
Colorado:		
American Metal Climax, Inc. [1]	Grand Junction	500
Cotter Corp. [1]	Canon City	400
Union Carbide Corp	Rifle	1,500
Do	Uravan	
Pinnacle Exploration, Inc	Marshall Pass	(2)
New Mexico:		
The Anaconda Co	Bluewater	3,000
Kerr-McGee Corp. [3]	Grants	6,000
United Nuclear-Homestake Partners [3]	do	3,500
South Dakota: Mines Development, Inc. [1]	Edgemont	650
Texas:		
Susquehanna-Western, Inc. [1]	Falls City	1,000
Do	Ray Point	[4] 1,000
Utah: Atlas Corp. [3] [5]	Moab	1,500
Washington: Dawn Mining Co. [1]	Ford	[6] 450
Wyoming:		
Federal-American Partners [3]	Gas Hills	900
Petrotomics Co. [1]	Shirley Basin	[7] 1,000
Union Carbide Corp	Gas Hills	1,000
Utah Construction & Mining Co. [3]	Gas Hills	1,200
Do	Shirley Basin	[4] 1,200
Western Nuclear, Inc. [3]	Jeffrey City	1,200
Total		26,000

[1] Private sales only. Mines Development, Inc. shipped a small quantity to AEC.
[2] Concentrate recovery from recirculating mine water—TPD not applicable.
[3] Proposed to reduce deliveries to AEC, contracts with which terminate Dec. 31, 1970.
[4] Under construction.
[5] Damaged by fire in Dec. 1968 and operations resumed in July 1969.
[6] Operation commenced early in 1970.
[7] Expansion by 50 percent was completed early in 1970.

Sources: U.S. Atomic Energy Commission. Major Activities in the Atomic Energy Programs, January-December 1969, January 1970, p. 53; U.S. Atomic Energy Commission. The Nuclear Industry 1969. Dec. 3, 1969, p. 38.

CONSUMPTION AND USES

The trend toward private ownership of uranium was reflected in sales; about 43 percent of uranium concentrate by value, were shipped to private firms in 1969, an increase of 5 percent over the previous year's value, but a slight decrease by volume. Apparent consumption, however, based on these sales and lower AEC purchases was about 11 percent lower than in 1968.

Weapons and Explosive Applications.—Output from the production reactors at Hanford near Richland, Wash., and at Savannah River near Aiken, S.C., was directed primarily toward making weapons for existing tactical and strategic systems. Economic consideration led to the startup of a system at the Savannah River plant to reclaim components from stockpile and thus reduce the need for new production.[23] The Rocky Flats plutonium weapons fabricating plant near Denver, Colo., was heavily damaged by fire on May 11. Damage was estimated at $45 million; this figure includes the large amount spent on decontamination but not the cost of plutonium recovery. By late 1969, about 80 percent of the damaged building and more than 99 percent of the plutonium had been retrieved.[24]

Underground testing of nuclear explosives was conducted, mostly at AEC's Nevada Test Site.[25] A controversial underground nuclear calibration test was carried out at Amchitka Island, Alaska, on October 2, but no serious detrimental after effects were observed.[26] Project Rulison, a joint Government-industry experiment under the Plowshare program, was detonated on September 10 in Grand Valley, Colo., 45 miles northeast of Grand Junction.[27] By exploding a 40-kiloton nuclear device at a depth of 8,430 feet, the AEC, U.S. Department of the Interior, and Austral Oil Co., with CER Geonuclear Corp. acting as program

[23] Pages 70, 72 of work cited in footnote 3.
[24] Pages 72–74 of work cited in footnote 3. U.S. Atomic Energy Commission Press Release M-257. Nov. 18, 1969. 6 pp.
[25] Pages 74–77, 305 of work cited in footnote 3.
[26] Pages 75–76 of work cited in footnote 3. U.S. Atomic Energy Commission. Press Release M-240, Oct. 22, 1969. 6 pp.
[27] Pages 195, 198 of work cited in footnote 3. Page 239 of work cited in footnote 19. Canadian Mining Journal. Rulison Detonated. V. 90, No. 10, October 1969, p. 27.

manager, hoped to stimulate natural gas recovery from the Mesaverde formation. Like the Amchitka experiment this, too, was the subject of considerable controversy, but there was no release of radiation to the atmosphere. Production tests were scheduled during 1970. Results of an earlier experiment, Project Gasbuggy, conducted in the San Juan basin, N. Mex., by El Paso Natural Gas Co., AEC, and the U.S. Bureau of Mines in December 1967, indicated an eightfold increase in production from the rock formations was possible because of the explosion.[28]

Civilian Reactors.—New estimates made by the AEC for the growth of nuclear power indicated that there would be 130,000 to 170,000 Mwe of installed nuclear power by 1980, but recent projections by private institutions showed a range of 160,000 to 195,000 Mwe by that time.[29]

In 1969 nuclear electrical capacity was increased by over 1,500 Mwe as three new plants—Oyster Creek Nuclear Power Plant, Unit 1, Toms River, N.J.; Nine Mile Point Nuclear Station, Scriba, N.Y.; and Robert Emmett Ginna Nuclear Power Plant, Unit 1, Ontario, N.Y.—went critical. The Oyster Creek boiling water reactor, about 35 miles north of Atlantic City, became operational on May 3 and reached its authorized power level on December 7. The Nine Mile Point reactor, also a boiling water type which is located on the shore of Lake Ontario about 7 miles northeast of Oswego, became operational on September 5. The Robert Emmett Ginna plant, which became operational on November 9, is a pressurized water reactor also situated on Lake Ontario, about 16 miles from Rochester.[30] Table 4 lists all domestic central-station nuclear powerplants which were in operation, being built, or planned at yearend.

[28] Page 198 of work cited in footnote 3.
[29] Pages 136–137 of work cited in footnote 19.
[30] Pages 121–122 of work cited in footnote 3.

Table 4.—Principal domestic civilian nuclear power reactors

Reactor	Location	Type [1]	Electrical capacity, megawatts (Mwe)	Initial criticality
OPERABLE				
Shippingport Atomic Power Station	Shippingport, Pa	PWR	90	1957
Dresden Nuclear Power Station, Unit 1	Morris, Ill	BWR	200	1959
Yankee Nuclear Power Station	Rowe, Mass	PWR	175	1960
Big Rock Point Nuclear Plant	Big Rock Point, Mich	BWR	70	1962
Elk River Reactor	Elk River, Minn	BWR	22	1962
Indian Point Station, Unit 1	Indian Point, N.Y	PWR	265	1962
Enrico Fermi Atomic Power Plant	Lagoona Beach, Mich	FBR	61	1963
Humboldt Bay Power Plant, Unit 3	Eureka, Calif	BWR	69	1963
Peach Bottom Atomic Power Station, Unit 1	Peach Bottom, Pa	HTGR	40	1966
San Onofre Nuclear Generating Station	San Clemente, Calif	PWR	430	1967
LaCrosse Boiling Water Reactor	Genoa, Wis	BWR	50	1967
Connecticut Yankee Atomic Power Plant	Haddam Neck, Conn	PWR	575	1967
Oyster Creek Nuclear Power Plant, Unit 1	Toms River, N.J	BWR	515	1969
Nine Mile Point Nuclear Station	Scriba, N.Y	BWR	500	1969
Robert Emmett Ginna Nuclear Power Plant, Unit 1	Ontario, N.Y	PWR	420	1969
Total operable capacity			3,482	
UNDER CONSTRUCTION				
Dresden Nuclear Power Station, Units 2 and 3	Morris, Ill	BWR	1,618	1970
Millstone Nuclear Power Station, Unit 1	Waterford, Conn	BWR	652	1970
H. B. Robinson S.E. Plant, Unit 2	Hartsville, S.C	PWR	700	1970
Palisades Nuclear Power Station, Unit 1	South Haven, Mich	PWR	700	1970
Monticello Nuclear Generating Plant	Monticello, Minn	BWR	545	1970
Quad-Cities Station, Units 1 and 2	Cordova, Ill	BWR	1,618	1970–71
Point Beach Nuclear Plant, Units 1 and 2	Two Creeks, Wis	PWR	994	1970–71
Surry Power Station, Units 1 and 2	Gravel Neck, Va	PWR	1,560	1970–71
Oconee Nuclear Station, Units 1, 2, and 3	Seneca, S.C	PWR	2,613	1970–72
Vermont Yankee Generating Station	Vernon, Vt	BWR	514	1971
Fort Calhoun Station, Unit 1	Fort Calhoun, Nebr	PWR	457	1971
Pilgrim Station	Plymouth, Mass	BWR	625	1971
Fort St. Vrain Nuclear Generating Station	Platteville, Colo	GCR	330	1971
Cooper Nuclear Station	Brownville, Nebr	BWR	778	1971
Browns Ferry Nuclear Power Plant, Units 1, 2, and 3	Decatur, Ala	BWR	3,194	1971–72
Turkey Point Station, Units 3 and 4	Turkey Point, Fla	PWR	1,303	1971–72

See footnotes at end of table.

Table 4.—Principal domestic civilian nuclear power reactors—Continued

Reactor	Location	Type [1]	Electrical capacity, megawatts (Mwe)	Initial criticality
UNDER CONSTRUCTION—Continued				
Peach Bottom Atomic Power Station, Units 2 and 3	Peach Bottom, Pa	BWR	2,130	1971–72
Indian Point Station, Units 2 and 3	Indian Point, N.Y	PWR	1,838	1971–73
Zion Station, Units 1 and 2	Zion, Ill	PWR	2,100	1971–73
Diablo Canyon Nuclear Power Plant, Unit 1	Diablo Canyon, Calif	PWR	1,060	1972
Maine Yankee Atomic Power Plant	Wiscasset, Maine	PWR	790	1972
Kewaunee Nuclear Power Plant	Carlton, Wis	PWR	527	1972
Crystal River Plant, Unit 3	Red Level, Fla	PWR	858	1972
Rancho Seco Nuclear Generating Station, Unit 1	Clay Station, Calif	PWR	800	1972
Edwin I. Hatch Nuclear Plant, Unit 1	Baxley, Ga	BWR	786	1972
Arkansas Nuclear One	London, Ark	PWR	850	1972
Calvert Cliffs Nuclear Power Plant, Units 1 and 2	Lusby, Md	PWR	1,600	1972–73
Donald C. Cook Plant, Units 1 and 2	Bridgman, Mich	PWR	2,114	1972–73
Three Mile Island Nuclear Station, Units 1 and 2	Goldsboro, Pa	PWR	1,641	1972–73
Salem Nuclear Generating Station, Units 1 and 2	Salem, N.J	PWR	2,100	1972–73
Prairie Island Nuclear Generating Plant, Units 1 and 2	Red Wing, Minn	PWR	1,060	1972–74
Total capacity under construction			38,455	
PLANNED				
Beaver Valley Power Station, Unit 1	Shippingport, Pa	PWR	847	1972
Hutchinson Island, Unit 1	Fort Pierce, Fla	PWR	800	1973
Duane Arnold Energy Center, Unit 1	Palo, Iowa	BWR	545	1973
James A. FitzPatrick Nuclear Power Plant	Scriba, N.Y	BWR	821	1973
Millstone Nuclear Power Station, Unit 2	Waterford, Conn	PWR	828	1973
North Anna Power Station, Unit 1	Mineral, Va	PWR	845	1973
Diablo Canyon Nuclear Power Station, Unit 2	Diablo Canyon, Calif	PWR	1,060	1973
Enrico Fermi Atomic Power Plant, Unit 2	Lagoona Beach, Mich	BWR	1,126	1973
Sequoyah Nuclear Power Plant, Units 1 and 2	Daisy, Tenn	PWR	2,248	1973–74
Brunswick Steam Electric Plant, Units 1 and 2	Southport, N.C	BWR	1,642	1973–75
Malibu Nuclear Plant, Unit 1	Corral Canyon, Calif	PWR	462	1974
Trojan Nuclear Plant, Unit 1	Rainier, Oreg	PWR	1,106	1974
Davis-Besse Nuclear Power Station	Oak Harbor, Ohio	PWR	872	1974
Joseph M. Farley Nuclear Plant	Dothan, Ala	PWR	829	1974
Consolidated Edison Co	Verplanck, N.Y	BWR	1,115	1975
Shoreham Nuclear Power Station	Brookhaven, N.Y	BWR	819	1975
William H. Zimmer Nuclear Power Station, Units 1 and 2	Moscow, Ohio	BWR	1,680	1975–76
Philadelphia Electric Co., Units 1 and 2	Pottstown, Pa	BWR	2,130	1975–77
Public Service Electric & Gas Co., Units 1 and 2	Newbold Island, N.J	BWR	2,200	1975–77
Oyster Creek Nuclear Plant, Unit 2	Toms River, N.J	PWR	1,100	1976
Bailly Generating Station	Dunes Acres, Ind	BWR	515	1976
Carolina Power & Light Co	North Carolina	BWR	821	1976
Pennsylvania Power & Light Co., 2 units	Not determined	BWR	2,104	1976–78
Bell Station	Lansing, N.Y	BWR	838	Not given
Duke Power Co., 2 units	Not determined	PWR	2,200	1977–79
Seabrook Nuclear Station	Seabrook, N.H	PWR	860	Not given
Total planned capacity			30,413	
Grand total			72,350	

[1] BWR Boiling light water cooled, light water moderated reactor.
FBR Fast Breeder Reactor.
GCR Gas cooled, graphite moderated reactor.
HTGR High temperature gas cooled, graphite moderated reactor.
PWR Pressurized light water moderated and cooled reactor.

Source: Adapted from "Nuclear Reactors Built, Being Built, or Planned in the United States as of Dec. 21, 1969," AEC Division of Technical Information, TID-8200 (21st Rev.) pp. 7–9.

It is apparent that boiling light water and pressurized light water reactors predominate. However, it is realized that other reactor concepts may prove economically feasible and some, such as the high-temperature gas cooled reactors (HTGR), have good neutron economy and contribute less thermal pollution to the environment. An example of this is the 40-Mwe HTGR plant at Peach Bottom, Pa., which had accumulated 453,600,000 kwh by October 3 when it was shut down for a periodic inspection. Also, construction was proceeding on the 330-Mwe Fort St. Vrain HTGR plant at Platteville, Colo., which was scheduled for initial operation in 1972. Further, the Molten Salt Reactor Experiment (MSRE) at Oak Ridge, Tenn., which is providing important data on problem areas of molten salt breeder reactor systems, was operated from October 2, 1968 to December 12, 1969, using both uranium-233 and uranium-235 fuel.[31] The status of other test reactors is shown in Chapter 5 of the AEC annual report.

With the proliferation of atomic powerplants has come the need for commercial fuel reprocessing plants. Necessarily, the AEC is concerned with safety, location, and disposal of the radioactive wastes. It proposed a policy permitting the plants to be located on private property, and the wastes, converted to AEC-approved solid form, to be shipped as soon as practicable to a Federal waste repository.[32] A 300-metric-ton-per-year plant was operated at West Valley, N.Y., by Nuclear Fuel Services, Inc., in which Getty Oil Co. purchased the majority share once held by W. R. Grace & Co.[33] Also, the General Electric Co. was building a 300-metric-ton annual capacity plant at Morris, Ill., and Atlantic Richfield Co. announced that it would build a $60 million plant, capable of processing 5 metric tons per day spent nuclear fuel in Chester County, S.C.[34]

Dual Purpose Reactors.—The "N" reactor at Hanford continued producing plutonium and byproduct steam. The steam was supplied to the Washington Public Power Supply System (WPPSS) generating plant which had an output in 1969 of 3.8 billion kilowatt hours (kwhr).[35]

Naval Reactors.—Eighty-six of the 110 nuclear-powered submarines authorized by Congress, including all 41 Polaris types and one deep-submergence research submarine, the NR–1, were in operation. In addition, four of the nine nuclear-powered surface ships were in operation. These ships, all of which have been deployed in Vietnam waters, are the aircraft carrier *Enterprise*, the guided-missile crusier *Long Beach*, and the guided-missile frigates *Bainbridge* and *Truxtun*.[36] Two guided-missile nuclear frigates are being built. The two reactors to be used in the aircraft carrier *Nimitz*, now under construction, each have about as much power as four of the *Enterprise* reactors. A sister ship was authorized by Congress in 1969.

Reactors for Export.—Two licenses were granted, both to one domestic firm, for the export of pressurized water power reactors. One license authorized export of components for an 810-Mwe reactor to be built near Gothenburg, Sweden; the second was for exporting parts for a 350-Mwe reactor to be constructed near Breznau, Switzerland.[37] In 1969, 33 large enriched uranium power reactors of the U.S. type were in operation, under construction, or on order in 12 foreign countries.[38] Ten were in operation. Those in operation were the 240-Mwe SENA plant in France, the 237-Mwe KRB, 240-Mwe KWL, and 283-Mwe KWO plants in West Germany, the 380-Mwe Tarapur plant in India, the 164-Mwe SENN and 257-Mwe SELNI plants in Italy, the 322-Mwe Japco #2 plant in Japan, the 153-Mwe Cabrera #1 plant in Spain, and the 350-Mwe NOK-1 plant in Switzerland.

Radioisotopes.—Although AEC was gradually withdrawing from production of radioisotopes, it encouraged industry to enter production, especially when it offered to loan high specific activity cobalt-60 free to organizations willing to perform heat source applications research and development at their own expense.[39] Sales from the Oak Ridge National Laboratory Isotopes Development Center during the first 11 months of 1969 totaled over 2.3 million curies of processed radioisotopes, which was a decrease of 32 percent over the same period in 1968. Following cancellation of the SNAP–29 program to develop a polonium-210 fueled thermoelectric generator for space flight, AEC increased its price for the isotope. Fuels for the Systems for Nu-

[31] Pages 95, 98–99 of work cited in footnote 3.
[32] U.S. Atomic Energy Commission. AEC Seeks Comment on Proposed Policy on Siting of Fuel Reprocessing Plants and Disposal of Wastes. Press Release M–132, June 2, 1969, 3 pp.
[33] Chemical & Engineering News. Upturn Ahead for Nuclear Industry in 1972. V. 47, No. 45, Oct. 27, 1969, pp. 36, 41.
Getty Oil Co. 41st Annual Report 1969, 36 pp.
Mining Congress Journal. V. 55, No. 4, Apr. 1969, p. 24.
[34] Chemical Week. V. 104, No. 16, Apr. 19, 1969, p. 62.
[35] Page 47 of work cited in footnote 3.
[36] Pages 81–84 of work cited in footnote 3.
[37] Page 130 of work cited in footnote 3.
[38] Pages 161–162 of work cited in footnote 19.
[39] Pages 10, 57–58 of work cited in footnote 3.

clear Auxiliary Power (SNAP) power systems operating, cancelled, or proposed include polonium-210, plutonium-238, and curium-242.[40] A proposed price increase for cesium-137 was cancelled by AEC because of a rapidly increasing sales rate and a reduction in production and distribution costs. Other applications of and new developments in radioisotopes are shown in chapters 9 and 10 of the AEC annual report. These include radiation processing to produce wood polymers and concrete polymers, radiation preservation of food, radioisotope X-ray fluorescence, and medical isotopes such as gallium-67, technetium-99, strontium-90, and cobalt-60. The market for reactor-produced radioisotopes was expected to grow at about 25 percent annually for the next several years.[41]

[40] Page 174 of work cited in footnote 3.
[41] Page 187 of work cited in footnote 19.

Table 5.—Projected commercial uranium requirements and sales [1]

(Tons of U_3O_8)

Year of delivery	Domestic sales and commitments		Projected domestic requirements (cumulative)
	Annual	Cumulative	
Pre-1969	5,700	5,700	------
1969	4,300	10,000	4,000
1970	9,000	19,000	11,500
1971	11,000	30,000	19,000
1972	13,200	43,200	30,000
1973	10,900	54,100	43,500
1974	8,900	63,100	58,700
1975	6,400	69,400	75,900
1976	2,700	72,100	96,300
1977	1,900	74,000	120,000
1978–82	3,600	77,600	292,500

[1] Of the 67,600 tons committed for delivery in 1970–1982, 1,300 tons is committed to overseas customers.

Source: U.S. Atomic Energy Commission. Major Activities in the Atomic Energy Programs. January–December 1969. January 1970, pp. 36–37.

Table 6.—Heavy water (D_2O) activity

(Short tons)

	1965	1966	1967	1968	1969
Domestic production	NA	186	207	206	197
Domestic sales	4	7.3	6	8	5.3
Domestic leases	--	38.4	62	--	--
Foreign shipments (sales)	27.4	232	334	245	[1] 230
Foreign leases	186	94	14.5	--	--

NA Not available.

[1] Heavy water commitments for foreign sales during next 2 to 3 years exceed 1,600 tons.

Source: AEC Major Activities in the Atomic Energy Programs, Yearly Reports.

Table 7.—Enriched uranium furnished to industry, excluding the weapons production chain

(Pounds, uranium)

	Fiscal year				
	1965	1966	1967	1968	1969
Furnished as UF_6	336,832	630,015	374,745	854,022	1,536,194
Furnished in forms other than UF_6	3,177	11	212	139	----
Total	340,009	630,026	374,957	854,161	1,536,194

Source: U.S. Atomic Energy Commission. The Nuclear Industry 1969. Dec. 3, 1969, p. 75.

Table 8.—Principal producers and fabricators of nuclear fuels

Company and location	Producer of uranium fuels		Fabricators of uranium fuels		Plutonium capability
	Metals, oxides, or compounds	Coated particles	Oxides	Metal	
Aerojet-General Corp., San Ramon, Calif	-------	-------	-------	X	X
Atomics International, Div. of North American Rockwell Corp., Canoga Park, Calif	-------	-------	X	X	X
The Babcock and Wilcox Co., Lynchburg, Va	-------	-------	X	-------	X
Combustion Engineering, Inc., Windsor, Conn	-------	-------	X	-------	-------
General Electric Co., San Jose, Calif	X	-------	X	-------	X
General Electric Co., Wilmington, N.C	X	-------	X	-------	-------
Gulf General Atomic, Inc., San Diego, Calif	-------	X	-------	X	-------
Kerr-McGee Corp., Oklahoma City, Okla	X	-------	-------	-------	-------
M&C Nuclear, Inc., Attleboro, Mass	-------	-------	-------	X	-------
National Lead Co., Albany, N.Y	X	-------	-------	X	-------
Nuclear Fuel Services, Inc., Erwin, Tenn	X	X	-------	-------	X
Nuclear Materials and Equipment Corp., Apollo, Pa	X	X	X	X	-------
Nuclear Materials and Equipment Corp., Leechburg, Pa	X	X	-------	X	X
Nuclear Metals Div., Whittaker Corp., West Concord, Mass	-------	-------	-------	X	-------
United Nuclear Corp., New Haven, Conn	-------	-------	X	X	-------
United Nuclear Corp., Hematite, Mo	X	X	-------	-------	-------
United Nuclear Corp., Pawling, N.Y	-------	-------	-------	-------	X
Westinghouse Electric Corp., Cheswick, Pa	-------	-------	X	-------	X
Westinghouse Electric Corp., Columbia, S.C	X	-------	X	-------	-------

Source: U.S. Atomic Energy Commission. The Nuclear Industry, 1969. Dec. 3, 1969, pp. 69, 72, 74, 84.

PRICES AND SPECIFICATIONS

Ore and Concentrate.—Only about 10 percent of all domestic ore reserves and production is controlled by small, independent miners who sell material under individually negotiated contracts. Although ore prices are not quoted, most mines were believed to charge prices similar to those in AEC Circular 5, which expired in 1962. Prices quoted in that circular, ranged from $1.50 per pound of contained U_3O_8 for ore grade of 0.10 percent to about $3.50 per pound for ore grade of 0.20 percent or more U_3O_8.

In 1969, the AEC contract price for specification grade concentrates was based on a formula first set forth in 1962 according to which the AEC will pay $1.60 per pound of U_3O_8, plus 85 percent of the allowable production costs during the preceding 6 years, with the maximum being $6.70 per pound. It was expected that the weighted average price per pound for deliveries to AEC in 1969–70 would be $5.86. In 1969, uranium concentrate containing 6,184 tons of U_3O_8 (12,367,123 pounds) was purchased by AEC from domestic mills for a total of $72,336,000. The assumed price for U_3O_8 concentrates sold to private industry was $6.10 per pound, which would make the total quantity sold to industry in 1969 worth about $58 million.

Refined Uranium.—Normal uranium metal was quoted periodically in American Metal Market at $18 to $24 per pound. Depleted uranium with less than 0.38 percent uranium-235, in the form of uranium hexafluoride (UF_6), was quoted at $2.50 per kilogram ($1.13 per pound) of contained uranium.

Special Nuclear Materials.—Base charges by the AEC per kilogram of uranium as UF_6 were $46.62, $139.69, and $450.49 for 1.0, 2.0, and 5.0 percent uranium-235 enrichment, respectively.[42] Enriched uranium was leased by the AEC to private parties at an annual charge (applied to base charges) which was 5.5 percent until April, 6.5 percent until November, and 7.5 percent thereafter. In January 1969, as a result of the Private Ownership of Special Nuclear Materials Act approved August 1964, the AEC began enriching privately owned uranium on a toll basis. The charge was $26 per kilogram of separative work unit (a measure of work done, not weight). Also, in accordance with an AEC ruling, lessees of enriched uranium would

[42] U.S. Atomic Energy Commission. Uranium Hexafluoride: Base Charges, Use Charges, Special Charges. Table of Enriching Services, Specifications, and Packaging. 32 F.R. 16289, Nov. 29, 1967.
Page 53 of work cited in footnote 19.

be allowed to purchase it starting in April 1969 by paying the required amounts of uranium feed and money.

Heavy Water.—In December 1969, AEC increased the sales price of heavy water by $1.50 to $30.00 per pound.[43] The increase was needed due to general escalation of salaries, wages, materials, and increased power costs. The new figure also became the base charge used to determine the cost of leasing heavy water.

Plutonium.—Through June 30, 1969, the base charge for plutonium of standard isotopic assays (Pu with 6 to 12 weight percent Pu^{240}, inclusive) was $43 per gram of the contained Pu^{239} plus Pu^{241}.[44] Base prices for other grades of plutonium also were reported and are given below:

Percent Pu^{240} in plutonium	Prices per gram of Pu^{239} plus Pu^{241} in plutonium
3	$60
6	48
8	43
12	42
25	60
30	70

Plutonium, having an isotopic purity of 90 percent Pu^{242} or higher, was presented for sale for the first time.[45] Pu^{242}, priced at $15.89 per milligram, is produced by irradiating Pu^{239} in nuclear reactors.

[43] U.S. Atomic Energy Commission. AEC To Increase Price of Heavy Water. Press Release M-272, Dec. 10, 1969.
[44] U.S. Atomic Energy Commission. Plutonium and Uranium Enriched in U^{233}: Charges. 33 F.R. 15353, Oct. 16, 1968.
[45] U.S. Atomic Energy Commission. High Purity Isotopes of Thorium, Uranium, and Plutonium Available for Sale By AEC. Press Release M-158, July 9, 1969, 2 pp.

FOREIGN TRADE

A small quantity of uranium ores and concentrates, expressed as U_3O_8 content, was exported to Egypt; this was the first shipment of U_3O_8 ore and concentrates from this country since 1966. Exports of uranium and thorium and their alloys, wrought and unwrought, totaled 788 pounds valued at $26,182, about 13 percent in quantity and 21 percent in value compared with those of 1968. About 47 percent was shipped to Canada, 21 percent to West Germany, and the rest to five other countries. Exports of uranium and thorium compounds totaling 105,620 pounds worth $316,561 were 93 percent by weight and 98 percent in value of those shipped in 1968. Thirty two percent of the uranium and thorium compounds was shipped to the United Kingdom, 19 percent to Japan, 12 percent to the Netherlands, 9 percent to South Vietnam, and the remainder to 12 other countries.

Table 9.—Exports of AEC produced nuclear materials, by countries, in calendar year 1969

(Pounds)

Country [1]	Enriched uranium: Less than 20 percent U^{235}: Total U	Less than 20 percent U^{235}: U^{235}	Greater than 20 percent U^{235}: Total U	Greater than 20 percent U^{235}: U^{235}	Uranium −233	Plutonium (Pu)	Heavy water (D_2O)
Australia	-------	-------	-------	-------	-------	(2)	3,992
Canada	5,049	181	377	351	-------	(2)	372,572
Euratom:							
Belgium	-------	-------	302	258	-------	(2)	-------
France	-------	-------	441	390	-------	-------	-------
Germany	228,015	4,758	1,808	1,080	-------	250	8,907
Italy	29,617	683	106	95	6	-------	878
Netherlands	7,123	176	68	62	-------	-------	-------
International Atomic Energy Agency (IAEA):							
Austria	-------	-------	-------	-------	-------	(2)	-------
Israel	-------	-------	7	4	-------	-------	-------
Italy	-------	-------	82	73	-------	-------	36,427
Japan	220,319	4,548	159	143	-------	129	41,916
Pakistan	-------	-------	-------	-------	-------	-------	16,467
Sweden	77,478	1,861	-------	-------	-------	(2)	-------
Switzerland	57,745	1,922	40	35	-------	-------	375
United Kingdom	61,731	1,263	573	536	-------	(2)	-------
Total	687,077	15,392	3,963	3,027	6	379	481,534

[1] Represents country of initial destination. May not be country of final destination.
[2] Less than ½ unit.

Source: Division of International Affairs, U.S. Atomic Energy Commission.

Quantities of exports of enriched uranium, uranium 233, plutonium, and heavy water, reported by AEC, are shown in table 9. The value of special nuclear materials exported in 1969 was three times that exported in 1968; large increases were made in shipments to West Germany, Japan, and the United Kingdom (table 10).

Table 10.—U.S. exports of special nuclear material,[1] by countries

(Thousand dollars)

Country	1965	1966	1967	1968	1969
Argentina	82	87	------	120	1
Australia	169	61	------	------	2
Belgium-Luxembourg	8,831	2,729	236	------	498
Canada	258	1,827	349	317	2,551
France	4,699	4,945	7,102	3,521	2,109
Germany, West	16,734	23,505	24,524	8,103	28,977
India	------	------	7,264	2	------
Italy	574	5,727	175	4,463	1,281
Japan	400	212	1,314	3,038	37,087
Netherlands	272	------	16	------	1
Sweden	236	58	71	332	427
Switzerland	------	26	------	8,188	8,982
Spain	------	49	2,956	------	2
United Kingdom	3,144	2,668	6	343	5,819
Other	160	12	2	1	29
Total	35,559	41,906	44,015	28,428	87,766

[1] Includes plutonium, uranium-233, uranium-235, and uranium enriched in istopes U^{233} and U^{235}.

Table 11.—U.S. exports of radioactive isotopes, compounds, and elements, n.e.c., by major countries [1]

(Thousand curies and thousand dollars)

Country	1968		1969	
	Quantity	Value	Quantity	Value
Arabia, n.e.c	6,168	$12	24,590	$33
Argentina	15,950	61	97,062	94
Australia	33,084	119	23,425	155
Belgium-Luxembourg	20,667	236	37,813	212
Brazil	14,603	24	6,486	40
Canada	314,099	743	721,445	1,585
Ceylon	302	45	---------	-----
Chile	3,786	16	5,257	30
Colombia	4,077	21	14,232	21
Egypt	10,420	21	23,240	10
France	548,534	330	18,652	260
Germany, West	123,151	499	333,464	585
Iceland	192,000	4	---------	-----
Indonesia	20,092	15	15,187	29
Israel	12,488	40	55,806	94
Italy	10,713	52	404,190	75
Japan	129,407	497	2,346,147	880
Kuwait	---------	-----	104,252	12
Libya	---------	-----	116,222	19
Mexico	12,989	124	20,468	82
Netherlands	16,704	33	30,059	104
New Zealand	2,307	11	1,373	7
Nicaragua	1,097	22	2	1
Nigeria	534,678	27	709,905	11
Peru	5,589	12	8,595	7
Saudi Arabia	---------	-----	1,306	15
South Africa, Republic of	13,953	22	20,135	13
Spain	14,202	54	22,267	22
Sweden	8,187	54	10,873	36
Switzerland	63,723	154	73,214	121
Taiwan	23,942	25	165	8
United Kingdom	80,774	348	280,594	510
Venezuela	6,243	29	37,405	63
Other	87,995	303	106,013	261
Total	2,331,924	3,953	5,669,844	5,395

[1] Includes radium, radium salts, and cobalt-60.

As shown in table 11, almost 2½ times as many radioactive isotopes, compounds, and elements were shipped in 1969 as in the previous year; 41 percent were sent to Japan (a large increase over 1968), 13 percent each to Canada and Nigeria, 7 percent to Italy, 6 percent to West Germany, 5 percent to the United Kingdom, and the remainder to 26 other countries.

Again in 1969, as has been the case since 1966, no uranium concentrates (U_3O_8) were imported for the AEC stockpile. Although the unit value decreased about 9 percent, imports for private users were about three times greater in quantity than those of the previous year (table 12) and practically all came from the Republic of South Africa. By law foreign uranium cannot be enriched in this country and then used in domestic reactors; it is probable, therefore, that the domestic private firms are, or will be, using most of what they import in reactors being built in foreign lands. Imports of other uranium compounds totaled 639 tons valued at $8,349,515; 88 percent came from Canada and the rest from the United Kingdom and the Republic of South Africa. Shipments of cobalt-60 (Co^{60}), predominantly from Canada, as shown in table 13, were 39 percent greater than those in 1968, by quantity, and 48 percent greater by value.

Table 12.—U.S. imports for consumption of uranium oxide, by countries

Country	1965		1966		1967		1968		1969	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Canada	741	$13,606	635	$11,892	106	$2,051	2	$30	165	$2,115
France	-----	------	-----	------	-----	------	-----	------	(1)	2
Germany, West	-----	------	-----	------	-----	------	18	186	(1)	11
Italy	-----	------	-----	------	-----	------	-----	------	(1)	(1)
Japan	(1)	(1)	-----	------	(1)	(1)	-----	------	-----	------
South Africa, Republic of	2,245	44,497	1,488	29,394	1,045	8,146	386	3,992	1,339	12,473
Spain	-----	------	-----	------	158	2,396	64	792	-----	------
Total	2,986	58,103	2,123	41,286	1,309	12,593	470	5,000	1,504	14,601

[1] Less than ½ unit.

Table 13.—U.S. imports for consumption of cobalt-60, by countries

Country	1967		1968		1969	
	Curie	Value (thousands)	Curie	Value (thousands)	Curie	Value (thousands)
Canada	379,575	$1,005	807,789	$1,390	1,115,269	$2,044
France	---------	---------	---------	---------	366	8
Germany, West	---------	---------	---------	---------	74	(1)
Saudi Arabia	---------	---------	---------	---------	9,387	2
South Africa, Republic of	---------	---------	---------	---------	30	3
United Kingdom	---------	---------	---------	---------	93	2
Total	379,575	1,005	807,789	1,390	1,125,219	2,059

[1] Less than ½ unit.

WORLD REVIEW

A European Nuclear Energy Agency report, giving production and capacities by countries, forecasts a 60 to 70 percent rise in short-term Free World uranium demand.[46] The current level of 23,500 tons U_3O_8 per year was expected to rise to 38,000 tons per year by 1973–74. This is based on projections of 100,000 to 125,000 Mwe of installed nuclear power capacity by 1975.

The Executive Commission of the European Economic Community (European Common Market) sought removal of restrictions, such as limits on quality and

[46] Organisation for Economic Co-Operation and Development. Uranium-Production and Short Term Demand. A Joint Report by the European Nuclear Energy Agency, Paris, France, and the International Atomic Energy Agency, Vienna, Austria, January 1969, 29 pp.

quantity, on supply from the United States to member countries. On November 1, a new multi-lease contract for enriched uranium was signed by Euratom and the U.S. Atomic Energy Commission, effective through December 31, 1970.[47] The new contract was said to conform closely to leasing conditions in effect for American users; it will expire at the time that the USAEC will have to review and standardize its terms and conditions of supply for all users.

On November 25, an agreement was reached in London to build uranium enrichment plants in two European countries, using the gas centrifuge technique which is cheaper than the gaseous diffusion process now used in the United States, the United Kingdom, and France.[48] The agreement was subject to the approval of the participating governments—West Germany, the United Kingdom, and the Netherlands. The plants, which will be ready by 1973, will be built at Almelo in the Netherlands, and at Capenhurst in the United Kingdom. They will be operated by the tripartite Enrichment Organization.

Argentina.—Uranium deposits, with ore of high quality and favorable for processing in the Malarque mill, were discovered near San Rafael in the province of Mendoza.[49]

Australia.—Uranium oxide fuel pellets will be produced in a pilot plant which was being built by the country's Atomic Energy Commission.[50] After the Sentinel Mining Co., which mines iron ore in Western Australia, reevaluated its opportunities and decided to limit its participation in the nuclear excavation of a harbor at Cape Keraudren, the Australian Atomic Energy Commission and the United States Atomic Energy Commission concluded that there was insufficient economic basis for continuing this study.[51] Subsequently, however, the managing director of Hamersley Iron Ore, Pty. Ltd., announced that he wanted to excavate iron ore in Western Australia by means of nuclear explosives.[52] To be approved by the Federal and Western Australian State Governments, the project would have to be proved safe, be economically superior to conventional methods, and have "visible" financial sponsors.

[47] Metal Bulletin. EEC Seeks U Freedom. No. 5405, June 10, 1969, p. 18.
American Metal Market. Lease Contract for Uranium. V. 76, No. 214, Nov. 12, 1969, p. 22.

[48] Bureau of Mines. Mineral Trade Notes. V. 67, No. 4, April 1970, p. 30.

[49] Mining Journal, (London). V. 273, No. 7007, Dec. 5, 1969, p. 515.

[50] Chemical Week. V. 105, No. 13, Sept. 27, 1969, p. 58.

[51] U.S. Atomic Energy Commission. U.S.—Australian Atomic Energy Commissions Decide Not to Proceed with Cape Keraudren Study. Press Release M-76, Mar. 29, 1969, 1 p.

[52] U.S. Embassy, Canberra, Australia. State Department Airgram A-405, Sept. 12, 1969, 2 pp.

Table 14.—Free world production of uranium oxide (U_3O_8), by country

(Short tons)

Country [1]	1967	1968	1969 [p]
Argentina	[r] 25	47	40
Australia [e]	330	330	330
Canada	3,738	3,700	3,855
France [2]	1,592	[e] 1,650	[e] 1,650
Gabon [e]	[r] 625	585	595
Malagasy Republic [e] [2]	55	------	------
Portugal [e]	[r] 105	105	105
South Africa, Republic of	3,360	3,874	3,610
Spain [e]	[r] 66	66	66
Sweden [e]	[r] 77	77	77
United States	9,125	12,338	10,934
Total [3]	[r] 19,098	22,772	21,262

[e] Estimate. [p] Preliminary. [r] Revised.
[1] Uranium is also believed to be produced in Czechoslovakia, East Germany, West Germany, Hungary, India, Japan, and U.S.S.R., but production data are not available.
[2] Contained in uranium ore.
[3] Totals are of listed figures only.

Table 15.—Nuclear power reactors in the world, June 30, 1969 [1]

Country	Status								
	Operating			Under construction			Planned		
	Mwe	No.	Type [2]	Mwe	No.	Type [2]	Mwe	No.	Type [2]
Canada	230	2	BHWR PHWR	2,282	5	4 PHWR 1 HWLWR	3,350	5	4 PHWR [3] 1
France	1,622	8	6 GCR 1 HWGCR 1 PWR	1,311	3	2 GCR 1 FBR(250)	1,480	2	(3)
Germany, West	842	4	2 BWR 1 PGWR 1 PWR	2,570	6	2 BWR 2 PWR 1 HTGR 1 HWGCR	9,040	16	1 FBR(300) 1 HTGR [3] 14
India	380	2	BWR	600	3	PHWR	200	1	PHWR
Italy	597	3	BWR GCR PWR	40	1	HWLWR	1,300	2	(3)
Japan	158	1	GCR	2,402	5	3 BWR 2 PWR	9,856	16	6 BWR 1 FBR(300) 1 HWLWR 3 PWR [3] 5
Netherlands	52	1	BWR	400	1	PWR	------	--	----------
Spain	153	1	PWR	920	2	1 BWR 1 GCR	3,000	6	1 PWR [3] 5
Sweden	------	--	----------	1,295	3	2 BWR 1 BHWR	3,619	6	2 BWR 2 PWR [3] 2
Switzerland	350	1	PWR	656	2	1 BWR 1 PWR	1,550	3	(3)
U.S.S.R.	1,165	10	8 LWGR 1 BWR 1 PWR	6,775	11	5 PWR 4 LWGR 2 FBR(750)	760	2	PWR
United Kingdom	4,131	26	24 GCR 1 AGR 1 HWLWR	6,380	11	8 AGR 2 GCR 1 FBR(250)	5,000	8	AGR
Others	------	--	----------	1,354	[4] 5	2 PHWR 2 PWR 1 HWGCR	9,944	[5] 24	7 PWR 1 PHWR 1 HWGCR [3] 15
Total	9,680	59	32 GCR 8 LWGR 7 BWR 6 PWR 2 PHWR 1 AGR 1 BHWR 1 HWGCR 1 HWLWR	26,985	58	13 PWR 9 BWR 9 PHWR 8 AGR 5 GCR 4 FBR 4 LWGR 2 HWGCR 2 HWLWR 1 BHWR 1 HTGR	49,099	91	15 PWR 8 AGR 8 BWR 6 PHWR 2 FBR 1 HTGR 1 HWGCR 1 HWLWR [3] 49

[1] Excluding United States and experimental power reactors (output below 20 Mwe).
[2] AGR Advanced gas cooled, graphite moderated reactor.
BHWR Boiling heavy water cooled, heavy water moderated reactor.
BWR Boiling light water cooled, light water moderated reactor.
FBR Fast Breeder Reactor.
GCR Gas cooled, graphite moderated reactor.
HTGR High temperature gas cooled, graphite moderated reactor.
HWGCR Heavy water moderated, gas cooled reactor.
HWLWR Heavy water moderated, boiling light water cooled reactor.
LWGR Light water cooled, graphite moderated reactor.
PHWR Pressurized heavy water moderated and cooled reactor.
PWR Pressurized light water moderated and cooled reactor.
[3] Not stated.
[4] Includes Argentina, Bulgaria (2), Czechoslovakia, and Pakistan.
[5] Includes Argentina (1), Australia (1), Austria (1), Belgium (3), Brazil (1), Czechoslovakia (1), Finland (2), Greece (1), Hungary (2), Israel (1), Korea, Rep. of (1), Mexico (1), N. Zealand (1), Norway (1), Pakistan (2), So. Africa, Rep. of (1), Taiwan (1), Thailand (1), and United Arab Republic (1).

Source: Power and Research Reactors in Member States. September 1969 Edition. International Atomic Energy Agency, Vienna, 1969, 82 pp.

Belgium.—An organization called Groupement Général du Combustible Nucleaire was set up by six Belgian firms to facilitate pooling of resources in the production and marketing of nuclear fuels.[53] Union Minière will concentrate the uranium ore, Métallurgie Hoboken will produce uranium oxide and metal, Métallurgie et Mécanique Nucleaires will produce the fuel elements, Belgonucleaire will handle radioactive

[53] Engineering and Mining Journal. V. 170, No. 5, May 1969, p. 162.

wastes, Société Générale des Minerais will conduct sales, shipments, and insurance operations, and Genie Métallurgique et Chimique will specialize in nuclear plant engineering and construction.

A new company, Société de Fluoration de l'Uranium (SFU), will build a plant at Mol, Belgium, to convert uranyl nitrate obtained from a fuel processing plant into uranium tetrafluoride.[54] The new process was said to bypass intermediate operations which form part of more established methods of conversion. Founders of the firm are Ugine Kuhlmann, France; Steinkohlen-Elektrizität, West Germany; Société Métallurgie Hoboken, Belgium; Reactor Centrum Nederland, Netherlands; AB Atomenergi (Swedish Atomic Energy Company), Sweden; Institutt for Atomenergi, Norway; and Atomic Energy Commission, Denmark.

Bolivia.—Uranium deposits, also containing silver and copper, were reported discovered at San Pablo de Napa in Lipez province, 1,000 miles southeast of La Paz.[55]

Brazil.—Four types of ore deposits were included in reserves announced by the Comissão Nacional de Energia Nuclear (CNEN); one type, at Jacobina, was said to be associated with gold in metaconglomerate and to be very similar to the gold-uranium reefs of South Africa's Witwatersrand.[56] Also, the CNEN said that a large deposit of very high grade, nonrefractory, uranium ore, totaling over 1 million tons containing 16 pounds of uranium oxide per ton (over 8,000 tons U_3O_8) was discovered on the Poços de Caldas plateau of Minas Gerais state.[57]

Canada.—The role of Canada as a supplier of large quantities of low-cost uranium reserves and its great potential for additional discoveries was presented in an official government publication.[58] It was predicted that annual uranium needs in the noncommunist world would rise to between 73,000 and 106,000 tons of uranium oxide concentrates (U_3O_8) in 1980 and that Canada, which currently has about 30 percent of the total noncommunist world production capability, will continue to be in a position to supply a major portion of the market in the future.

Exploration, drilling, and developmental activities were continued by a number of mining companies. In Ontario, promising locations included Agnew Lake in the Elliot Lake area west of Sudbury, and Dungannon, Cardiff, Dickens, Palmerston, South Canonto, and Monmouth townships in the Bancroft area of the southeastern part of the province. The geology, origin, and distribution of uranium deposits in a well-known Ontario locality were reviewed, largely from a historical viewpoint, in a recent publication.[59] The author discussed prospecting guides and methods and concluded that although new and more expensive exploration techniques will require developing, new reserves are needed and exploration should be continued in this area.

In northwestern Quebec, in the Grindstone Lake area near Temiskaming, extensive reconnaissance has shown significant radioactivity in widespread sedimentary formations.[60] Exploratory drilling by Gulf Minerals Co., a subsidiary of Gulf Oil Corp., was underway near Wollaston Lake in the Athabasca region of northern Saskatchewan.[61] Canadian firms became active in the area and a U.S. firm, Phillips Petroleum Co., agreed to a long-term exploration program with four Canadian companies, including Denison Mines Ltd.[62] Exploration work was started in the northwest part of Manitoba, in an area considered to be an extension of the Wollaston Lake area.[63] In the fall, New Continental Oil Company of Canada, Limited, announced two uranium discoveries in the

[54] European Chemical News. SFU Treats Nuclear Fuels, v. 16, No. 404, Oct. 31, 1969, p. 18.

[55] Mining Journal. (London). V. 272, No. 6984, June 27, 1969, p. 569.

[56] World Mining. V. 5, No. 9, August 1969, p. 59.

[57] World Mining. V. 5, No. 3, March 1969, p. 53.

[58] Williams, R. M. Canada's Future in Uranium Supply. Department of Energy, Mines, and Resources, Mineral Resources Branch, Mineral Information Bulletin—MR 98, Ottawa, Canada, 1969, 65 pp.

[59] Robertson, James A. Geology and Uranium Deposits of the Blind River Area, Ontario. Can. Min. and Met. Bull., v. 62, No. 686, June 1969, pp. 619–634.

[60] Northern Miner. (Toronto). Sturdy-Talisman Uranium Project Turns Up Strong, Lengthy Zones. v. 55, No. 27, Sept. 25, 1969, pp. 1 and 8.

[61] Northern Miner. (Toronto). Intensive Exploration Begins as Result of Gulf Discovery. V. 54, No. 46, Feb. 6, 1969, p. 1.
———. Gulf Drill Cuts Probable Ore in First Hole. V. 54, No. 51, Mar. 13, 1969, pp. 1 and 5.
———. Gulf "U" Find Seen Important. V. 55, No. 14, June 26, 1969, pp. 1 and 16.
Chemical & Engineering News. V. 47, No. 29, July 14, 1969, p. 35.

[62] Mining Journal. (London). V. 272, No. 6980, May 30, 1969, p. 467.

[63] Northern Miner. (Toronto). Wollaston Hole of Yukon Antimony Has Good Grade "U". V. 55, No. 30, Oct. 16, 1969, pp. 1 and 7.

Baker Lake region, Northwest Territories.[64] A large-scale exploration and diamond drilling program is planned when weather conditions permit.

Atomic Energy of Canada, Limited, was authorized to construct and operate an 800-ton-per-year heavy water (deuterium oxide) plant at Douglas Point, Ontario, on Lake Huron. Work at the site started early in 1969; completion is slated for 1972–73.[65] Two other such plants are being built in Nova Scotia; one at Glace Bay, is to be operated by Deuterium of Canada Ltd.; the other, at Point Tupper (Port Hawkesbury), is to be run by Canadian General Electric Company Ltd. Completion of the Glace Bay plant was more than 2 years behind schedule.[66] Failure to complete the plant has resulted in a critical shortage of deuterium oxide and Canadian officials have had to purchase supplies abroad.[67]

In March, Ontario Hydro requested the Atomic Energy Control Board of Canada for authorization to construct a 4-unit, 3,000-Mwe nuclear powerplant, to be called the Bruce Power Generating Station, near the Douglas Point Nuclear Power Station which it has operated since September 1968.[68] The latter 200-Mwe plant is on the eastern shore of Lake Huron, midway between Kincardine and Port Elgin. Later in the year, fear of leakage of highly toxic hydrogen sulfide from the deuterium oxide plant being built at Douglas Point led the operator to move the Bruce station to a site also on Lake Huron but about a mile away.[69] Ontario Hydro will operate the Pickering Canadian $560 million, 2,000-Mwe plant, situated 20 miles east of downtown Toronto, with the first two units—1,000 Mwe—scheduled for startup in 1971. At Point-aux-Roches, Quebec, on the south shore of the St. Lawrence River about 10 miles downstream from Three Rivers, Atomic Energy of Canada, Limited, is building the Gentilly Nuclear Power Station (CANDU-BLW). This is a 250-Mwe natural uranium reactor which is cooled by boiling light water and moderated by heavy water. It is scheduled for 1971 operation by Hydro-Quebec.

All shipments and packaging of radioactive materials, entering or leaving Canada, were required to comply with standards recommendations made by the International Atomic Energy Agency (IAEA) which had been incorporated into Canadian regulations.[70]

Finland.—By 1991, it was expected that there would be eight nuclear powerplants, with capacities of 440 to 1,000 Mw, in operation in Finland.[71] At that time, electrical power from the atom will account for 5,500 to 7,000 Mw, which will be nearly 50 percent of that nation's electrical energy requirements.

France.—Mines in the Franc area, representing deposits in France proper, Gabon, Niger and the Central Africa Republic, were said to contain 10 percent of the world's proven uranium reserves.[72] The operating firms agreed to set up a joint marketing organization—Uranex—in order to sell about 2,000 tons of excess uranium per year on the international market. The partners in the undertaking are the Commissariat a l'Energie Atomique (CEA), Compagnie Péchiney Mokta, and Compagnie Francaise des Mines d'Uranium. Société des Usines Chimiques de Pierrelatte will process the uranium ore into uranium hexafluoride for Uranex. Pierrelatte also will make uranium hexafluoride from uranium concentrates obtained by the CEA from Belgium's Société Générale des Minerais.[73]

The director of the Electricité de France, the Government power system, admitted the superiority of American-designed enriched uranium nuclear powerplants and said that the French-designed natural uranium reactors, though a technical success, are an economic failure.[74]

Germany, West.—This country's representative in the Prime Contractor Organization of the centrifuge project of the

[64] Bureau of Mines. Mineral Trade Notes. V. 67, No. 1, January 1970, p. 25.
[65] Atomic Energy of Canada Limited. 1968-1969 Annual Report. 1969. Queen's Printer and Controller of Stationery, Ottawa, Canada, 44 pp.
[66] Bureau of Mines. Mineral Trade Notes. V. 66, No. 6, June 1969, p. 28.
[67] European Chemical News. V. 16, No. 404, Oct. 31, 1969, p. 10.
[68] Atomic Energy Control Board of Canada. Twenty-Third Annual Report, 1968–1969. Ottawa, Canada, 22 pp.
[69] Engineering News-Record. V. 183, No. 19, Nov. 6, 1969, p. 25.
[70] Pages 13 and 14 of work cited in footnote 68.
[71] Pages 29 and 30 of work cited in footnote 48.
[72] American Metal Market. French Forming Consortium to Make Big Push in Uranium. V. 76, No. 205, Oct. 28, 1969, pp. 1 and 11.
Metal Bulletin. Uranium Mines to Form Uranex. No. 5438, Oct. 7, 1969, p. 18.
[73] Chemical & Engineering News. V. 47, No. 27, June 30, 1969, p. 17.
[74] Chemical Week. Vive l'U.S. Nuclear Plant. V. 105, No. 18, Nov. 5, 1969, p. 33.

United Kingdom, the Netherlands, and West Germany, was Gesellschaft für Nukleare Verfahrenstechnik m.b.H. (GnV), and in the Enrichment Organization, Uran-Isotopentrennungs G.m.b.H. (URANIT).[75] Both German companies were established in November, the former in Bensberg and the latter in Jülich. GnV, which will develop, plan, and build isotope separation facilities using gas centrifuges, is owned equally by Internationale Atomreaktorbau G.m.b.H., Bensberg; Dornier G.m.b.H., Friedrichshafen; ERNO-Raumfahrttechnik G.m.b.H., Bremen; and Maschinen-Fabrik Augsburg-Nürnberg, Augsburg. URANIT is owned by Gelsenkirchener Bergwerks-Aktien-Gesellschaft, Essen; Nuklear-Chemie und -Metallurgie G.m.b.H., Wolfgang/Hanau; and Farbwerke Hoechst.

Proposed purchases of $50 million worth of enriched uranium from the United States would offset in part American defense expenditures in Germany.[76]

India.—The two atomic reactors at Tarapur, Maharashtra State, went critical in February and power output reached full capacity of 380,000 kw in July.[77] At Jaduguda, in Bihar State, the Uranium Corporation of India commissioned a crushing and grinding plant, with a daily capacity of 1,000 tons of uranium ore, and at Hyderabad construction was underway on a uranium oxide plant which will produce ceramic-quality reactor-grade oxide.[78] To assure a supply of heavy water for two Canadian-type nuclear plants (heavy-water moderated), a French company, L'Air Liquide et Compagnie de Construction Mecanique, will build an $11 million, 67 tons per year heavy water plant near Bombay.[79] The plant will use an ammonia-hydrogen exchange process.

Italy.—About 2.5 metric tons per year of mixed uranium and plutonium oxides fuel will come from a pilot plant built at the Italian Nuclear Research Center at Casaccia.[80] It was claimed that this continuous process, which makes microspheres, yields greater economy and better fuel quality than traditional methods of fuel fabrication.

Japan.—The Japanese have been experimenting with both gaseous diffusion and centrifugal methods for enriching uranium and intend to make a choice between the two by 1972.[81] An industrial group from the Mitsubishi combine was organized to look into commercial uranium enrichment.[82] Power Reactor & Nuclear Fuel Development Corp. (PNC) worked on the gas centrifuge, and the Institute of Physical and Chemical Research experimented with gaseous diffusion. Although Japan has depended largely on Canada for its uranium concentrate needs, the Government-sponsored PNC intended to study closely deposits in British Columbia, Canada; Congo (Kinshasa); and Niger, as well as to perform basic studies in Australia, Angola, Nigeria, Senegal, Thailand, and in other parts of Canada.[83]

The world's fourth nuclear-powered merchant ship, the Mutsu, was launched by the Ishikawajima-Harima Heavy Industries Co. shipyard in Tokyo.[84] The ship will be powered by a 36-Mwt pressurized water reactor and was scheduled for completion in 1972.

Mexico.—A 60 ton per year uranium oxide (U_3O_8) plant, which consumes 60 tons of ore per day, was built at Villa Aldama, 35 kilometers northeast of Chihuahua by the Comisión de Fomento Minero (Commission for Mining Development) and the Comisión Nacional de Energía Nuclear (CNEN), the National Nuclear Energy Commission.[85] A study by a team from Mexico, the United States, and the AIEA concluded that nuclear multipurpose plants (desalination and electricity generation) were the answer to water shortages in northwestern Mexico and the southwestern U.S.[86] These 1-billion-gallon-per-day and 200-Mwe plants were expected to produce water for 16 to 40 cents per 1,000

[75] Bureau of Mines. Mineral Trade Notes. V. 67, No. 4, April 1970, p. 30.

[76] American Metal Market. State Dept. Vows U.S. Uranium Sale. V. 76, No. 196, Oct. 15, 1969, p. 21.

[77] Bureau of Mines. Mineral Trade Notes. V. 66, No. 5, May 1969, p. 34. Nuclear India. Full Power from Tarapur Atomic Station in July. V. 7, No. 9, p. 2.

[78] Mining & Mineral Engineering (London). V. 5, No. 11, December 1969, p. 49.

[79] Chemical Week. V. 105, No. 15, Oct. 11, 1969, p. 56.

[80] Chemical Week. V. 104, No. 23, June 7, 1969, p. 49.

[81] Chemical Engineering. V. 76, No. 13, June 16, 1969, pp. 27–28.

[82] Chemical Week. V. 105, No. 3, July 19, 1969, p. 51.

[83] American Metal Market. Japan to Launch All-Out Uranium Search. V. 76, No. 116, June 20, 1969, p. 24.

[84] Chemical Engineering News. V. 47, No. 26, June 23, 1969, p. 35.

[85] Bureau of Mines. Mineral Trade Notes. V. 66, No. 9, September 1969, p. 22.

[86] Chemical Week. V. 104, No. 5, Feb. 1, 1969, p. 42.

gallons and electricity for between 1.8 and 3.1 mills per kilowatt hour.

Netherlands.—In March, it was reported by the Algemeen Nederlands Persbureau, the country's news service, that work would begin in Bornestraat, Almelo, at the end of June on a plant to construct centrifuges and, shortly thereafter, on an adjacent pilot plant which will produce enriched uranium.[87]

Initial production of enriched uranium by the ultracentrifuge system would be 6 tons per year, which will be increased to 600 tons per year if the experiment proves successful.

Niger.—Construction continued on a 750 tons per year concentrator, which is being built by Société des Mines de l'Air at its Arlit uranium mine.[88] The process to be used was developed by Ugine-Kuhlmann of France.

South Africa, Republic of.—Uranium reserves in this country, considered the largest in the world, were augmented with the discovery by Newmont Mining Corp. of 2.3 million tons of additional ore at the O'okiep mine in which it has a 57.5 percent interest.[89] Three South African gold mining firms—President Brand, Free State Saaiplaas, and Welkom—agreed to produce uranium jointly.[90] President Brand will treat its own slimes and those of the other two companies in a uranium extraction plant, with production expected in 1971. Late in the year a new uranium extraction plant, operated by Western Deep Levels Ltd., came on-stream.[91] The initial capacity will be 70,000 tons per month of upgraded ore from the Carbon Leader Reef, which is about 25 percent of the total tonnage milled at the Western Deep Levels gold plant.

Spain.—Among the Western European nations, Spain was said to rank second in uranium ore deposits, and among free nations, sixth.[92] It was announced that the Instituto Nacional de Industria (INI) and the Junta de Energia Nuclear (JEN) will build a concentrator in Ciudad Rodrigo, near Salamanca, which will make 450 tons of U_3O_8 concentrate per year from local ores.[93]

Sweden.—AB Atomenergi mines and processes uranium ore at Ranstad in south-central Sweden.[94] The production capacity is about 120 metric tons of uranium metal equivalent in the form of concentrate but, in order to reduce the necessary subsidy, actual production has been less than three-sevenths capacity. Over a 3 year period, the Government expected to spend $5 million on the development of methods for extracting uranium from shale deposits at Mt. Billingen in western Sweden.[95]

United Kingdom.—According to cost estimates for electricity generation stated by the Minister of Power, base load generating costs for advanced gas reactor (AGR) nuclear stations with an assumed life of 25 years are commensurate with coal- and oil-fired plants.[96] Future nuclear power generation and operating costs in England were presented.[97] In order to lower operating costs, research reactors, BEPO at Harwell and the Materials Testing Reactor at Dounreay, were shut down in December 1968 and May 1969, respectively.[98] In an appendix, the United Kingdom Atomic Energy Authority's 1969 report showed the Authority's reactors as of March 31, 1969, including their location, start-up date, fuel, purpose of operation, and other pertinent data. It also was stated that an optimum combination of advanced thermal reactors and fast reactors, by the late 1970's and 1980's, could result in a saving of £1,000 million to £1,200 million in power generation costs.

U.S.S.R.—As a result of a Government program, it appeared that a small portable

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[87] Bureau of Mines. Mineral Trade Notes. V. 66, No. 9, September 1969, p. 23.

[88] World Mining. Uranium Plant Capacity at Arlit is Revised Upwards. V. 5, No. 10, September 1969, p. 48.

[89] Mining in Canada. November 1969, p. 42.

[90] Skilling's Mining Review. Joint Uranium Production Scheme Planned by African Gold Companies. V. 58, No. 38, Sept. 20, 1969, p. 12.

[91] South African Mining and Engineering Journal. First Uranium from WDL. V. 80, No. 4009, Pt. II. Dec. 12, 1969, pp. 1309–1311.
Mining Journal (London). Western Deep Levels' Uranium Plant. V. 273, No. 7008, Dec. 12, 1969, p. 538.

[92] Bureau of Mines. Mineral Trade Notes. V. 67, No. 2, February 1970, pp. 32–33.

[93] Foreign Trade (Ottawa, Canada). Spain Builds Second Uranium Concentrator. V. 131, No. 10, May 10, 1969, p. 30.

[94] Bureau of Mines. Mineral Trade Notes. V. 67, No. 2, February 1970, pp. 34–35.

[95] Mining Journal (London). Swedish Uranium Programme. V. 272, No. 6973, Apr. 11, 1969, p. 307.

[96] Atom 69. Nuclear Costs: An Illustrated Summary of the Fifteenth Annual Report of the United Kingdom Atomic Energy Authority from 1st April 1968 to 31st March 1969. 23 pp.

[97] Bainbridge, G. R., and C. Beveridge. The Future Operating Role of Nuclear Power Stations. Atom (Monthly Information Bulletin of the United Kingdom Atomic Energy Authority), No. 155, September 1969, pp. 248–262.

[98] United Kingdom Atomic Energy Authority. 15th Annual Report and Accounts, 1968–1969. H. M. Sta. Off. London, July 23, 1969, 121 pp.

nuclear powerplant will be usable in remote permafrost areas, such as those in Siberia which show promise of discoveries and commercial development of gas, oil, and minerals.[99] This 1,500-kw water-cooled reactor can be dismantled for transport, quickly reassembled, and has a small nuclear charge which will last 3½ years before requiring refueling.

TECHNOLOGY

The results of various geological, mineralogical, and geochemical studies on uranium-bearing deposits and materials conducted by the U.S. Geological Survey were reported in 1969.[1] One paper, on the content of radioactive material in water, is of particular environmental interest, because it shows the quantities of soluble uranium and radium contributed to the oceans by major United States rivers almost 10 years ago.

A resumé of the types of uranium deposits (such as the blanket-type deposits of the Powder River Basin of Wyoming) and of geologic, geophysical, geochemical, remote sensing, and drilling methods for uranium was published in 1969.[2] Remote sensing methods are recent developments and include infrared sensing, photogeology, and radar. Included in the report was a table showing a comparison of the methods used in prospecting for uranium in soils, vegetation, stream sediments and stream waters, and general terrain. Finally, an exploration program, including a determination of the minimum acceptable size and grade for a uranium ore body, was outlined. In another publication, methods using gamma spectrometry, radon surveys, and trace element surveys were discussed.[3] With an airborne spectrometer sensitive to gamma radiation, it is possible to distinguish the energy levels for uranium, thorium, and potassium, making it possible to recognize areas with rocks rich in potassium and delineate them from those enriched in uranium and thorium.[4] A similar method was used in Yugoslavia to sample the Zirovski Vrh uranium-ore deposit.[5]

In studies of elemental associations of uranium minerals in soils and stream sediments, copper and copper/lead ratios over 0.80 were shown to be good indicators of uranium mineralization.[6] It was believed that this knowledge would be useful in prospecting for uranium in remote areas. A description of prospecting techniques used in an uraniferous area of New Zealand concluded with the observation that fluorimetric analysis of plants and soils gave a reliable indication of uranium in the area.[7] Counter discussions on uranium prospecting included resumés of procedures used in testing soils and water.[8] In two Canadian localities—the Gatineau Hills, Quebec, and Elliot Lake, Ontario regions—radon tests of soils were said to be superior to the use of Geiger counters and

[99] Engineering News-Record. Siberia Spurs Development of Small Nuclear Reactors. V. 182, No. 22, May 29, 1969, p. 13.

[1] Granger, Harry C., and Robert B. Raup. Geology of Uranium Deposits in the Dripping Spring Quartzite, Gila County, Ariz. U.S. Geol. Surv. Prof. Paper 595, 1969, 108 pp.

Hilpert, Lowell S. Uranium Resources of Northwestern New Mexico. U.S. Geol. Surv. Prof. Paper 603, 1969, 166 pp.

Mallory, E. C., Jr., J. O. Johnson, and R. C. Scott. Water Load of Uranium, Radium, and Gross Beta Activity at Selected Gaging Stations, Water Year 1960–61. U.S. Geol. Surv. Water-Supply Paper 1535-0, 1969, pp. 01–031.

Tilling, Robert I., and David Gottfried. Distribution of Thorium, Uranium, and Potassium in Igneous Rocks of the Boulder Batholith Region, Montana, and its Bearing on Radiogenic Heat Production and Heat Flow. U.S. Geol. Surv. Prof. Paper 614-E, 1969, pp. E1–E29.

Williams, Paul L., compiler. Geology, Structure, and Uranium Deposits of the Moab Quadrangle, Colorado and Utah. Miscel. Geologic Investigations Map I-360 (reprinted 1969, issued 1964).

[2] Saum, N. M., and J. M. Link. Exploration for Uranium Part I. Mineral Industries Bulletin, v. 12, No. 4, July 1969, 23 pp. Colorado School of Mines Research Institute, Golden, Colo.

[3] Stewart, J. R. Recent Instrumentation Advances in Uranium Prospecting. South African Min. and Eng. J., v. 80, No. 3964, part 1, Jan. 24, 1969, pp. 196–198, 200.

[4] South African Mining and Engineering Journal. Improved Airborne Spectrometer. V. 80, No. 3966, part 1, Feb. 7, 1969, p. 303.

[5] Omaljev, V. A New Method of Radiometric Spot Sampling. Mining and Metallurgy Quarterly, No. 4, 1968, pp. 5–21.

[6] Cohen, Noel E., Robert R. Brooks, and Roger D. Reeves. Pathfinders in Geochemical Prospecting for Uranium in New Zealand. Econ. Geol., v. 64, No. 5, August 1969, pp. 519–525.

[7] Whitehead, Neil E., and Robert R. Brooks. A Comparative Evaluation of Scintillometric, Geochemical and Biogeochemical Methods of Prospecting for Uranium. Econ. Geol., v. 64, No. 1, January–February 1969, pp. 50–55.

[8] Bowie, S. H. U., and D. Ostle. A Comparative Evaluation of Scintillometric, Geochemical and Biogeochemical Methods of Prospecting for Uranium. Econ. Geol., v. 64, No. 8, December 1969, p. 933 (letter dated July 23, 1969).

Brooks, R. R., and N. E. Whitehead. A Comparative......etc.—A Reply. Econ. Geol., v. 64, No. 8, December 1969, pp. 933–934 (letter dated Aug. 5, 1969).

scintillometers in outlining radioactive sources.[9]

Scientists of the Bureau of Mines continued their research on uranium mining and extraction, and environmental control methods.[10] An improved method for eluting and recovering uranium, applicable to resin-in-pulp and moving-bed type ion exchange, was developed, having a lesser number of stages, reduced retention time, and requiring less resin. A relatively low-cost chemical method, which cost $335 per acre for a 34.5 acre tract, was used to stabilize acidic and basic uranium leach plant residues against wind erosion. The extent of radiation experienced by miners was studied and ventilation systems analyzed for possible improvement to achieve recommended radiation standards. Factors affecting the costs of nuclear explosives in the mining of Colorado oil shale were discussed.

Under the sponsorship of the U.S. AEC, much research was conducted in the fields of biology, medicine, and environment, in fundamental physical research, and in nuclear reactor technology.[11] In metallurgy and materials science, tungsten and rhenium alloys were studied as potential materials for containing reactor fuel, and certain superplastic aluminum-zinc alloys showed promise of potential use as nuclear cladding materials resistant to neutron irradiation. In nuclear engineering, much time was devoted to the liquid metal cooled fast breeder reactor (LMFBR) concept as a logical means to conserve the nation's fuel resources. Based upon irradiation performance, uranium-plutonium nitride fuel for the LMFBR seemed very promising. Dependent upon the commercial development of fusion power, abundant energy resources, in the form of deuterium or heavy hydrogen, are available in the oceans. Feasibility studies in the controlled thermonuclear research program were directed primarily toward developing lower cost superconducting materials and methods of confining the superhot plasma in a fusion reactor. Economic studies indicated that power systems in the range of 2 million to 10 million kilowatts would be most attractive for the deuterium-tritium fuel cycle. Safety research was conducted on both water and fast reactors; environmental studies, including those on thermal effects, deformation and seismic activity, and meteorology (urban and rural air diffusion), were conducted on reactor plant siting and operation.

It was suggested that ventilation techniques for underground mining operations, including uranium mines, could be improved by increasing the ventilation rate, filtering the air several times with properly selected filters which remove radon daughter products, and using methods to reduce the flux of radon into the mine.[12] At Elliot Lake, data were obtained on factors affecting the rate of radon emanation in Canadian uranium mines.[13] The factors were: Rock pressures, barometric pressures, temperature, geological noncomformities, ventilating air velocities, and rock porosity, and lastly, the apparent flux from broken ore. Instant measurements of the concentration of airborne radioactive particles in uranium mines were made possible with a new instrument, an Instant Working Level Meter, developed by Massachusetts Institute of Technology (MIT) under an AEC contract.[14]

Another comprehensive report, from the Colorado School of Mines Research Institute, included a discussion on beneficiating ores, recovering uranium values from ores by in situ (in place) leaching, heap leaching, and leaching by means of bacteria, handling ores by such methods as blending and sampling and preparing it by such

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[9] Dyck, Willy. Uranium Exploration Using Radon in Soils. Canadian Min. J., v. 90, No. 8, August 1969, pp. 45–49.

[10] George, D'Arcy R., and J. Richard Ross. Improved Eluex Process for Eluting Uranium from Ion Exchange Resins. BuMines Rept. of Inv. 7227, 1969, 10 pp.

Havens, Richard, and Karl C. Dean. Chemical Stabilization of the Uranium Tailings at Tuba City, Ariz. BuMines Rept. of Inv. 7288, 1969, 12 pp.

Rock, R. L. Radiation-Ventilation Relationships in Six Underground Uranium Mines. BuMines Inf. Circ. 8413, 1969, 17 pp.

Williams, Frank E., Paul L. Russell, and M.J. Sheridan. Potential Applications for Nuclear Explosives in a Shale-Oil Industry. BuMines Inf. Circ. 8425, 1969, 37 pp.

[11] U.S. Atomic Energy Commission. Fundamental Nuclear Energy Research—1969. January 1970, 312 pp.

[12] Schroeder, Gerald L., and Robley D. Evans. Some Basic Concepts in Uranium Mine Ventilation. Trans. Soc. Min. Eng., AIME, v. 244, No. 3, September 1969, pp. 301–307.

[13] Thompkins, R. W., and K. C. Cheng. The Measurement of Radon Emanation Rates in a Canadian Uranium Mine. Canadian Min. and Met. Bull., v. 62, No. 692, December 1969, pp. 1356–1362.

[14] U.S. Atomic Energy Commission. New Meter Developed for Use in Uranium Mines. Press Release M–37, Feb. 12, 1969, 2 pp.

means as crushing and grinding.[15] It described acid and alkaline leaching operations at mills; the recovery of uranium-enriched solution by means of thickeners, filters, classifiers, and cyclones; the use of ion exchange and solvent extraction for concentrating and purifying solutions; and refining operations at gaseous diffusion plants to produce uranium hexafluoride.

Similar papers contained a table showing direct operating costs for uranium milling in the United States, Canada, and Australia.[16] They concluded that improvements could likely be made in bacterial leaching of the ore, in grinding, in mill leach circuits, in solvent extraction purification, and in automatic control. Other papers suggested the utilization of bacterial oxidation and leaching as a method for treating Elliot Lake (Ontario, Canada) uranium ores.[17]

The increasing number and sizes of nuclear powerplants is leading to the proliferation of fuel processing plants and the need for a policy concerned with plant siting and related waste management facilities. At a symposium sponsored by the U.S. AEC and AIME at Iowa State University papers were presented on nonaqueous and aqueous nuclear fuel reprocessing methods as well as on basic data and thermodynamics.[18] The AEC issued a series of reports prepared under the direction of the Division of Reactor Development and Technology on advanced reactor concepts.[19] The studies were conducted to enable government and industry to determine which concepts may be expected to compete economically with the light water reactors now most commonly used by the electric power industry.

In the future, uranium-plutonium carbide may be used as a fast reactor fuel. Newly developed techniques, which result in products of high purity and reproducible density and dimensions, may easily be adapted to the semiremote handling procedures required with recycled plutonium and may have production applications.[20]

An innovation may lower the construction cost of nuclear powerplants. The size of the containment vessel, built to contain steam in the event of a reactor accident, can be reduced if live steam is cooled in an ice chamber. An insulated cold storage compartment lining the inside wall of the containment structure, which is loaded with 22 million dispenser-sized ice cubes, can absorb the heat energy from the live steam in about 10 seconds.[21]

Environmental pollution, currently of extreme concern, has always been of foremost importance in the strict AEC regulation of uranium waste disposal. At a meeting in Oregon, a number of papers on disposal were presented.[22] Although emphasis was on safe storage and disposal methods for the nuclear industry, the techniques discussed were also applicable to municipal and industrial wastes. Schemes for use in the nuclear industry included solidification techniques such as pot calcination, spray solidification, phosphate glass solidification, and fluidized-bed calcination, with only the last now being used commercially. Costs of the fluidized-bed calcination process were optimistically projected as follows: Investment, $2.65 per gallon of acidic waste; operating, $2.25 per gallon. Another proposal was the use of certain soils with adequate ion-exchange capacity to act as

[15] Merritt, Robert C., and W. B. Pings. Processing of Uranium Ores, Part II. Min. Industries Bull. Colorado School of Mines Research Institute, Golden, Colo., v. 12, No. 6, November 1969, 20 pp.

[16] Smith, S. E., and P. A. White. Review of Uranium Ore Processing Research. South African Min. and Eng. J., v. 80, No. 3976, Part 1, April 18, 1969, pp. 862–864, 866, 868, 870.

———. Uranium Ore Processing. Eng. and Min. J., v. 170, No. 6, June 1969, pp. 113–115.

[17] McCreedy, H. H., V. F Harrison, and W. A. Gow. A Proposed Method, Using Bacteria, for the Continuous Leaching of a Uranium Ore. Canadian Min. and Met. Bull., v. 62, No. 682, February 1969, pp. 135–140.

McGregor, R. A. Uranium Dividends from Bacterial Leaching. Min. Eng., v. 21, No. 3, March 1969, pp. 54–55.

[18] Chiotti, P., ed. Symposium on Reprocessing of Nuclear Fuels. Nuclear Metallurgy, V. 15, August 1969, 753 pp. Available from the National Technical Information Service, Springfield, Va., CONF–690801.

[19] U.S. Atomic Energy Commission. An Evaluation of High-Temperature Gas-Cooled Reactors. WASH Rept. 1085, December 1969, 220 pp.

———. An Evaluation of a Heavy-Water-Moderated Boiling-Light-Water-Cooled Reactor. WASH Rept. 1086, December 1969, 263 pp.

———. An Evaluation of Advanced Converter Reactors. WASH Rept. 1087, April 1969, 139 pp.

———. An Evaluation of Steam-Cooled Fast Breeder Reactors. WASH Rept. 1088, April 1969, 360 pp.

———. An Evaluation of Gas-Cooled Fast Breeder Reactors. WASH Rept. 1089, April 1969, 241 pp.

———. An Evaluation of Alternate Coolant Fast Breeder Reactors. WASH Rept. 1090, April 1969, 154 pp.

[20] Nelson, P. A., D. E. Grosvenor, S. Vogler, N. P. Quattropani, and P. W. Krause. Synthesis and Fabrication of (U, Pu)C Nuclear Fuel Pellets From U-Pu Alloy. Ceramic Bull., v. 48, No. 9, September 1969, pp. 863–866.

[21] Engineering News-Record. Ice Cubes Cool Costs of Nuclear Power Plants. V. 182, No. 13, Mar. 27, 1969, p. 20.

[22] Chemical Engineering. Atomic and Pulping Wastes: New Schemes for Treatment. V. 76, No. 21, Oct. 6, 1969, pp. 108, 110.

mechanical filters and reactive media controlling the composition of liquid radioactive wastes. The disposal of radioactive wastes in solid rock which was also discussed, consisted of using large chambers in bedrock for storage or of using hydraulic fracturing to inject a mixture of radioactive waste, cement, and clay under high pressure into a hole drilled into an impermeable formation such as shale. Another publication showed methods and costs for disposal of waste in salt mines as well as comparing nuclear power generation with waste production until the year 2000.[23]

The AEC issued a book which will help consumers select the proper isotopes.[24] Radiation and shielding, methods of production, and peaceful uses of radioisotopes were discussed and shielding and shipping information was given.

The radioactive isotope californium-252, which emits large quantities of neutrons by spontaneous fission, was the subject of several brochures issued by the AEC.[25] Although only about a gram per year can be produced presently, the application sizes are very small (a few micrograms for many applications) and in these compact sources less free space is required to accommodate decay helium. Included in practical applications for californium-252, many of which are subject to further developmental work, are radiotherapy and neutron radiography in medicine, neutron activation techniques in industry, and prospecting and neutron logging in wells. By the early 1970's the estimated unit price was expected to be $15 to $25 per microgram.

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[23] McClain, W. C., and R. L. Bradshaw. Radioactive Wastes in Salt Mines. Mines Mag. v. 59, No. 8, August 1969, pp. 11–14.

[24] McKinney, F. E., S. A. Reynolds, and P. S. Baker. Isotope Users's Guide. U.S. Atomic Energy Commission. Availability from the National Information Service, Springfield, Va., ORNL–IIC–19. September 1969, 96 pp.

[25] Californium-252. Its Use and Market Potential. Savannah River Operations Office, U.S. Atomic Energy Commission, Aiken, S.C., May 1969, 26 pp.

Californium-252 Progress. Savannah River Operations Office, U.S. Atomic Energy Commission, Aiken, S.C., No. 1, October 1969, 32 pp.

Vanadium

By Gilbert L. DeHuff [1]

As the year advanced demand for vanadium, particularly abroad, and prices rose. Domestic production was maintained at a high rate, but the new sources of supply in Arkansas and the Republic of South Africa did not contribute to the extent expected due to difficult startup problems. Government sales of surplus vanadium pentoxide were resumed in August after a lapse of 2 years.

Legislation and Government Programs.— On March 27 the Office of Emergency Preparedness increased the conventional-war stockpile objective for vanadium from 1,500 to 2,100 short tons of contained vanadium. The portion contained in ferrovanadium remained at 1,200 tons, with the increase entirely as vanadium contained in vanadium pentoxide.

The first sale of surplus Government stocks of vanadium in more than 2 years was made in August when 383,866 pounds of vanadium contained in pentoxide was sold to competitive bidders. A second sale, in October, resulted in the award by competitive bidding of 477,821 pounds of vanadium contained in pentoxide. At a third similar sale in December, 501,980 pounds of vanadium contained in pentoxide was sold. A total of 1,363,667 pounds of contained vanadium was sold during the year. A provision of all sales was that the material was not to be exported, or resold and exported, from the United States.

As of December 31, 1969, the Government inventory totaled 5,306 short tons of vanadium, all of which was in the national stockpile. Of this total, 1,200 tons was contained in ferrovanadium, and the remaining 4,106 tons was contained in vanadium pentoxide.

[1] Physical scientist, Division of Ferrous Metals.

Table 1.—Salient vanadium statistics

(Short tons of contained vanadium)

	1965	1966	1967	1968	1969
United States:					
Production:					
Ore and concentrate:					
Recoverable vanadium [1]	5,226	5,166	4,963	6,483	5,577
Value ... thousands	$18,284	$22,210	$21,331	$23,143	$26,334
Vanadium pentoxide recovered	6,160	6,496	5,921	6,149	5,906
Consumption	4,708	5,481	5,245	5,495	6,154
Exports:					
Ferrovanadium and other vanadium alloying materials (gross weight)	220	482	351	278	644
Vanadium ores, concentrates, oxides, and vanadates	928	886	788	463	258
Imports (general):					
Ferrovanadium (gross weight)	51	8	14	626	449
Ores and concentrates	------	72	42	31	------
World production	9,834	10,029	10,266	11,799	11,349

[1] Measured by receipts of uranium and vanadium ores and concentrates at mills, plus vanadium recovered from ferrophosphorus derived from domestic phosphate rock.

DOMESTIC PRODUCTION

Western uranium-vanadium ores continued to be the principal domestic source of vanadium, but the quantity recovered from ferrophosphorus was again significant. Union Carbide Corp., Wilson Springs, Ark., recovered vanadium from Arkansas vanadium ore. Although problems in both mining and milling continued at Wilson Springs, it appeared that these may have been largely overcome by the end of the year. Some vanadium residues and spent catalysts, as well as some imported vanadiferous slag, were included in the feed at various mills. Vanadium recovered from imported vanadiferous slag is not included in the vanadium pentoxide (recovered) production figures of tables 1 and 4 for 1969, but these figures for earlier years do include some vanadium from this source. None of the figures for any year include the vanadium pentoxide equivalent, vanadium content, or any other provision for the vanadium involved in any operation recovering ferrovanadium directly from slag.

Only American Metal Climax, Inc.'s, mill at Grand Junction, Colo., and that of Union Carbide Corp. at Rifle, Colo., recovered vanadium from domestic uranium-vanadium or vanadium-uranium ores, or from the byproduct liquors or sludges of other uranium mills. Although Atlas Minerals, Division of Atlas Corp., rebuilt its uranium mill at Moab, Utah, which had been destroyed by fire at the end of 1968, it did not rebuild the vanadium extraction circuit. However, Atlas did convert some accumulated red cake into fused vanadium pentoxide.

Kerr-McGee Corp., Soda Springs, Idaho, recovered vanadium from ferrophosphorus obtained as a byproduct from Idaho phosphate rock. Ferrophosphorus was included in the feed at some other mills.

Table 2.—Recoverable vanadium of domestic origin produced in the United States, by States

(Short tons of contained vanadium)

State	1965	1966	1967	1968	1969
Colorado	4,017	3,697	3,317	3,492	W
Utah	387	353	471	563	W
Arizona and other States [1]	822	1,116	1,175	2,428	W
Total	5,226	5,166	4,963	6,483	5,577

W Withheld to avoid disclosing of individual company confidential data; included in total.
[1] Includes Arkansas 1968–69, Idaho 1965–69, New Mexico 1965–69, North Dakota 1965, South Dakota 1965–67, Wyoming 1965–67.

Table 3.—Mine production and recoverable vanadium of domestic origin produced in the United States

(Short tons)

Year	Mine production [1]	Recoverable vanadium [2]
1965	5,641	5,226
1966	5,685	5,166
1967	5,088	4,963
1968	7,105	6,483
1969	5,737	5,577

[1] Measured by receipts of uranium and vanadium ores and concentrates at mills, vanadium content.
[2] Recoverable vanadium contained in uranium and vanadium ores and concentrates received at mills, plus vanadium recovered from ferrophosphorus derived from domestic phosphate rock.

Table 4.—Production of vanadium pentoxide in the United States [1]

(Short tons)

Year	Gross weight	V_2O_5 content
1965	11,498	10,996
1966	11,955	11,595
1967	10,915	10,569
1968	12,105	10,976
1969	12,120	10,542

[1] Includes vanadium pentoxide and metavanadate produced directly from all domestic sources, plus small byproduct quantities from imported chromium ores.

CONSUMPTION AND USES

Domestic consumption of vanadium contained in ferrovanadium, other vanadium alloys, metal, and some chemicals continued to increase. The quantity used for alloying with titanium was substantially higher, and demand for high-strength low-alloy constructional steels and line pipe remained strong.

A new vanadium-aluminum master alloy was marketed early in the year. Containing 50 percent each of the two elements, it was claimed to offer cost advantages in the production of various titanium-aluminum-vanadium alloys, while contributing certain other benefits as well. This new alloy supplemented, rather than replaced, the conventional 40-percent-vanadium and 85-percent-vanadium grades of vanadium-aluminum master alloy that have been available for a long time.

Foote Mineral Co. announced that it would expand its Cambridge, Ohio, plant to more than double production capacity for Solvan and standard ferrovanadium during 1970 and produce a broader range of vanadium products. Pilot-plant production of vanadium acetylacetonate, a polymerization catalyst, was started at Cambridge.

Table 5.—Consumption and consumer stocks of vanadium materials in the United States

(Short tons of contained vanadium)

Type of material	1968		1969	
	Consumption	Ending stocks	Consumption	Ending stocks
Ferrovanadium [1]	4,712	783	5,193	1,272
Oxide	155	20	113	20
Ammonium Metavanadate	94	13	110	11
Other [2]	534	161	739	203
Total [3]	5,495	977	6,154	1,507

[1] Includes other vanadium-iron-carbon alloys.
[2] Consists principally of vanadium-aluminum alloy and relatively small quantities of other vanadium alloys and vanadium metal.
[3] Data may not add to totals shown due to independent rounding.

Table 6.—Consumption of vanadium in the United States by end uses

(Short tons of contained vanadium)

End Use	1969
Steel:	
Carbon	1,296
Stainless and heat resisting	37
Alloy (excluding stainless and tool)	2,739
Tool	648
Cast irons	55
Superalloys	63
Alloys (exclude alloy steels and superalloys):	
Cutting and wear resistant materials	W
Welding and alloy hard-facing rods and materials	12
Nonferrous alloys	618
Other alloys [1]	7
Chemical and ceramic uses:	
Catalysts	196
Other [2]	W
Miscellaneous and unspecified	484
Total [3]	6,154

W Withheld to avoid disclosing individual company confidential data, included in Miscellaneous and unspecified.
[1] Includes magnetic alloys.
[2] Includes pigments.
[3] Data may not add to total shown due to independent rounding.

PRICES

The dealers price for technical-grade vanadium pentoxide (mainly for export), as quoted by Metals Week, held at 95 cents per pound of contained V_2O_5 into the second quarter of the year. This price then began to move upward—apparently following rising prices and strong demand in Europe and Japan—to be quoted as $1.45 to $1.50 from late October into December, and $1.75 to $1.80 at yearend. The domestic producer price for technical-grade fused flake vanadium pentoxide was

$1.51 in the third quarter and was increased later to $1.64 effective January 1, 1970, f.o.b. plant. The producer price for technical-grade, air dried vanadium pentoxide also was increased to $1.64 per pound of contained V_2O_5 effective January 1, 1970, f.o.b. plant, after having been $1.54 from September 11.

The average price obtained in the August Government sale of fused black vanadium pentoxide was $1.26 per pound of contained V_2O_5. The October and December sale prices averaged $1.35 and $1.64, respectively. The average for the total sold during the year was $1.43. The pentoxide sold by the Government was of poorer quality than that sold commercially.

The domestic price for ferrovanadium remained at $2.90 per pound of contained vanadium, packed, f.o.b. plant, until it was increased to $3 effective May 15 or July 1 depending on the producer. Further increases followed to $3.12 effective September 11 or October 1, and to $3.47 effective December 9 or January 2. Prices for Carvan and Solvan, also f.o.b. plant, increased at the same times from $2.46 per pound of contained vanadium in the first part of the year to $2.58, $2.70, and finally to $2.96 for the start of the new year.

FOREIGN TRADE

The average declared value for exports of ore, concentrates, and technical-grade oxides was $1.41 per pound of contained vanadium pentoxide in 1969, compared with $1.19 in 1968 and $1.44 in 1967. The average declared value of ferrovanadium exported in 1969 was $2.20 per pound of alloy, compared with $1.90 in 1968 and $1.99 in 1967. Exports of both ferrovanadium and vanadium pentoxide were at a high level in the last quarter of 1969.

Table 7.—U.S. exports of vanadium, by countries

(Thousand pounds and thousand dollars)

Destination	Ferrovanadium and other vanadium alloying materials containing over 6 percent vanadium				Vanadium ore, concentrates, pentoxide, vanadic acid, vanadium oxide and vanadates (except chemically pure grade)			
	1968		1969		1968		1969	
	Gross weight	Value	Gross weight	Value	Vanadium content	Value	Vanadium content	Value
Australia	---	---	---	---	14	$25	---	---
Austria	---	---	---	---	179	387	---	---
Belgium-Luxembourg	---	---	---	---	318	649	1	$1
Brazil	---	---	1	$3	---	---	4	10
Canada	295	$562	245	521	24	58	35	81
Chile	1	2	---	---	---	---	1	1
Colombia	1	1	---	---	---	---	(1)	(1)
France	(1)	(1)	79	214	64	154	28	109
Germany, West	---	---	373	769	63	134	172	447
Hong Kong	---	---	(1)	1	---	---	---	---
India	59	143	---	---	35	64	---	---
Italy	---	---	---	---	---	---	19	37
Japan	---	---	107	200	144	303	107	248
Libya	---	---	---	---	---	---	2	4
Mexico	61	108	110	205	5	13	7	20
Netherlands	6	15	94	228	---	---	106	221
Netherlands Antilles	---	---	---	---	(1)	1	---	---
Rhodesia, Southern	---	---	---	---	7	13	---	---
Spain	---	---	37	85	---	---	---	---
Sweden	---	---	173	495	22	46	23	95
Trinidad and Tobago	---	---	---	---	---	---	1	3
Turkey	15	32	---	---	---	---	---	---
United Kingdom	---	---	---	---	50	125	10	23
Venezuela	117	189	69	113	---	---	---	---
Total	555	1,052	1,288	2,834	925	1,972	516	1,300

[1] Less than ½ unit.

There were no imports classified as ore and concentrates in 1969. Vanadiferous slag (classified as metal-bearing residues) was imported from Chile, the Republic of South Africa, and the U.S.S.R.

Table 8.—U.S. imports of ferrovanadium, by countries

(Thousand pounds and thousand dollars)

Country	General imports				Imports for consumption			
	1968		1969		1968		1969	
	Gross weight	Value	Gross weight	Value	Gross weight	Value	Gross weight	Value
Australia	---	---	31	$53	---	---	31	$53
Austria	531	$725	262	384	531	$725	255	373
Belgium-Luxembourg	r 72	r 130	159	268	r 58	r 104	153	258
France	5	9	26	43	5	9	---	---
Germany, West	567	796	128	223	527	735	111	189
Italy	---	---	42	51	---	---	42	51
Sweden	77	137	94	167	77	137	94	167
United Kingdom	---	---	155	183	---	---	77	94
Total	r 1,252	r 1,797	897	1,372	r 1,198	r 1,710	763	1,185

r Revised.

WORLD REVIEW

In addition to the production reported in table 9, the Republic of South Africa, the U.S.S.R., and Chile produced vanadiferous slag from iron ores, and some other countries had relatively small unreported vanadium production from secondary sources, wastes, or as byproducts of the recovery of other metals. Canada has recovered vanadium pentoxide from oil residues since 1965. Beginning somewhat earlier, Japan has been producing ammonium metavanadate and/or vanadium pentoxide from waste sulfuric acid resulting from the production of titanium dioxide. West Germany recovers vanadium as vanadium pentoxide and ammonium metavanadate from South-West African lead-vanadium concentrates (credited in table 9 to South-West Africa); from vanadiferous slags; and probably from other unreported byproduct or secondary sources as well. It is presumed that France still recovers vanadium pentoxide as a byproduct of bauxite processing and possibly from other sources. Italy and Sweden may also have recovered vanadium from some of the above sources in 1969 as well as in earlier years.

Table 9.—World production of vanadium in ores and concentrates, by countries [1]

(Short tons)

Country	1967	1968	1969 p
Finland [2]	1,292	1,321	1,484
Norway e	816	937	965
South Africa, Republic of [2]	2,115	2,498	2,873
South-West Africa (in lead-vanadate concentrate) e	r 1,080	560	450
United States (recoverable vanadium)	4,963	6,483	5,577
Total [3]	r 10,266	11,799	11,349

e Estimate. p Preliminary. r Revised.
[1] Vanadium also was produced in the U.S.S.R. but data are insufficient for estimation.
[2] Vanadium in vanadium pentoxide product. Republic of South Africa includes vanadium in ammonium metavanadate, but doesn't include vanadium contained in slag (production of which began in 1968).
[3] Total is of listed figures only.

Strong demand abroad for vanadium in the latter part of the year was due in large part to increased pipeline construction in Europe, Japan, and Siberia and to the use of high-strength low-alloy constructional steels. With the new sources of supply contending with startup problems of some magnitude, the results were a marked increase in overseas prices for vanadium in its various forms and an abnormally high rate of ferrovanadium exports from the United States in the last quarter of the year.

Canada.—A discovery of vanadium in association with uranium on Prince Edward Island was reported to bear some geological similarity to the uranium-vanadium deposits of the Colorado Plateau sandstones. Data were insufficient to assess the possible economic significance.[2]

South Africa, Republic of.—In the fiscal year ended June 30, 1969, Highveld Steel and Vanadium Corp. Ltd. produced approximately 15,000 tons of vanadium slag for export. Vanadium recovery was less than anticipated due to problems encountered in going from pilot-plant to full-scale commercial operation. Because different methods are used by the company's customers for producing ferrovanadium from the slag, buyers specifications for the material differ. Highveld modified its operations in an effort to meet these different requirements more satisfactorily.

Sales of vanadium pentoxide by the company's Vantra division increased by almost 40 percent and production was increased. Process variations were under investigation in an endeavor to obtain an even higher rate of production.

Union Carbide Corp. announced expansion plans for the vanadium plant of its wholly owned subsidiary, Ucar Minerals Corp., located near Pretoria at Bon Accord. When completed by mid-1971 at an expected cost of $2.6 million, Union Carbide will have its first plant outside the United States for the manufacture of Carvan. Fraser Chalmers Corp. was awarded an engineering and construction contract for the job.

Uganda.—A study of the highly weathered Bukusu alkaline complex in southeastern Uganda showed that vanadium was associated with magnetite in sufficient quantity in the Nangalwe area that it could possibly be recovered as a byproduct should the economic potential of the magnetite be exploited. Concentrations up to 0.35 percent V_2O_5 were found in the low-titanium magnetite deposits at this location. Certain similarities with the copper-bearing Palabora carbonatite complex in the Republic of South Africa were noted.[3]

United Kingdom.—Ferrovanadium imports totaled 513 tons in 1969, compared with 282 tons in 1968. Norway, Sweden, and Austria were the principal suppliers in both years, but 16 tons came from the Republic of South Africa in 1969 and 7 tons from Luxembourg in 1968.[4]

[2] Prest, V. K., H. R. Steacy, and T. J. Bottrill. Occurrences of Uranium and Vanadium in Prince Edward Island. Geol. Survey Canada Paper 68–74, 1969, 14 pp.

[3] Baldock, J. W. Geochemical Dispersion of Copper and Other Elements at the Bukusu Carbonatite Complex, Uganda. Trans., Inst. Min. and Met. (London), v. 78, No. 747, February 1969, pp. B12–B28.

[4] Metal Bulletin (London). No. 5459, Dec. 19, 1969, p. 23.

TECHNOLOGY

Bureau of Mines studies of the effects of interstitial impurities on low-temperature properties of high-purity electrolytic vanadium were extended to measure the effects of nitrogen, oxygen, carbon, and boron on strength and ductility in the intermediate temperature range of 25° to 600° C. Nitrogen and oxygen additions, up to 0.11 and 0.22 percent respectively, caused strain-aging in vanadium at 300° to 400° C, and the vanadium was strengthened substantially in a linear relationship. The addition of boron or carbon had relatively little influence on strength in the temperature range investigated. There was marked grain refinement, and the small improvement in strength which was observed was attributed to this and to dispersion hardening. The nitrogen and oxygen additions did not affect grain size.[5]

The mechanical properties of vanadium containing up to 5 atomic percent titanium or molybdenum were measured in the temperature range of 77° to 673° K. Both bomb-reduced commercial vanadium metal and electrorefined vanadium metal were used.[6]

Vanadium alloys are a promising alternate to stainless steels for use as fuel cladding in liquid-metal-cooled fast breeder atomic reactors (LMFBR). The principal functions of the fuel jacket are to provide complete containment of the fuel and the fission products (gaseous and metallic), to protect the fuel alloy from the possible deleterious effects of the liquid-sodium coolant, and to lend structural support to

[5] Keith, G. H., and H. G. Iverson. Some Strain-Aging Effects in Electrorefined Vanadium. BuMines Rept. of Inv. 7222, 1969, 26 pp.

[6] Keith, G. H. Interactions of Titanium and Molybdenum Additions With Interstitial Impurities in Vanadium. BuMines Rept. of Inv. 7262. 1969, 22 pp.

the fuel columns that make up the core assembly. A comparison of the mechanical and thermal properties of several vanadium-titanium and vanadium-titanium-chromium alloys with two different austenitic stainless steels (type 304 and type 316) showed that vanadium alloy fuel jackets would be subjected to only one-third the thermal stresses that are generated in austenitic stainless steel jackets during reactor excursions between 500° and 700° C when the fuel is not in intimate contact. The difference is attributed to 37-percent higher tensile strength, 40-percent higher thermal conductivity, and 70-percent lower thermal expansivity of the vanadium alloys.[7]

One of the problems in the choice between vanadium alloys and stainless steels for use as fuel cladding in LMFBR reactors is the susceptibility of the former to corrosion by contact with sodium, the preferred coolant for this type of reactor. This corrosion takes the form of an increase in weight due to transport of the interstitial elements (nitrogen, carbon, and oxygen) through the sodium from the stainless steel components of the system. An adverse effect on the mechanical properties of the vanadium alloys results. Experiments by Westinghouse Electric Corp., Advanced Reactors Division, under contract with the U.S. Atomic Energy Commission, with three vanadium alloys—Vanstar 7 (V-9Cr-3Fe-1.3Zr-0.05C), Vanstar 9 (V-6Fe-5Cb-1.3Zr-0.05C), and V-20Ti—showed that the observed weight gain for the V20Ti reference alloy was three times that for each of the other two. Although the mechanical properties were adversely affected, at 700° C the Vanstar alloys still retained more than adequate ductility for cladding applications after 1,500 hours of exposure to sodium.[8]

In a Norwegian method for producing ferrovanadium by direct reduction of vanadiferous slag, obtained in refining vanadiferous pig iron, the slag is treated with 75 percent ferrosilicon to reduce a substantial part of of its iron content to metal without reduction of the vanadium oxide. The resulting iron metal is removed, and the remaining material is reduced to ferrovanadium with silicon metal or a highly reducing alloy of silicon.[9]

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[7] Yaggee, F. L., E. R. Gilbert, and J. W. Styles. Thermal Expansivities, Thermal Conductivities, and Densities of Vanadium, Titanium, Chromium and Some Vanadium-Base Alloys. J. Less-Common Metals, v. 19, No. 1, September 1969, pp. 39–51.

[8] Whitlow, G. A., R. J. Hornak, S. L. Schrock, and E. C. Bishop. The Effects of Exposure to Sodium on the Metallurgical and Mechanical Properties of Vanadium Alloys. J. Less-Common Metals, v. 18, No. 4, August 1969, pp. 357–371.

[9] Assigned to Christiania Spigerverk. Production of Vanadium From Vanadium-Containing Materials. British Pat. 1,165,487, Oct. 1, 1969.

Vermiculite

By William N. Hale [1]

Production of crude vermiculite in the United States during 1969 was 7 percent higher than in 1968 and value increased 20 percent. Output of exfoliated vermiculite increased 17 percent, and the value rose 18 percent. The average unit value of crude vermiculite increased 12 percent or $2.35 per ton, and the average unit value of exfoliated vermiculite increased 1 percent or $0.58 per ton.

DOMESTIC PRODUCTION

Crude Vermiculite.—Output increased 7 percent over that of 1968 to 310,000 tons valued at $6.8 million. Five companies operating eight mines in four States produced the entire domestic output. Principal production came from W. R. Grace & Co., Zonolite Division operations in Lincoln County, Mont., and Laurens County, S.C. Other producers were Solomon's Mines, Inc., from an operation in Maricopa County, Ariz.; American Vermiculite Co. and Patterson Vermiculite Co., from operations in Laurens County, S.C.; and Lanmont, Inc., from a property in Llano County, Tex.

Exfoliated Vermiculite.—Production of exfoliated material increased 17 percent in quantity and 18 percent in value over 1968 totals. Twenty-seven firms operating 53 plants in 33 States exfoliated 249,519 tons of vermiculite. W. R. Grace & Co., Zonolite Division, the largest producer, operated 22 plants in 20 States. Over 51 percent of the exfoliated vermiculite output came from operations in six States. The six major producing States in order of output and the respective number of plants in each State were: California (3), South Carolina (2), Texas (4), Florida (5), New Jersey (3), Illinois (3). Other production came from Minnesota, three plants; Arizona, Louisiana, North Carolina, Oregon, Pennsylvania, two plants each; and Arkansas, Colorado, Georgia, Hawaii, Kentucky, Maryland, Massachusetts, Michigan, Missouri, Montana, Nebraska, New Mexico, New York, North Dakota, Ohio,, Oklahoma, Tennessee, Utah, Washington, Wisconsin, one plant each.

Table 1.—Salient vermiculite statistics

	1965	1966	1967	1968	1969
United States:					
Sold and used by producers:					
Crude____________thousand short tons__	249	262	255	290	310
Value____________thousand dollars__	$4,460	$4,955	$4,974	$5,684	$6,805
Average value per ton______________	$17.91	$18.91	$19.51	$19.60	$21.95
Exfoliated_________thousand short tons__	177	193	180	213	250
Value____________thousand dollars__	$13,424	$15,130	$14,278	$16,845	$19,916
Average value per ton______________	$75.84	$78.39	$79.32	$79.08	$79.66
World: Production, crude____thousand short tons__	380	382	371	419	463

CONSUMPTION AND USES

Exfoliated vermiculite producers reported the following end-use percentages for 1969: aggregates (concrete, plaster, cement), 44 percent; insulation (loose fill, block, pipe covering, packing), 34 percent; agriculture (horticulture, soil conditioning,

[1] Geologist, Albany Mineral Supply Field Office, Albany, Oreg.

fertilizer carrier, litter), 15 percent; and miscellaneous uses (largely as a firebase), 7 percent. The end-use pattern of exfoliated vermiculite shifted slightly, increasing 4 percent in aggregates and 3 percent in miscellaneous uses; it dropped 6 percent in insulation and 1 percent in agriculture.

PRICES

The average unit value of crude vermiculite, beneficiated at the mine, was $21.95 per short ton, compared with $19.60 in 1968. The average unit value of exfoliated vermiculite was $79.66 per short ton, f.o.b. producer's plant, compared with $79.08 in 1968. During the year, the market prices quoted by Engineering and Mining Journal for crude vermiculite from Montana and South Carolina ranged from $18 to $35 per ton, f.o.b. mine. Crude vermiculite from the Republic of South Africa ranged from $29.55 to $40.15 per ton, c.i.f. Atlantic ports.

FOREIGN TRADE

Imports of crude vermiculite from the Republic of South Africa in 1968 declined to 10,576 tons from the 15,963-ton total in 1967. Crude vermiculite was imported duty free into the United States.

WORLD REVIEW

Canada.—Crude vermiculite imported from the United States and the Republic of South Africa was exfoliated in Canada. Six companies exfoliated 332,319 cubic yards of vermiculite at the following 10 operations in 1968: Calgary and Edmonton, Alberta; Vancouver, British Columbia (two plants); St. Boniface and Winnepeg, Manitoba; St. Thomas, Ontario; Lachine and Montreal, Quebec; and Regina, Saskatchewan. The following end-use percentages were reported by exfoliated vermiculite producers in 1968: loose fill insulation, 75 percent; plaster aggregate, 11 percent; insulating concrete, 8 percent; and miscellaneous uses, largely for fireproofing, 6 percent. The exfoliated vermiculite, marketed in bags holding 3 or 4 cubic feet, was sold at prices ranging from Can$0.30 to $0.40 per cubic foot.[2]

South Africa, Republic of.—Crude vermiculite production was 17 percent higher than in 1968. Total exports increased 9 percent over the 1968 tonnage, and value increased 14 percent. The average unit value of crude vermiculite exported from South Africa increased $0.87 per ton. Palabora Mining Co., Ltd., Vermiculite Division, the only producer in South Africa, planned to expand its open-pit mining and milling operation in the northern Transvaal, and was determining the feasibility of recovering vermiculite from pyroxenite and serpentine by wet-process methods.

[2] Wilson, H. S. Lightweight Aggregates, 1968. Canada Dept. of Energy, Mines, and Resources, Ottawa, June 1969, 4 pp.

Table 2.—Free world production of vermiculite, by countries

(Short tons)

Country	1967	1968	1969 p
Argentina	3,201	2,547	NA
Brazil	240	2,724	e 4,630
India	349	2,588	5,713
Kenya	277	308	855
South Africa, Republic of	111,885	121,453	141,963
Tanzania	100	33	140
United States (sold or used by producers)	r 254,733	289,504	309,467
Total [1]	r 370,785	419,157	462,768

e Estimate. p Preliminary. r Revised. NA Not available.
[1] Totals are of listed figures only.

Table 3.—Republic of South Africa: Exports of crude vermiculite by countries
(Short tons)

Destination	1967	1968	1969
Australia	2,833	3,988	NA
Canada	3,884	3,850	NA
France	9,418	9,899	NA
Germany, West	9,296	13,058	NA
Italy	19,088	20,164	NA
Japan	4,995	4,647	NA
Netherlands	1,744	1,283	NA
Spain	2,942	3,902	NA
Sweden	1,340	1,584	NA
United Kingdom	30,214	27,745	NA
United States	15,963	10,576	NA
Other countries	3,903	5,356	NA
Total	105,620	r 106,052	115,584
Total value [1]	$1,980,055	r $2,119,344	$2,409,697
Average value	$18.75	r $19.98	$20.85

r Revised. NA Not available.
[1] Converted to U.S. currency at the rate of 1 rand equals $1.398 (1967), and $1.40 (1968, 1969).

TECHNOLOGY

Properties of regulated-set cement, developed by the Portland Cement Association, were described at the Vermiculite Institute 28th Annual Meeting, held at Point Clear, Ala.[3] The cement eliminates marginal weather problems sometimes encountered in placing vermiculite concrete roof decks.

An electron-microscopy study of vermiculite clays was undertaken to ascertain whether variations in mode of formation and in chemical composition affected the shape of the particles.[4]

Gold Field Laboratories, Mining Division, in collaboration with Palabora Mining Co., Ltd., developed for use in mines, a plaster of exfoliated vermiculite and a bonding agent that effectively sealed off surfaces treated with the mixture. The vermiculite plaster was an effective firebreak for sealing off underground mine fires.[5]

Fire rating tests were made on vermiculite plaster and concrete by the South African Bureau of Standards.[6]

Patents were issued on the use of unexfoliated vermiculite in polyurethane foams to improve the fire resistance of the foam composition [7], and on its use in fire-retardant roof-deck construction.[8] Vermiculite was blended with asbestos fiber on bentonite, and the resulting vermiculite-clay paper was used in electronic applications.[9]

Crude vermiculite was mixed into a hot solution of ammonia, nitrates, or phosphates under conditions which caused exfoliation of the vermiculite particles and adsorption of the fertilizer values.[10]

Exfoliated vermiculite was used as a mulch in covering furrows in an agricultural seed bed. The vermiculite layer was sprayed with aqueous polyvinyl acetate which dried and bonded the vermiculite particles and protected the layer from weathering destruction; the emerging seedlings could penetrate the mulch.[11]

A British patent was issued for using a mixture of ground charcoal and unexfoliated vermiculite for covering molten metals as a flux or heat insulation to delay heat loss from the surface of the ingot or melt.[12]

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[3] Pit and Quarry. Vermiculite Institute Names New President and Reports Sales Increases in 1968. V. 62, No. 2, August 1969, p. 30.

[4] Kishk, Fawzy M., and Isaac Barshad. Morphology of Vermiculite Clay Particles As Affected by Their Genesis. Am. Mineralogist, v. 54, No. 5–6, May–June 1969, pp. 849–857.

[5] Botha, B. J. R. Vermiculite Sealing Plaster in Mines. South African Min. and Eng. J., v. 80, pt. 1, No. 3967, Feb. 14, 1969, p. 363.

[6] The South African Mining and Engineering Journal. Vermiculite Plaster as Fireproofing Aid. V. 80, pt. 1, No. 3986, June 27, 1969, p. 1449.

[7] Saunders, J. H. (assigned to Mobay Chemical Co.). Fire-Resistant Polyurethane Foam. U.S. Pat. 3,455,850, July 15, 1969.

[8] Curtis, F. W. (assigned to Lexsuco, Inc.). Fire Retardant Insulative Structure and Roof Deck Construction Comprising the Same. U.S. Pat. 3,466,222, Sept. 9, 1969.

[9] Kraus, J. W., and F. R. Hurley (assigned to W. R. Grace & Co.). Preparation of Vermiculite Paper. U.S. Pat. 3,434,917, Mar. 25, 1969.

[10] Chapin, J. K., Jr., and D. V. Robinson (assigned to W. R. Grace & Co.). Method of Thermally Expanding Vermiculite in a Hot Liquid and Product Prepared by Such Process. U.S. Pat. 3,459,531, Aug. 5, 1969.

[11] Rothfelder, R. E. (assigned to W. R. Grace & Co.). Mulching Process. U.S. Pat. 3,475,435, Oct. 28, 1969.

[12] Neu, M. G. (assigned to Foseco International, Ltd.). British Pat. 1,151,507, May 7, 1969, 2 pp.

Table 4.—Vermiculite exfoliating plants in the United States in 1969

Company	State	County
Arizonolite Co	Arizona	Maricopa.
California Zonolite Co	California	Alameda, Los Angeles.
Carolina Wholesale Florist Co	North Carolina	Lee.
Cleveland Gypsum Co., Division of Cleveland Builders Supply Co.	Ohio	Cuyahoga.
Coralux Perlite Corp. of New Jersey	New Jersey	Middlesex.
Filter Media Co., Inc	Louisiana	St. John the Baptist.
Hyzer & Lewellen	Pennsylvania	Bucks.
International Vermiculite Co	Illinois	Macoupin.
La Habra Products, Inc	California	Orange.
Lanmont, Inc	Texas	Llano.
MacArthur Co	Minnesota	Ramsey.
Mica Pellets, Inc	Illinois	De Kalb.
The B. F. Nelson Manufacturing Co	Minnesota	Hennepin.
Patterson Vermiculite Co	South Carolina	Laurens.
Robinson Insulation Co	Montana	Cascade.
	North Dakota	Ward.
Solomon's Mines, Inc	Arizona	Maricopa.
Southwest Vermiculite Co	New Mexico	Bernalillo.
Supreme Perlite Co	Oregon	Multnomah.
Texas Vermiculite Co	Oklahoma	Oklahoma.
	Texas	Bexar.
		Dallas.
Verlite Co. (Schmelzer Sales Assoc., Inc.)	Florida	Hillsborough.
Vermiculite of Hawaii, Inc	Hawaii	Honolulu.
Vermiculite Industrial Corp	New Jersey	Essex.
Vermiculite-Intermountain	Utah	Salt Lake.
Vermiculite-Northwest, Inc	Oregon	Multnomah.
	Washington	Spokane.
Vermiculite Products, Inc	Texas	Harris.
Zonolite Division, W. R. Grace & Co	Arkansas	Pulaski.
	Colorado	Denver.
	Florida	Duval, Hillsborough, Palm Beach.
	Georgia	Fulton.
	Illinois	Cook.
	Kentucky	Campbell.
	Louisiana	Orleans.
	Maryland	Prince Georges.
	Massachusetts	Hampshire.
	Michigan	Wayne.
	Minnesota	Hennepin.
	Missouri	St. Louis.
	Nebraska	Douglas.
	New Jersey	Mercer.
	New York	Cayuga.
	North Carolina	Guilford.
	Pennsylvania	Lawrence.
	South Carolina	Greenville, Laurens.
	Tennessee	Davidson.
	Wisconsin	Milwaukee.

Zinc

By Donald E. Moulds [1]

The free world production and consumption of zinc continued at a record level in 1969, although in the second half of the year indicated supply had surpassed requirements. Mine production was again expanded 7 percent to 4.56 million tons, and smelter output increased 12 percent to 4.26 million tons. Consumption maintained a growth slightly above metal output with a resulting reduction in producer stocks, until June; then decreased consumption and expanded supply reversed the trend in producer stocks and resulted in a 102,000-ton increase in these stocks during the June-December period. The price of zinc in the world market trended upward throughout the year as metal demand and competition for smelter feed materials brought pressure. The producer price, both domestic and foreign, stabilized, however, in September for the remainder of the year.

The domestic industry continued the upward trend in consumption and production although at a reduced rate. Consumption of slab zinc increased 2.6 percent to 1.37 million tons. Mine production increased 4.5 percent to 553,100 tons, although all mining areas reported an inadequate supply of experienced underground personnel to achieve desired production rates. Smelter production of slab zinc increased 1 percent over the strike-curtailed 1968 output to 1.11 million tons. Increased imports of zinc metal and zinc in ore provided an easier supply, although this was

[1] Physical scientist, Division of Nonferrous Metals.

Table 1.—Salient zinc statistics

	1965	1966	1967	1968	1969
United States:					
Production:					
Domestic ores, recoverable content short tons	611,153	572,558	549,413	529,446	553,124
Value thousands	$178,284	$166,044	$151,562	$142,950	$161,512
Slab zinc:					
From domestic ores short tons	551,215	523,580	438,553	499,491	458,754
From foreign ores do	443,187	501,486	500,277	521,400	581,843
From scrap do	83,619	83,263	73,505	79,865	70,553
Total do	1,078,021	1,108,329	1,012,335	1,100,756	1,111,150
Secondary zinc [1] do	271,694	277,967	247,254	276,092	307,714
Exports of slab zinc do	5,939	1,406	16,809	33,011	9,298
Imports (general):					
Ores (zinc content) do	428,040	521,320	534,092	543,366	602,120
Slab zinc do	152,990	278,175	222,112	306,540	329,008
Stocks, December 31:					
At producer plants do	28,622	64,798	81,916	65,379	67,662
At consumer plants do	150,763	129,593	102,535	101,818	100,492
Consumption:					
Slab zinc do	1,354,092	1,410,197	1,236,808	1,333,699	1,368,323
All classes do	1,742,067	1,806,543	1,591,997	1,728,400	1,797,110
Price, Prime Western, East St. Louis cents per pound	14.50	14.50	13.85	13.50	14.65
World:					
Production:					
Mine short tons	r 4,741,537	r 4,942,013	5,330,400	5,509,882	5,864,751
Smelter do	4,352,571	4,498,252	4,547,754	5,053,329	5,519,820
Price: Prime Western grade, London cents per pound	14.12	12.75	12.37	11.89	12.96

r Revised.
[1] Excludes redistilled slab zinc.

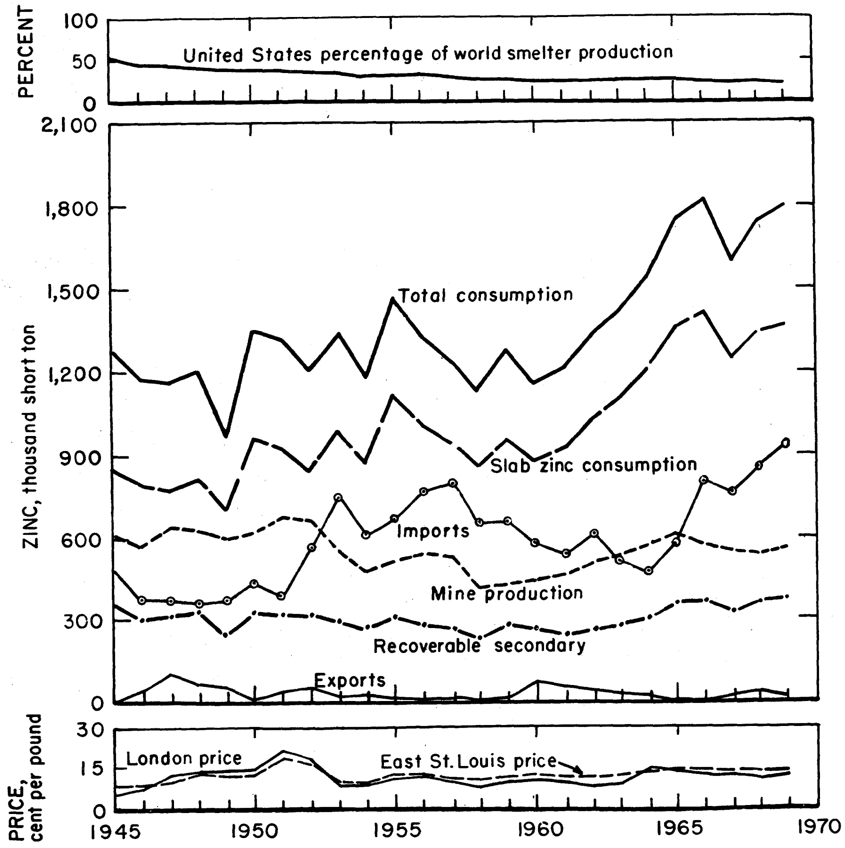

Figure 1.—Trends in the zinc industry in the United States.

offset in part by reduced shipments from Government stocks. Producer stocks of slab zinc trended downward until June and then began to gradually build, especially late in the year. Consumer stocks trended upward until midyear and then declined, and the total producer-consumer stock buildup at plants amounted to about 7,000 tons. The base price for prime western grade zinc, f.o.b. East St. Louis, in response to the world market began to move up in January, and after several producer price actions, it stabilized at 15.5 cents per pound on September 12.

Legislation and Government Programs.—Sale of zinc by the General Services Administration as an off-the-shelf item to commercial consumers under authority of Public Law 89–322, and transfers to other Government agencies under Public Law 89–9 continued. Commercial sales in 1969 amounted to 17,092 tons. No sales were made after October. Approximately 22,600 tons remained in the commercial authorization. Government transfers, all prior to midyear, totaled 165 tons, and about 42,240 tons remains of the initial 50,000 ton authorization. The actual decrease in zinc stockpile inventory in 1969 was 18,421 tons leaving 1,142,185 tons in the stockpile.

The Lead-Zinc Small Producers Stabilization Act of October 3, 1961 (Public Law

87-347), as amended, expired December 31, 1969. The price of zinc reached 14.5 cents per pound, the ceiling for payments on qualified production under the program, on May 1. Payments during the period January through April 1969 totaled $69,573 on sales of 2,296 tons of lead and 4,729 tons of zinc. In the 8-year period of the program, payments totaling $2,589,597 were made to 91 producers in 11 States on sales of 35,830 tons of lead and 68,860 tons of zinc. Payments of $1.1 million to 26 producers in Oklahoma represented nearly 43 percent of the total. The quality of lead and zinc on which payments were made represented about 3 percent of the total domestic production during the periods when prices were below the 14.5-cent-per-pound ceiling established by the act.

The International Lead and Zinc Study Group held its 13th session in Geneva on October 8-14. The Group, representing 30 countries, reviewed statistical data and concluded that supply and demand were then in close balance, but it expected an easier supply situation in 1970. It was noted that the annual growth of zinc consumption over the last 10 years had been 6.1-percent. Among other matters discussed were the growth of lead and zinc industries in developing countries, trade liberalization, promotion of consumption, and trends in metal production capacity.

DOMESTIC PRODUCTION

MINE PRODUCTION

Domestic mines produced 553,100 tons of recoverable zinc in concentrate, a 4.5-percent increase over the strike-curtailed production in 1968. In Tennessee, the upward trend in production initiated in 1967 continued and output achieved a record 124,500 tons. A highlight of the 1969 output was the 41,000 tons produced in Missouri as a byproduct of the new lead-belt mines. The Missouri production caused a shift in the concentration of domestic production; States west of the Mississippi River furnished 44 percent of domestic production in 1969 compared with 40 percent in 1968.

The sources of zinc production in 1969, classified according to principal metal value, were as follows: [2] 63 percent from zinc ores; 18 percent from lead-zinc ores; 9 percent from lead ores; 6 percent from copper-lead-zinc ores; and 4 percent from all other sources. The average zinc content of the 8.9 million tons of zinc ore mined in 1969 was 3.93 percent, slightly lower than the 3.99 percent indicated for 1968.

The Balmat mine of St. Joseph Lead Co. in New York State continued to be the largest domestic mine. The leading 25 mines listed in table 4 contributed 73 percent of the domestic output. The first five mines produced 28 percent and the top 10 mines, 45 percent.

Tennessee, with eight mines in the leading 25, produced almost 23 percent of the domestic output. A slight increase in 1969 resulted in a new record for the State at 124,500 tons of recoverable metal. American Zinc Co. established a record output of 127,100 tons of zinc concentrates in fiscal year 1969 from the Young, New-Market, Immel, Coy, and Mascot No. 2 mines. New mining procedures and accelerated development at the New Market mine resulted in improved production, and a development program was in progress at the Immel and Coy mines.[3] The New Jersey Zinc Co. operated the Jefferson City and Flat Gap mines and United States Steel Corp. operated the Zinc Mine Works throughout the year. Zinc production at the Copperhill mine of Tennessee Copper Co. was curtailed by a 3-week strike beginning on September 15. The New Jersey Zinc Co., a subsidiary of Gulf and Western Industries, Inc., announced early in the year a major zinc ore discovery in central Tennessee. The deposit, which has not been fully explored was reported to have a potential exceeding the known occurrences of zinc in the eastern Tennessee district and could approach or surpass the Tri-State district.

The Penobscot unit of Callahan Mining Corp. in Maine moved almost 1.2 million tons of waste and mined 205,300 tons of ore of which 183,300 tons, averaging 5.4 percent zinc, was treated in the concentration plant.[4]

[2] Details of this breakdown are given in table 3 of the "Lead" chapter in this volume.
[3] American Zinc Co. Annual Report. 1969, p. 5.
[4] Callahan Mining Corp. Annual Report. 1969, p. 9.

New York output of zinc, all from the Balmat-Edwards Division of St. Joseph Lead Co., decreased 11 percent from 1968 production. The lower production was attributable to changes in grade and ore tonnage milled, as well as to a labor shortage and construction work in progress for the new mine and mill facilities to be completed.[5]

Idaho production decreased slightly in 1969 mainly due to permanent closure of the Page mine by American Smelting and Refining Co. upon depletion of the ore. The Bunker Hill mine of Gulf Resources & Chemical Corp. increased production, but shaft construction and slow development of the Star mine deep ore body resulted in an overall 7½-percent decrease in mine output of zinc in concentrates during the year.[6] The 1¼-mile-deep development of the Star-Morning unit area, owned by Gulf Resources & Chemical Corp. and Hecla Mining Co., was scheduled to be in operation in the second quarter of 1970. The work, started in 1966, comprises a new No. 4 main shaft, ore and waste-handling facilities, and a hoisting plant capable of a 7,100-foot vertical lift.[7]

Zinc production in Colorado in 1969 essentially regained the level of production prior to the strike-curtailed output of 1967–68. The Eagle mine of The New Jersey Zinc continued to be the dominant producer, followed by the Idarado mine of Newmont Mining Corp. The start of milling operations at the Keystone mine in Crested Butte was announced on September 3. The mine and mill, operated by Keystone Mines Co., can process 300 tons per day of lead-zinc-silver ore. Newmont Mining Corp. and American Smelting and Refining Co., jointly developing a lead-zinc deposit near Leadville, completed the 1,650-foot Black Cloud shaft in February 1970. The deposit was stated to have an estimated 2.4 million tons of ore averaging 9.95 percent zinc, as well as comparatively high values in lead and silver. A 300-ton-per-day mill associated and facilities are expected to be in production early in 1971.[8] Federal Resources began sinking a shaft in September to reach a newly discovered ore body below the old workings of the Camp Bird mine near Ouray.

Pennsylvania, New Jersey, and Virginia production by New Jersey Zinc Co. increased approximately 1,500 tons to 76,800 tons.

United States Smelting Refining and Mining Co. operated the U.S. and Lark mine throughout the year. The ore was processed at the Midvale, Utah, flotation mill along with other custom ores. Other substantial Utah producers were the Burgin mine of Kennecott Copper Corp., the Mayflower mine of Hecla Mining Co., and United Park City Mines Co. Development work at the Burgin mine, Tintic, Utah, to increase the ore production rate to 800 tons per day continued, and the development shaft at the new Trixie area, also at Tintic, was completed. Production of zinc at the Burgin mine and at Kennecott's Missouri lead operation totaled 15,300 tons in 1969.[9] The Mayflower mine operated by Hecla Mining Co. and owned by New Park Mining Co. produced 117,500 tons of ore averaging 3.13 percent zinc.[10]

Missouri became the fifth-ranking zinc-producing State in 1969, the first full year of operation of the new lead-belt mines and mills of St. Joseph Lead Co., Kennecott Copper Corp., Cominco-Dresser Industries, and American Metals Co.-Homestake Mining Co. Zinc is a byproduct of lead production. The ratio of zinc to lead in 1969 was 1 ton of zinc for each 8.64 tons of lead, and it is expected to increase as the output of the new lead belt supplants production from the old lead belt.

American Smelting and Refining Co. resumed operation of the Ground Hog unit at Vanadium, N. Mex. in May after being shutdown since 1965. Monthly ore production reached almost 9,000 tons in December, and 6,125 tons of zinc in concentrates was produced in 1969.[11] United States Smelting Refining Mining Co. operated the Continental No. 1 mine, Fierro, N. Mex., a copper-zinc deposit, and the Princess mine at Bayard, N. Mex. The Princess mine was gradually phased out during the year. The Bullfrog mill at Bayard, N. Mex., processed zinc ore from the Princess mine and also copper ore from the New Continental mine at a 400-ton-per-day rate.

Cypress Mines, Corp., began production

[5] St. Joseph Lead Co. Annual Report. 1969, p. 8.
[6] Gulf Resources & Chemical Corp. Annual Report. 1969, p. 6.
[7] Hecla Mining Co. Annual Report. 1969, p. 8.
[8] Newmount Mining Corp. Annual Report. 1969, p. 12.
[9] Kennecott Copper Corp. Annual Report. 1969, p. 12.
[10] Hecla Mining Co. Annual Report. 1969, p. 8.
[11] American Smelting and Refining Co. Annual Report. 1969, pp. 5–6.

in midyear from the newly developed Bruce mine near Bagdad, Ariz., and achieved a monthly rate of 9,000 tons of copper-zinc ore. Standard Metals Corp. began construction of a 250-ton-per-day flotation mill near Kingman, Ariz., to concentrate copper-zinc ores from its Antlers mine. American Smelting and Refining Co. resumed operations at the Van Stone mine at Northport, Wash., in April, and concentrates containing 6,137 tons of zinc were produced during the year.[12] Eagle-Picher Industries Inc. completed the development work at the Swalley lease near Baxter Springs, Okla., and began shipping ore to its Central mill at Carden, Okla. Zinc production from the Illinois-Wisconsin area decreased 16 percent from the 1968 total and over 25 percent from the 1967 total.

SMELTER AND REFINERY PRODUCTION

Production of slab zinc increased 1 percent in 1969 to a record 1.11 million tons as operations continued normal at all of the plants except the electrolytic refinery of The Anaconda, Mont., which was shut down at the end of August. Output during the first half of 1969 was at the high level established in the last 3 quarters of 1968. Over 100,000 tons was produced in January and in March, and the 6-month average was 97,900 tons. Shipments during this period exceeded production by some 29,300 tons with a corresponding decline in stocks. The reduction in output beginning in August, however, resulted in an average monthly production of 92,600 tons for the year. Shipments were reduced severely, and September was the only month in the last half of the year in which shipments exceeded production.

Secondary zinc production increased 11 percent to 307,700 tons as continuous operations in the brass mills provided a larger supply of new and old scrap. The total supply from secondary sources, processed into slab zinc, zinc dust, alloys, and chemicals, amounted to 376,400 tons and represented 21 percent of the total consumption of zinc the same as in 1968.

Slab Zinc.—The slab zinc production of 1.11 million tons was derived from domestic ores, 41 percent; foreign ores, 52 percent, and secondary materials, 7 percent. The domestic ores continued the decline, begun in 1966, in percentage of total feed. In 1965 domestic ores represented 55 percent of the total slab zinc output, as imports were curtailed by the quotas in effect until October 1965. In 1969 electrolytic zinc comprised 41 percent of the slab zinc; distilled zinc, 53 percent, and redistilled at primary and secondary plants, 6 percent. Special high grade represented 42 percent of the total produced and prime western grade, 32 percent. The reduction in prime western and the increase in high grade indicated a demand for higher grade zinc in the continuous galvanizing lines which came on stream during the year. The increase of 18 percent in brass special grade reflects the normal operation of brass mills during the year.

The Zinc Smelting Division of St. Joseph Lead Co. increased metal output to 215,600 tons in 1969 compared with 206,200 tons in 1968. Zinc oxide output was also increased to 35,200 tons.[13] American Smelting and Refining Co. produced 140,900 tons at its Amarillo and Corpus Christi, Tex. plants in comparison with 124,000 tons in the strike curtailed production in 1968[14] and begun operation of a new zinc-dust plant at Whiting, Ind. The Anaconda Company closed its electrolytic refinery at Anaconda, Mont., at the end of August because of a shortage of concentrates from outside sources and reactivated two cell blocks at its Great Falls, Mont., refinery to bring that plant up to full capacity. Production in 1969 was 180,300 tons compared with 148,400 in 1968 and 180,700 tons in the recent high year of 1966.[15] The Bunker Hill Co., a subsidiary of Gulf Resources & Chemical Corp., increased zinc metal production 3 percent to 106,000 tons despite production curtailments in the first quarter arising from severe weather.[16] American Zinc Co. produced 127,600 tons of slab zinc during the fiscal year 1969, or about 5,900 tons more than production the year before at its Dumas, Tex., and East St. Louis, Ill., plants.[17] The company also produced a record 44,000 tons of zinc pigments at its Columbus, Ohio and Hillsboro, Ill. plants.

Slag-Fuming Plants.—Processing of lead smelter slags to recover the 7 to 13 percent

[12] American Smelting and Refining Co. Annual Report. 1969, p. 6.
[13] St. Joseph Lead Co. Annual Report. p. 12.
[14] American Smelting and Refining Co. Annual Report. 1969, p. 26.
[15] The Anaconda Company. Annual Report. 1969, p. 34.
[16] Gulf Resources & Chemical Corp. Annual Report. 1969, p. 6.
[17] American Zinc Co. Annual Report. 1969, p. 6.

of contained zinc was continued at five plants—American Smelting and Refining Co. at Selby, Calif., and El Paso, Tex.; The Anaconda Company at East Helena, Mont.; Bunker Hill Co. at Kellogg, Idaho; and International Smelting & Refining Co., at Tooele, Utah. Material processed during the year consisted of 741,100 tons of new hot-slags, 76,200 tons of old slags, and 8,600 tons of ores. The total of 825,900 tons was substantially above the 612,700 tons treated in 1968. The yield of oxide fume was 144,900 tons containing 94,700 tons of recoverable zinc compared with 113,600 tons of fume and 72,900 tons of zinc in 1968.

Secondary Zinc Smelters.—Zinc recovered from processing secondary materials amounted to 376,400 tons compared with 354,700 tons in 1968. New scrap from reprocessing various alloys, primarily zinc-base and copper-base, provided 78 percent of the feed material. Zinc-base scrap declined with the curtailed activity in diecasting, while copper-base scrap reflected the full-year operation at brass mills. Old scrap continued to be a minor component of secondary zinc. The recovered zinc was mainly reused in copper-base alloys. Processing to metal decreased from 34 percent of the total in 1968 to 29 percent in 1969.

Byproduct Sulfuric Acid.—The recovery of sulfur from stack gases evolved in the roasting of zinc sulfide ores and in retorting processes has been intensified to meet increasingly rigid clean-air requirements. The sulfur dioxide is usually processed to sulfuric acid. A measure of the progress in air pollution abatement is the byproduct acid output. In 1965 about 961,600 tons of sulfuric acid was produced, or 0.89 ton per ton of slab zinc, while in 1969, the 1,086,900 tons of sulfuric acid produced represents 0.98 ton per ton of slab zinc.

Zinc Dust.—Production of zinc dust decreased in 1969 after an upward trend for several years. Of the 55,100 tons produced about 33,200 tons came from metal distilled from scrap.

CONSUMPTION AND USES

Consumption of slab zinc increased 2.6 percent to 1.37 million tons. Zinc-base alloys required 42 percent of the slab zinc; galvanizing, 35 percent; brass mills, 13 percent; rolled zinc, 4 percent; and zinc oxide, 3 percent. The remaining 3 percent was used in many small-tonnage applications. The 1-percent drop in galvanizing was essentially in light-gage sheet and in wire rope and reflected the depressed construction and automobile markets. Galvanized pipe, containers, and fencing requirements were bright spots in the galvanizing area. The 11-percent increase in brass requirements reflected a full-year operation at brass plants compared with strike-curtailed production in 1967–68. A shortage of copper in 1969 undoubtedly adversely affected the demand for slab zinc. Zinc-base alloys, the major factor in the recent growth of zinc demand, posted only a 2-percent increase and reflected the curtailed demand from the automobile industry. Rolled zinc use was similar to that in 1968, while the use of slab zinc for high-purity zinc oxide in the French process increased almost 19 percent and thus continued the growth trend initiated in 1964. The average annual compound growth in the last 5 years was about 15 percent per year.

Consumption of slab zinc by grades was as follows: Special High grade, 50 percent; Prime Western grade, 29 percent; High grade, 10 percent; Brass Special, 9 percent; and Intermediate and remelt grades each about 1 percent. The pattern in 1969 indicated a shift in demand with Brass special decreasing 5½ percent compared with 1968 consumption. Special High grade posted a 1-percent increase, and Prime Western increased 5 percent.

Rolling mills used 48,700 tons of slab zinc and produced 46,500 tons of salable products, mainly strip and foil and photoengraving plate. Imports of rolled products—plates, sheets, and strip—amounted to 970 tons; exports were 2,700 tons. While the overall value of domestic output increased slightly, as did the value of imported rolled zinc, the value of exports declined, and the value added by rolling also decreased. The total tonnage through the rolling mills, including 24,400 tons remelted and rerolled from scrap, amounted to 70,900 tons compared with 69,500 tons in 1968.

Illinois continued to lead the United States in consumption of slab zinc with 14 percent of the total and was followed by Michigan, Pennsylvania, Indiana, and New

York. The zinc-consuming industries in these five States represent 56 percent of the domestic requirements for slab zinc. The largest end uses were diecasting in Michigan, galvanizing in Ohio, and brass products in Connecticut.

ZINC PIGMENTS AND COMPOUNDS

Production.—Production of zinc pigments and compounds increased in total to 341,700 tons, or slightly above the record 336,100 tons in 1968. Shipments of 340,200 tons were slightly below production, in contrast to the indicated 2,800-ton excess of shipments over production in 1968. Zinc oxide production of 220,400 tons represented a 5-percent increase for the year, and the value increase amounted to 11 percent. Leaded zinc oxide production however, was less than one-half the 1968 tonnage, and shipments, while less than the 1968 total, did exceed production by 2,000 tons indicating a substantial drawdown of stocks. Production and shipments of zinc chloride decreased approximately 17 percent, while zinc sulfate production

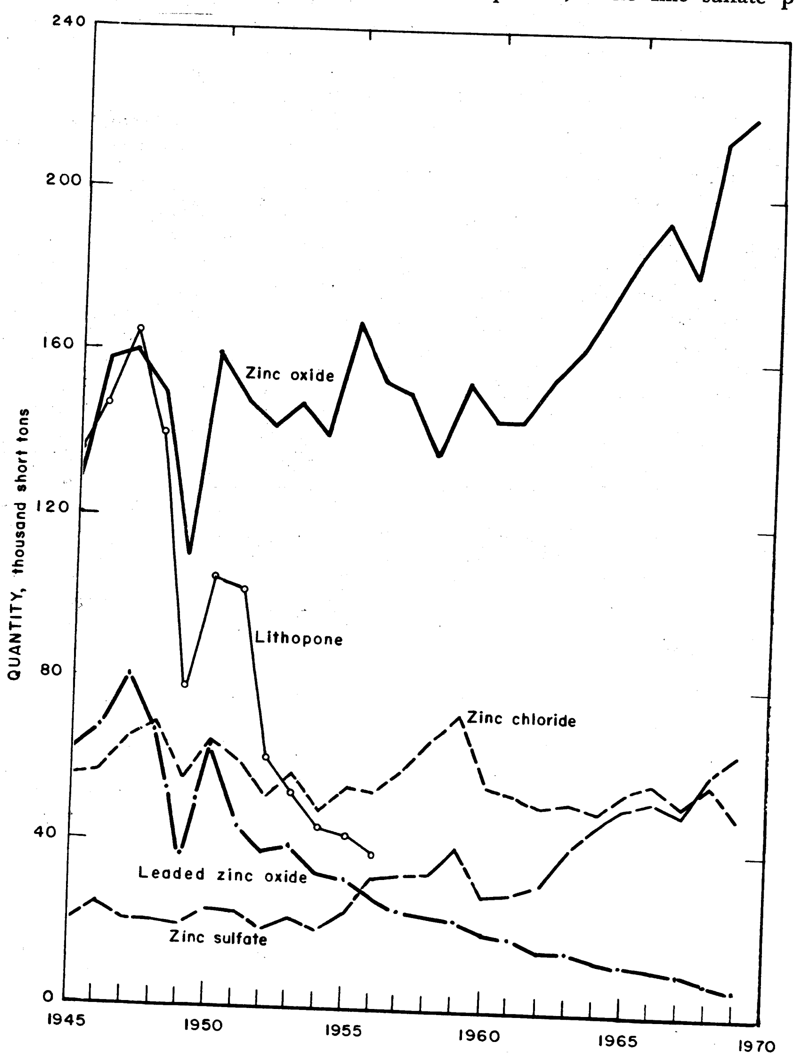

Figure 2.—Trends in shipments of zinc pigments.

increased 20 percent to 68,500 tons and exceeded shipments by almost 3,900 tons.

Zinc pigments and compounds were produced from ore, refined metal, and secondary materials, depending on the process used. Lead-free zinc oxide production by the American process from ores amounted to 59 percent of the total. The French process using slab contributed 29 percent, and the remaining 12 percent was derived from secondary materials and residues. Production of zinc oxide and sulfate consumed 120,700 tons of zinc in ores, of which 89,900 tons, or 74 percent, was from domestic mines. The amount of domestic zinc in ores consumed in pigments represented 16 percent of the domestic mine production in 1969 and was significantly above the 12.6 percent posted in 1968.

Consumption and Uses.—The leading requirements for zinc oxide is in manufacture of rubber, a use which continued to trend upward to a record 116,000 tons and represented 53 percent of the lead-free zinc oxide consumption. The use in photosensitive copying paper continued to gain in tonnage; at 27,600 tons, it was the second largest requirement in 1969 and surpassing the 25,200 tons used in paint pigments, especially in the widely used alkyd-latex paints. Zinc oxide in various chemical compounds continued at the high level established in 1968, while agricultural and ceramic requirements declined compared with 1968.

Consumption of leaded zinc oxide in paint pigments has developed about 2,000 tons per year since 1966. Zinc sulfate shipments increased in gross weight, but moisture content was indicated at 22 percent compared with 10 percent in 1968. Agriculture requirements decreased, as did the various other uses on a dry basis.

Prices.—The pricing of zinc oxide followed the uptrend in the price of slab zinc, although the January 10 increase of one-half cent in slab zinc was not reflected in the zinc oxide price until April 1, and the one-half-cent rises in slab zinc on May 1 and September 2 were not reflected until October. The price of American-process zinc oxide, lead-free, carload lots, freight allowed, thus increased from 15¼ cents per pound to 15¾ cents on April 1 and to 16½ cents per pound on October 1. French process, green seal grade, advanced from 17½ cents per pound to 18 cents and then to 18¾ cents on April 1 and October 1, respectively. Leaded zinc oxide, 35 percent grade, increased from 15¾ cents per pound to 16¼ cents and then to 17 cents.

Zinc sulfate, monohydrate, 36-percent in carload lots, was quoted at 9½ cents per pound until early August when a range of 9½ to 10 cents per pound developed. The price stabilized in early September at 10 cents. Zinc chloride, 50-percent, in tank cars, continued throughout the year at the 6.20-cents-per-pound price effective October 1, 1968.

Foreign Trade.—Exports of zinc oxide in 1969 amounted to 3,780 tons. Shipments were directed to 38 countries. Canada was the leading destination with 1,454 tons, followed by West Germany and Belgium-Luxembourg. Lithopone exports amounted to 1,090 tons to 31 countries. South Vietnam was the largest importer with 612 tons, followed by Canada with 323 tons.

Imports of zinc compounds for consumption totaled 23,500 tons in 1969 compared with 20,800 tons in 1968. Zinc oxide amounted to 14,600 tons, all except 242 tons of which was lead-free. Mexico was the largest source with 6,180 tons, followed by Canada, 4,780 tons; Japan, 750 tons; and West Germany, 650 tons. Poland supplied 25 tons in 1969. Lithopone imports of 261 tons were mainly from West Germany and the Netherlands. Zinc chloride came mainly from West Germany, 730 tons; Belgium-Luxembourg, 422 tons; and Canada, 190 tons. Zinc sulfate imports increased sharply in 1969 to 6,240 tons, of which 5,000 tons came from Mexico and 1,060 tons from Australia. The total value of zinc compound imports was $4.48 million compared with $4.15 million in 1968.

STOCKS

Producer Stocks.—Stocks of slab zinc at producer plants at the beginning of the year amounted to 65,380 tons, of which 64,700 tons was located at primary reduction plants and 680 tons at secondary plants. Shipments exceeded production for the first 5 months with a resulting decline in stocks of 30,000 tons at smelters and 5,000 tons elsewhere by the end of May. A slight buildup of 10,000 tons occurred in the period June to October, but in November and December production substantially exceeded shipments, and stocks increased to 67,700 tons at yearend of which secondary plants held 890 tons.

Consumer Stocks.—Slab zinc stocks held by consumers opened the year at 101,800 tons and were reduced to 94,600 tons by the end of March. A buildup in the second quarter brought stocks back to the 101,800-ton level at the end of June. The buildup continued in the third quarter to 105,700 tons at the end of September. Increased supply and declining demand in the fourth quarter included consumers to reduce inventories, and stocks ended the year at 100,500 tons essentially unchanged from beginning stocks. In view of reduced demand for die-cast alloy, the major change in stocks by grade was the 9,000-ton reduction in special high grade and the increase in the other general-purpose grades of slab zinc.

PRICES

The domestic price of prime western grade zinc at East St. Louis, stable at 13½ cents per pound since June 20, 1967 began an upward trend on January 10 when American Zinc Co. announced increases that raised the price to 14 cents per pound. Other producers followed the move, and 14 cents per pound was the domestic quotation by January 14. Effective April 30, American Zinc Co. again increased the price a ½ cent per pound to 14½ cents, and by May 1 all other producers had followed the increase. National Zinc Co. initiated, effective September 2, an increase of 1 cent per pound bringing the price to 15½ cents per pound. Between September 2 and September 12 a range of 14½ to 15½ cents existed in the market as other producers split on the price increase, but on September 12 the 15½-cent price was adopted by all domestic producers and continued in effect the remainder of 1969.

The producer price in continental Europe opened the year at 12¼ cents per pound (U.S. equivalent) and moved up in late April to 12.96 cents and again in early August to 13.93 cents per pound where it continued to yearend. The average producer price for the year was 13.02 cents per pound

The London Metal Exchange monthly average price trended upward throughout the year except for a slight reversal in February. The peak in daily spot prices for zinc occurred in late November when the price exceeded 14½ cents per pound. The closing spot price on December 31 was 13.88 cents per pound.

FOREIGN TRADE

Exports of slab zinc decreased to 9,300 tons, of which India received 90 percent. The substantial reduction essentially resulted from curtailed shipments of zinc from Government stocks to India by the U.S. Agency for International Development. Exports of semimanufactured products—sheets, plates, strips, etc.—amounted to 2,700 tons compared with 3,000 tons in 1968. Canada was the major destination with 44 percent, followed by Pakistan, 29 percent, and India, 13 percent. Zinc scrap exports also decreased in 1969 with Canada receiving 62 percent of the 2,000 tons, followed by the United Kingdom and Venezuela, 3 percent each, and 10 other countries, principally in South America, receiving small shipments. Exports of semifabricated forms almost doubled to 28,800 tons. The semimanufactured zinc was shipped, in castings and other forms, to 31 countries with the United Kingdom 57 percent and Canada, 33 percent. The total value of zinc exports, excluding pigments, was $11.4 million compared with $16.8 million in 1968.

Imports of semimanufactured zinc articles, other than compounds, consisted of 866 tons of plates, sheets, and strip, 71 tons of wire, 65 tons of bars, 15 tons of piping, 8,272 tons of zinc dust, powder, and flake, 1,770 tons of waste and scrap, and 716 tons of dross and skimmings. The value of semimanufactured items totaled $3.47 million, of which zinc dust accounted for 76 percent and waste and scrap, 7 percent. Canada was the leading supplier followed by Belgium-Luxembourg and Yugoslavia.

General imports amounted to 602,100 tons of zinc in ore and 329,000 tons of metal. The tonnage of both zinc in ore and zinc metal established new records well above the previous highs in 1968. Imports for consumption indicated that a substantial tonnage of ore and metal was delivered to warehouses rather than to consumers. The major suppliers of zinc in ore were Canada, 58 percent; Mexico, 25 percent; and Peru, 10 percent. Of the imported metal, Canada furnished 46 percent; Japan, 16 percent; Australia, 10 percent; and Peru, 9 percent. The value of imports for consumption of ore and metal was $164 million compared with $145 million in 1968.

WORLD REVIEW

The reporting and compiling of statistical data on zinc production and consumption throughout the world vary in reporting guidelines, sources, and scope of estimating. Mine production in the free world in 1969 thus ranges from the 4.43 million tons of the American Bureau of Metal Statistics (ABMS) [18] through the 4.66 million tons of the Bureau of Mines to the preliminary total of 4.74 million tons by the International Lead and Zinc Study Group.[19] The addition, the Bureau of Mines estimate of 1.20 million tons for the communist areas, excluding Yugoslavia, results in a world total of 5.86 million tons of mined zinc. This preliminary total represents an increase of about 6 percent over the revised total for 1968. Smelter output likewise varies widely; the Bureau of Mines reports insofar as possible primary metal, while the Lead and Zinc Study Group reports slab zinc output from both primary and secondary sources. Free world smelter output thus ranges from the 4.33 million tons reported by ABMS through the 4.35 million tons reported by the Bureau of Mines to 4.48 million tons reported by the Lead Zinc Study group. The output of Communist countries is estimated by the Bureau of Mines at 1.17 million tons; thus, world production is indicated at 5.52 million tons. This preliminary total indicates a 9 percent increase in 1969 over the revised total for 1968. The Lead and Zinc Study Group compiles data on both free world production and consumption of slab zinc on a contained metal basis, and the preliminary total 4.43 million tons consumed, compared to 4.52 million tons produced, indicates a surplus of some 90,000 tons of metal, of which 54,000 tons was reportedly an increase in 1969 free world producer stocks. The preliminary total for consumption indicates a 7-percent increase over consumption in 1968, well below the 10-percent increase achieved in 1968.

Mine production of zinc expanded about 4 percent in North America, and the 2.17 million tons produced represented 37 percent of the world output. South American production also expanded by some 13 percent, and Australia increased output 19 percent. The combined output of North and South America and Australia represented 53 percent of world production. Canada continued to lead in output with almost 23 percent of the world total, followed by the U.S.S.R., Australia, the United States, Peru, Japan, and Mexico.

Smelter production increased almost 4 percent in North America and 18 percent in Australia, while South America increased 3 percent. The combined output from these three continents represented 36 percent of world production. The United States continued to lead in metal output with 19 percent of the world total. Japan supplanted the U.S.S.R. as the second largest producer as a result of an 18-percent increase over 1968 output. The annual growth of zinc metal output in Japan has been phenomenal with an average annual compound rate of 15 percent since 1961. West Germany posted a 78-percent increase in zinc metal output owing to a new electrolytic smelter and expansion at two other zinc plants.

The world zinc industry continued to emphasize, as in recent years, exploration for new ore deposits and development and construction of new mine, mill, and smelter facilities. Essentially all of the major producing countries have announced new projects, in progress or planned, which will substantially increase zinc production.

Argentina.—Cía. Minera Aguilar, S.A., an affiliate of St. Joseph Lead Co., utilized its expanded capacity to produce 67,900 tons of zinc concentrates. The greatest bulk of the concentrates was shipped to

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[18] American Bureau of Metal Statistics Yearbook. 1969, pp. 70–71.

[19] International Lead and Zinc Study Group Bulletin. July 1970, pp. 16–18.

the electrolytic zinc plant of Compañía Sulfacid, S.A., near Rosario and to Compañía Metalurgica Austral's zinc smelter at Commodoro Rivadavia.[20]

Australia.—The highlight for zinc production was the major expansion in output at the Mount Isa Mines Ltd., 52.7-percent owned by American Smelting and Refining Company (Asarco). Production of zinc during fiscal year 1969 increased from 54,900 tons to 87,700 tons as the mining rate achieved 16,000 tons per day, the planned goal of the major expansion program started in 1959. Plans were announced to bring into production a new mine in the nothern leases to be known as the Hilton mine. A production rate of 7,000 tons per day of silver-lead-zinc ore is scheduled for 1976. Reserves have been estimated at 39 million short tons averaging 7.7 percent lead and 9.6 percent zinc.[21]

The Broken Hill mines of North Broken Hill, Ltd., The Zinc Corp., Ltd., New Broken Hill Consolidated, Ltd., and Broken Hill South Ltd. had a relatively quiet labor situation except for a strike in March. Production was expanded during the year and developments were in progress that should increase the annual zinc production from the area to 280,000 tons from the current 260,000 tons.

E.Z. Industries, Ltd., operating mines at Rosebury in Tasmania and a smelter at Risdon was in the process of doubling mine production from the present level of 50,000 tons per year and also of expanding the smelter from 150,000 to 220,000 tons per year. A new zinc ore body at Beltana South, Australia, which may come into production late in 1970, was announced by E.Z. Industries. The 40,000-ton-per-year capacity of the Broken Hill Associated Smelters plant at Port Pirie for distilling lead-zinc slags continued operating at full capacity. Sulphide Corp. Pty. Ltd. operated its 55,000-ton-per-year Imperial smelter and brought into production its new zinc metal upgrading plant at Cockel Creek, New South Wales.

Canada.—Canadian production of zinc in ore expanded from 500,000 tons in 1963 to 1,300,000 tons in 1969 and established Canada as the leading world exporter of zinc. In 1969, 805,000 tons in concentrates and 308,000 tons of metal were exported. Ontario now ranks first in zinc output, followed by Northwest Territories, Quebec, New Brunswick, and British Columbia. These five Provinces supply 81 percent of the total mine production.

The highlight of Canadian zinc mining in 1969 was the completion of the Anvil open pit mine, concentration, and transportation facilities and the first shipment of 18,000 tons of concentrates to Japan in December. The more than $60 million project, owned 60 percent by Cyprus Mines Corp. and 40 percent by Dynasty Exploration Ltd. had reserves, as of April 1969, of 63.5 million tons of ore averaging 3.4 percent lead and 5.7 percent zinc. The initial planned capacity is 240,000 tons per year of 54-percent-zinc concentrates, all of which have been contracted by Japanese smelters over an 8-year period. An expansion of the concentrator is underway to increase capacity about 25 percent. The additional concentrates will be shipped to West Germany. The production from the Yukon, reflecting the Anvil mine output, increased from 2,700 tons in 1968 to 17,000 tons in 1969.

The development of Mattagami Lake mines, Quebec and New Brunswick mines in 1963–64, initiation of operations at the Pine Point mine in Northwest Territories in 1965, and startup of the Kidd Creek mine in Ontario in 1966, the Nigadoo River mines in 1967, and the Anvil mine in 1969 have all added large tonnages to the output of Cominco Ltd., Hudson Bay Mining and Smelting, Ltd., Noranda Mines Ltd., Buchans Unit of Asarco, Heath Steele Mines, Ltd., and some small producers.

The four plants operated by Canadian Electrolytic Zinc, Ltd.; Cominco Ltd.; East Coast Smelting and Chemical Co., and Hudson Bay Mining and Smelting Co. Ltd. have an annual capacity of 524,000 tons of refined zinc. Texas Gulf Sulphur Co. announced in April plans to build an electrolytic zinc plant near Timmins, Ontario, to process about one-half of the concentrates from the Kidd Creek open pit. The plant will cost about $50 million and is scheduled for operation in early 1972.

Germany, West.—A major development in the European zinc industry was the increased metal output in West Germany. The 105,500-ton increase resulted from a full year of operation at the Datteln electrolytic zinc refinery, a joint venture of

[20] St. Joseph Lead Co. Annual Report. 1969, p. 16.

[21] American Smelting and Refining Co. Annual Report. 1969, p. 14.

Stolberger Zinc A.G. and Metallgesellschaft A.G. The refinery began operation in August 1968 with a designed capacity of 80,000 tons of zinc per year. Increased activity by Preussag at the Harlingerade and Oker plants pointed toward an annual zinc capacity of 140,000 tons.

Japan.—While mine production of zinc increased about 6,100 tons in 1969, smelter output increased 117,500 tons as a result of plant expansion at Mitsui Mining and Smelting Co., Toho Zinc Co., Nippon Mining Co. Ltd., and Mitsubishi Metal Mining Co. Ltd. and the startup of a new Imperial Smelting process plant by Hachinohe Smelting Co. early in 1969. The annual capacity for zinc metal production was indicated at about 800,000 tons per year, which was almost achieved in 1969. Imports of zinc ores in 1969 increased from 451,000 tons to 478,000 tons and originated principally in Peru, Canada, Australia, South Korea, Bolivia, and Mexico. The large zinc output of the Anvil mine in Canada and the Matilde mine in Bolivia was contracted for delivery in concentrates to Japanese smelters.

Mexico.—Zinc ore production increased from 264,600 tons in 1968 to 279,300 tons in 1969, while smelter output was essentially unchanged at 88,500 tons. Asarco Mexicana, S.A., 49-percent owned by Asarco, produced 64,700 tons of refined zinc and 56,000 tons of zinc in concentrates and fume. Asarco Mexicana is constructing a new concentrator at the San Martin, Zacatecas mine with double the capacity of the old mill. Construction of a new mill at the San Antonia mine, Santa Eulalia, Chihuahua, was also in progress, and the new mill at the Plomosas mine in Chihuahua acheived capacity by mid-1969.[22]

Cía. Metalúrgica Mexicana Peñoles S.A. continued development of La Negra mine at Maconi, Queretaro, with production scheduled at the end of 1970. Peñoles also announced construction of an electrolytic zinc refinery, to be completed in 1972, at Torreón with a capacity of 120,000 tons per year. Asarco Mexicana began a study on building an electrolytic zinc refinery of similar capacity, to supplement its present retort refinery in Nueva Rosita, Coahuila and the Zincamex refinery at Saltillo, Coahuila. The combined zinc refinery capacity will exceed 330,000 tons annually when the projects are completed.

Peru.—Mine output of zinc in 1969 increased from 321,218 tons in 1968 to 346,954 tons, while smelter output declined to 68,600 tons. Operation of the Cerro de Pasco Corp. smelting complex at La Oroya was interrupted by a labor stoppage in April and in August and September. Over a month's worth of production was lost.

Toho Zinc Co. Ltd. of Japan contracted with Banco Minero del Peru to jointly prospect and develop the Gran Bretaña mine located some 230 miles east of Lima. Confirmed deposits are said to total 1 million tons of ore averaging over 20 percent zinc.

Compañia Minerales Santander Inc. a subsidiary of St. Joseph Lead Co., continued development of its underground zinc-lead mine and shipped 81,200 tons of zinc concentrates during the year.[23]

San Ignacio de Morocoha S.A. completed installation of a concentration plant at the new San Vicente mine in central Peru. The plant will produce about 48,000 tons of zinc in concentrates annually for shipment to Japan.

TECHNOLOGY

The International Lead-Zinc Research Organization (ILZRO) conducts an industry-sponsored research and development program for zinc and lead that covers a wide range of individual projects in zinc chemistry, corrosion protection, diecasting, and wrought zinc. Progress in the various programs is published in semiannual reviews, which are available from Zinc Institute Inc., 292 Madison Ave., New York, N.Y. 10017. The Zinc Development Association and the Zinc Institute Inc. review and publish abstracts of all current world literature on the uses of zinc and on research work on zinc. An index of these abstracts may also be secured from the Zinc Institute.

The Bureau of Mines published the results of a study on various materials for use as retort flasks in horizontal distillation furnaces and the laboratory evaluation

[22] American Smelting and Refining Co. Annual Report. 1969, pp. 13–15.
[23] St. Joseph Lead Co. Annual Report. 1969, p. 16.

of the most promising modifications.[24] The properties of a zinc-copper-titanium alloy at extrusion temperatures between 400° and 720° F were also published.[25] The Bureau of Mines developed a process for producing high-purity zinc and tin by electrorefining from liquid amalgams. Commercial grades of zinc and tin were dissolved in mercury to produce saturated amalgam anodes for electrorefining to cathode metal.[26] Also investigated were alternate processes for aluminum removal from melted zinc-base alloy scrap. Spent sal skimmings were found to give the best results.[27]

[24] Tyrell, M. E., and K. J. Liles. Horizontal Zinc Retorts. BuMines Rept. of Inv. 7215, 1969, 88 pp.
[25] Neumeier, L. J., and J. S. Risbeck. Effect of Varied Extrusion Temperature on the Properties of Zinc-Copper-Titanium Alloy. BuMines Rept. of Inv. 7229, 1969, 22 pp.
[26] Chambers, D. H., and A. W. Maynard. High-Purity Zinc and Tin by Amalgam Electrorefining. BuMines Rept. of Inv. 7313, 1969, 10 pp.
[27] Montagna, D., and J. A. Ruppert. Refining Zinc-Base Die-Cast Scrap Using Low-Cost Fluxes. BuMines Rept. of Inv. 7315, 1969, 10 pp.

Table 2.—Mine production of recoverable zinc in the United States, by States

(Short tons)

State	1965	1966	1967	1968	1969
Arizona	21,757	15,985	14,330	5,441	9,039
California	225	335	441	3,525	3,327
Colorado	53,870	54,822	52,442	50,258	53,715
Idaho	58,034	60,997	56,528	57,248	55,900
Illinois	18,314	15,192	20,416	18,182	13,765
Kansas	6,508	4,769	4,765	3,012	1,900
Kentucky	5,654	6,586	6,317	W	W
Missouri	4,312	3,968	7,430	12,301	41,099
Montana	33,786	29,120	3,341	3,778	6,143
Nevada	3,858	5,827	3,035	2,104	941
New Jersey	38,297	25,237	26,041	25,668	25,076
New Mexico	36,460	29,296	21,380	18,686	24,308
New York	69,880	73,454	70,555	66,194	58,728
Oklahoma	12,715	11,237	10,670	6,921	2,744
Oregon	W	-----	-----	-----	(1)
Pennsylvania	27,635	28,080	35,067	30,382	33,035
Tennessee	122,387	103,117	113,065	124,039	124,532
Utah	27,747	37,323	34,251	33,158	34,902
Virginia	20,491	17,666	18,846	19,257	18,704
Washington	22,230	24,772	21,540	13,884	9,738
Wisconsin	26,993	24,775	28,953	25,711	22,901
Other States	-----	-----	-----	9,702	12,627
Total [2]	611,153	572,558	549,413	529,446	553,124

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Less than ½ unit.
[2] Totals are of listed figures only.

Table 3.—Mine production of recoverable zinc in the United States, by months

(Short tons)

Month	1968	1969	Month	1968	1969
January	42,894	42,205	August	46,679	47,289
February	41,985	43,040	September	45,081	47,403
March	41,667	45,076	October	47,038	47,303
April	43,723	48,112	November	44,178	46,325
May	45,297	48,067	December	43,254	45,467
June	44,664	47,151			
July	42,986	45,686	Total	529,446	553,124

Table 4.—Twenty-five leading zinc-producing mines in the United States in 1969, in order of output

Rank	Mine	County and State	Operator	Source of zinc
1	Balmat	St. Lawrence, N.Y	St. Joseph Lead Co	Lead-zinc ore.
2	Friedensville	Lehigh, Pa	The New Jersey Zinc Co	Zinc ore.
3	Eagle	Eagle, Colo	do	Do.
4	Sterling Hill	Sussex, N.J	do	Do.
5	Young	Jefferson, Tenn	American Zinc Co	Do.
6	Bunker Hill	Shoshone, Idaho	The Bunker Hill Co	Lead-zinc ore, silver tailings.
7	New Market	Jefferson, Tenn	New Market Zinc Co	Zinc ore.
8	Austinville and Ivanhoe	Wythe, Va	The New Jersey Zinc Co	Lead-zinc ore.
9	Zinc Mine Works	Jefferson, Tenn	United States Steel Corp	Zinc ore.
10	Jefferson City	do	The New Jersey Zinc Co	Do.
11	Edwards	St. Lawrence, N.Y	St. Joseph Lead Co	Do.
12	Immel	Knox, Tenn	American Zinc Co	Do.
13	Idarado	Ouray and San Miguel, Colo.	Idarado Mining Co	Copper-lead-zinc ore.
14	Star-Morning	Shoshone, Idaho	Hecla Mining Co	Lead-zinc ore.
15	Fletcher	Reynolds, Mo	St. Joseph Lead Co	Lead ore.
16	U.S. and Lark	Salt Lake, Utah	United States Smelting, Refining and Mining Co.	Lead, lead-zinc ores.
17	Copperhill	Polk, Tenn	Tennessee Copper Co	Copper-zinc ore.
18	Flat Gap	Hancock, Tenn	The New Jersey Zinc Co	Zinc ore.
19	Burgin	Utah, Utah	Kennecott Copper Corp	Lead, lead-zinc ores.
20	Bruce	Yavapai, Ariz	Cyprus Mines Corp	Copper-zinc ore.
21	Shullsburg	Lafayette, Wis	Eagle-Picher Industries, Inc.	Zinc ore.
22	Mascot No. 2	Knox, Tenn	American Zinc Co	Do.
23	Page	Shoshone, Idaho	American Smelting and Refining Co.	Lead-zinc ore.
24	Penobscot Unit	Hancock, Maine	Callahan Mining Corp	Copper-zinc ore.
25	Hanover	Grant, N. Mex	The New Jersey Zinc Co	Zinc ore.

Table 5.—Primary and redistilled secondary slab zinc produced in the United States

(Short tons)

	1965	1966	1967	1968	1969
Primary:					
From domestic ores	551,215	523,580	438,553	499,491	458,754
From foreign ores	443,187	501,486	500,277	521,400	581,843
Total	994,402	1,025,066	938,830	1,020,891	1,040,597
Redistilled secondary	83,619	83,263	73,505	79,865	70,553
Total (excludes zinc recovered by remelting)	1,078,021	1,108,329	1,012,335	1,100,756	1,111,150

Table 6.—Distilled and electrolytic zinc, primary and secondary, produced in the United States, by methods of reduction

(Short tons)

Method of reduction	1965	1966	1967	1968	1969
Electrolytic primary	408,128	433,576	371,267	398,265	453,539
Distilled	586,274	591,490	567,563	622,626	587,058
Redistilled secondary:					
At primary smelters	70,306	71,560	58,341	67,101	60,607
At secondary smelters	13,313	11,703	15,164	12,764	9,946
Total	1,078,021	1,108,329	1,012,335	1,100,756	1,111,150

Table 7.—Distilled and electrolytic zinc, primary and secondary, produced in the United States, by grades

(Short tons)

Grade	1965	1966	1967	1968	1969
Special high	479,736	452,722	436,849	449,659	468,792
High	112,451	139,814	92,956	117,224	136,416
Intermediate	17,985	23,555	26,522	56,686	57,180
Brass special	86,695	103,184	91,079	75,840	89,306
Select	309	-----	-----	-----	-----
Prime western	380,845	389,054	364,929	401,347	359,456
Total	1,078,021	1,108,329	1,012,335	1,100,756	1,111,150

Table 8.—Primary slab zinc produced in the United States, by States where smeltered

(Short tons)

State	1965	1966	1967	1968	1969
Idaho	91,000	90,983	92,134	102,946	105,700
Illinois	114,131	96,809	115,659	119,657	131,243
Montana	143,927	174,821	111,834	142,929	174,034
Oklahoma	154,187	165,162	163,826	172,174	143,575
Pennsylvania and West Virginia	278,870	291,403	271,192	302,884	286,164
Texas	212,287	205,888	184,185	180,301	199,881
Total	994,402	1,025,066	938,830	1,020,891	1,040,597

Table 9.—Primary slab zinc plants by group capacity in the United States in 1969

Type of plant	Plant location	Slab zinc capacity (short tons)
Electrolytic plants:		
American Smelting and Refining Company	Corpus Christi, Tex	
American Zinc Co	Sauget, Ill	
The Anaconda Company	Anaconda, Mont	510,700
Do	Great Falls, Mont	
The Bunker Hill Co	Kellogg, Idaho	
Horizontal-retort plants:		
American Smelting and Refining Company	Amarillo, Tex	
American Zinc Co	Dumas, Tex	
Blackwell Zinc Co., American Metal Climax, Inc	Blackwell, Okla	
Eagle-Picher Industries, Inc	Henryetta, Okla	
National Zinc Co	Bartlesville, Okla	
Vertical-retort plants:		715,000
Matthiessen & Hegeler Zinc Co	Meadowbrook, W. Va	
The New Jersey Zinc Co	Depue, Ill	
Do	Palmerton, Pa	
St. Joe Minerals Corp	Josephtown, Pa	

Table 10.—Secondary slab zinc plants by group capacity in the United States in 1969

Company	Plant location	Slab zinc capacity (short tons)
American Smelting and Refining Company	Sand Springs, Okla	
Do	Trenton, N.J	
American Zinc Co	Hillsboro, Ill	
Apex Smelting Co	Chicago, Ill	
Arco Die Cast Metals Co	Detroit, Mich	
W. J. Bullock, Inc	Fairfield, Ala	
General Smelting Co	Bristol, Pa	54,400
Gulf Reduction Co	Houston, Tex	
H. Kramer Co	El Segundo, Calif	
Pacific Smelting Co	Torrance, Calif	
Sandoval Zinc Co	Sandoval, Ill	
Superior Zinc Corp	Bristol, Pa	
Wheeling-Pittsburgh Steel Corp	Martins Ferry, Ohio	

Table 11.—Stocks and consumption of new and old zinc scrap in the United States in 1969

(Short tons)

Class of consumer and type of scrap	Stocks Jan. 1[1]	Receipts	Consumption			Stocks Dec. 31
			New scrap	Old scrap	Total	
Smelters and distillers:						
New clippings	160	623	670	-----	670	113
Old zinc	415	6,512	-----	6,456	6,456	471
Engravers' plates	462	3,177	-----	3,392	3,392	247
Skimmings and ashes	12,887	63,395	64,646	-----	64,646	11,636
Sal skimmings	357	-----	243	-----	243	114
Die-cast skimmings	2,498	5,215	4,890	-----	4,890	2,823
Galvanizers' dross	9,648	69,714	66,496	-----	66,496	12,866
Diecastings	3,199	38,107	-----	37,929	37,929	3,377
Rod and die scrap	197	2,532	-----	1,502	1,502	1,227
Flue dust	2,277	6,788	5,465	-----	5,465	3,600
Chemical residues	6,281	7,664	9,878	-----	9,878	4,067
Total	38,381	203,727	152,288	49,279	201,567	40,541
Chemical plants, foundries, and other manufacturers:						
New clippings	-----	-----	-----	-----	-----	-----
Old zinc	4	5	-----	7	7	2
Engravers' plates	-----	-----	-----	-----	-----	-----
Skimmings and ashes	1,841	10,072	9,623	-----	9,623	2,290
Sal skimmings	5,892	7,703	8,154	-----	8,154	5,441
Die-cast skimmings	-----	-----	-----	-----	-----	-----
Galvanizers' dross	-----	-----	-----	-----	-----	-----
Diecastings	14	386	-----	383	383	17
Rod and die scrap	45	57	-----	88	88	14
Flue dust	207	3,420	3,138	-----	3,138	489
Chemical residues	1,123	27,240	26,919	-----	26,919	1,444
Total	9,126	48,883	47,834	478	48,312	9,697
All classes of consumers:						
New clippings	160	623	670	-----	670	113
Old zinc	419	6,517	-----	6,463	6,463	473
Engravers' plates	462	3,177	-----	3,392	3,392	247
Skimmings and ashes	14,728	73,467	74,269	-----	74,269	13,926
Sal skimmings	6,249	7,703	8,397	-----	8,397	5,555
Die-cast skimmings	2,498	5,215	4,890	-----	4,890	2,823
Galvanizers' dross	9,648	69,714	66,496	-----	66,496	12,866
Diecastings	3,213	38,493	-----	38,312	38,312	3,394
Rod and die scrap	242	2,589	-----	1,590	1,590	1,241
Flue dust	2,484	10,208	8,603	-----	8,603	4,089
Chemical residues	7,404	34,904	36,797	-----	36,797	5,511
Total	47,507	252,610	200,122	49,757	249,879	50,238

[1] Figures partly revised.

Table 12.—Production of zinc products from zinc-base scrap in the United States

(Short tons)

Product	1965	1966	1967	1968	1969
Redistilled slab zinc	83,619	83,263	73,505	79,865	69,256
Zinc dust	33,512	34,326	32,801	37,903	33,747
Remelt spelter	5,324	6,970	4,831	3,580	3,978
Remelt die-cast slab	14,760	13,003	14,520	14,570	16,979
Zinc-die and diecasting alloys	5,463	4,333	3,882	4,128	4,401
Galvanizing stocks	1,450	1,585	1,690	2,107	1,849
Secondary zinc in chemical products	47,997	39,834	38,289	45,654	45,298

Table 13.—Zinc recovered from scrap processed in the United States, by kinds of scrap and forms of recovery

(Short tons)

Kind of scrap	1968	1969	Form of recovery	1968	1969
New scrap:			As metal:		
Zinc-base	144,039	134,668	By distillation:		
Copper-base	127,463	156,381	Slab zinc [1]	78,631	68,677
Aluminum-base	3,100	3,494	Zinc dust	37,334	33,241
Magnesium-base	324	221	By remelting	5,500	5,639
Total	274,926	294,764	Total	121,465	107,557
Old scrap:			In zinc-base alloys	17,532	19,980
Zinc-base	41,408	40,284	In brass and bronze	163,490	196,244
Copper-base	35,390	37,975	In aluminum-base alloys	6,041	6,853
Aluminum-base	2,900	3,288	In magnesium-base alloys	541	459
Magnesium-base	99	80	In chemical products:		
Total	79,797	81,627	Zinc oxide (lead-free)	19,316	21,049
			Zinc-sulfate	11,860	11,986
Grand total	354,723	376,391	Zinc chloride	13,347	10,917
			Miscellaneous	1,131	1,346
			Total	233,258	268,834
			Grand total	354,723	376,391

[1] Includes zinc content of redistilled slab made from remelt die-cast slab.

Table 14.—Zinc dust produced in the United States

Year	Short tons	Value		Year	Short tons	Value	
		Total (thousands)	Average per pound			Total (thousands)	Average per pound
1965	51,958	$19,328	$0.186	1968	61,566	$22,041	$0.179
1966	55,485	20,418	.184	1969	55,055	21,361	.194
1967	50,273	18,098	.180				

Table 15.—Consumption of zinc in the United States

(Short tons)

	1965	1966	1967	1968	1969
Slab zinc	1,354,092	1,410,197	1,236,808	1,333,699	1,368,323
Ores (recoverable zinc content)	[1] 122,892	[1] 126,696	[1] 114,301	[1] 124,109	126,712
Secondary (recoverable zinc content) [2]	265,083	269,650	240,888	270,592	302,075
Total	1,742,067	1,806,543	1,591,997	1,728,400	1,797,110

[1] Includes ore used directly in galvanizing.
[2] Excludes redistilled slab and remelt zinc.

Table 16.—Slab zinc consumption in the United States, by industry uses

(Short tons)

Industry and product	1965	1966	1967	1968	1969
Galvanizing:					
Sheet and strip	270,826	264,312	236,135	256,319	251,625
Wire and wire rope	43,884	39,114	36,745	36,089	32,348
Tubes and pipes	63,224	68,848	61,792	63,621	65,898
Fittings (for tubes and pipes)	8,641	10,150	11,768	13,801	11,418
Tanks and containers	NA	4,285	4,137	3,815	5,561
Structural shapes	NA	17,838	18,779	20,238	19,454
Fasteners	NA	4,340	4,234	4,826	5,536
Pole-line hardware	NA	11,400	9,985	9,050	9,409
Fencing, wire cloth, and netting	NA	15,821	16,544	15,984	17,984
Job galvanizing	51,011	NA	NA	NA	NA
Other and unspecified uses	44,835	59,859	58,486	58,074	57,091
Total	482,421	495,967	458,605	481,817	476,324
Brass products:					
Sheet, strip, and plate	58,864	97,095	67,237	86,185	90,777
Rod and wire	45,510	60,079	40,759	49,888	56,989
Tube	10,030	12,148	8,884	9,818	10,928
Castings and billets	3,050	3,378	2,295	2,286	5,958
Copper-base ingots	7,402	9,352	8,121	12,153	13,642
Other copper-base products	1,992	3,500	4,241	1,576	1,175
Total	126,848	185,552	131,537	161,906	179,469
Zinc-base alloy:					
Diecasting alloy	629,809	596,371	525,960	551,896	565,839
Dies and rod alloy	535	495	420	807	504
Slush and sand casting alloy	7,626	9,170	8,738	10,243	10,048
Total	637,970	606,036	535,118	562,946	576,391
Rolled zinc	45,882	52,612	45,443	48,943	48,650
Zinc oxide	25,781	28,438	29,774	34,937	41,447
Other uses:					
Wet batteries	1,188	1,529	1,284	1,823	1,536
Desilverizing lead	2,444	2,776	1,394	2,973	3,957
Light-metal alloys	8,124	10,239	8,805	8,422	7,562
Other [1]	23,434	27,048	24,848	29,932	32,987
Total	35,190	41,592	36,331	43,150	46,042
Grand total	1,354,092	1,410,197	1,236,808	1,333,699	1,368,323

NA Not available.
[1] Includes zinc used in making zinc dust, bronze powder, alloys, chemicals, castings, and miscellaneous uses not elsewhere mentioned.

Table 17.—Slab zinc consumption in the United States in 1969, by grades and industry uses

(Short tons)

Industry	Special high grade	High grade	Intermediate	Brass special	Prime [1] western	Remelt	Total
Galvanizing	25,157	23,127	1,249	109,080	315,369	2,342	476,324
Brass and bronze	46,214	84,839	226	6,690	38,510	2,990	179,469
Zinc-base alloys	573,143	1,444	64	808	679	253	576,391
Rolled zinc	18,548	16,186	5,843	-----	8,073	-----	48,650
Zinc oxide	7,437	8,470	-----	-----	25,540	-----	41,447
Other	20,486	3,764	199	11,574	9,962	63	46,042
Total	690,979	137,830	7,581	128,152	398,133	5,648	1,368,323

[1] Includes select grade.

Table 18.—Rolled zinc produced and quantity available for consumption in the United States

	1968			1969		
	Short tons	Value		Short tons	Value	
		Total (thousands)	Average per pound		Total (thousands)	Average per pound
Production: [1]						
Photoengraving plate	12,004	$8,703	$0.363	10,745	$7,958	$0.370
Other plate over 0.375 inch thick	W	W	W	W	W	W
Sheet zinc less than 0.375 inch thick	W	W	W	W	W	W
Strip and foil	31,468	14,037	.223	31,970	14,151	.221
Rod and wire	W	W	W	W	W	W
Total rolled zinc	47,524	25,804	.272	46,540	25,850	.278
Imports	754	290	.192	966	418	.216
Exports	3,048	2,228	.365	2,714	1,746	.322
Available for consumption	45,313	-----	----	44,974	-----	----
Value of slab zinc (all grades)	-----	-----	.135	-----	-----	.147
Value added by rolling	-----	-----	.137	-----	-----	.131

W Withheld to avoid disclosing individual company confidential data; included in total.
[1] Figures represent net production. In addition, 21,936 tons in 1968 and 24,388 tons in 1969 were rerolled from scrap originating in fabricating plants operating in connection with zinc-rolling mills.

Table 19.—Slab zinc consumption in the United States in 1969, by industries and States

(Short tons)

State	Galvanizers	Brass mills [1]	Diecasters [2]	Other [3]	Total
Alabama	41,113	W	-----	W	42,467
Arizona	W	-----	-----	W	W
Arkansas	-----	-----	-----	W	W
California	33,724	2,751	12,964	W	W
Colorado	W	W	W	W	3,248
Connecticut	3,258	47,274	W	W	57,078
Delaware	W	W	W	W	1,375
Florida	3,312	-----	W	-----	W
Georgia	W	-----	W	-----	W
Hawaii	W	-----	-----	-----	W
Idaho	-----	-----	W	W	W
Illinois	39,793	34,164	90,771	W	193,482
Indiana	67,291	W	36,218	W	145,028
Iowa	726	-----	-----	W	1,576
Kansas	-----	W	W	W	W
Kentucky	W	W	-----	W	18,491
Louisiana	W	-----	-----	W	1,597
Maine	W	-----	-----	-----	W
Maryland	25,194	W	-----	W	W
Massachusetts	3,316	W	-----	W	8,532
Michigan	4,511	17,085	137,969	W	160,025
Minnesota	2,389	W	-----	-----	W
Mississippi	W	-----	-----	-----	W
Missouri	10,477	W	W	W	21,690
Nebraska	1,073	W	-----	W	1,676
New Hampshire	-----	W	-----	-----	W
New Jersey	2,844	6,224	W	3,137	W
New York	12,445	W	71,515	W	105,255
North Carolina	W	-----	W	W	1,763
Ohio	92,675	W	89,450	1,264	W
Oklahoma	5,733	-----	W	W	10,237
Oregon	705	W	W	-----	1,119
Pennsylvania	66,869	W	27,292	W	157,602
Rhode Island	W	-----	-----	W	608
South Carolina	W	-----	-----	-----	W
Tennessee	737	-----	1,854	420	3,011
Texas	15,404	W	W	W	51,992
Utah	W	W	-----	-----	890
Virginia	255	26	W	7	W
Washington	1,080	-----	-----	1,036	2,116
West Virginia	12,034	W	-----	W	14,268
Wisconsin	1,387	W	9,876	W	19,863
Undistributed	25,637	68,955	98,229	130,212	337,686
Total [4]	473,982	176,479	576,138	136,076	1,362,675

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Includes brass mills, brass ingot makers, and brass foundries.
[2] Includes producers of zinc-base alloy for diecastings, stamping dies, and rods.
[3] Includes slab zinc used in rolled zinc products and in zinc oxide.
[4] Excludes remelt zinc.

Table 20.—Production and shipments of zinc pigments and compounds [1] in the United States

Pigment or compound	1968 Production (short tons)	1968 Shipments: Short tons	1968 Value [2]: Total (thousands)	1968 Value [2]: Average per ton	1969 Production (short tons)	1969 Shipments: Short tons	1969 Value [2]: Total (thousands)	1969 Value [2]: Average per ton
Zinc oxide [3]	209,963	213,826	$58,944	$276	220,358	219,723	$65,492	$298
Leaded zinc oxide [3]	11,125	7,995	2,030	254	4,949	6,956	1,609	231
Zinc chloride, 50° B [4]	57,914	57,508	W	W	47,909	48,909	W	W
Zinc sulfate	57,131	59,647	10,357	174	68,482	64,592	12,135	188

W Withheld to avoid disclosing individual company confidential data.
[1] Excludes lithopone; figure withheld to avoid disclosing individual company confidential data.
[2] Value at plant, exclusive of container.
[3] Zinc oxide containing 5 percent or more lead is classed as leaded zinc oxide.
[4] Includes zinc chloride equivalent of zinc ammonium chloride and chromated zinc chloride.

Table 21.—Zinc content of zinc pigments [1] and compounds produced by domestic manufactures, by sources

(Short tons)

Pigment or compound	1968 Ore: Domestic	1968 Ore: Foreign	1968 Slab zinc	1968 Secondary material	1968 Total zinc in pigments and compounds	1969 Ore: Domestic	1969 Ore: Foreign	1969 Slab zinc	1969 Secondary material	1969 Total zinc in pigments and compounds
Zinc oxide	80,218	23,651	36,541	27,366	167,776	82,643	23,949	41,362	28,115	176,069
Leaded zinc oxide	3,231	3,886	-----	-----	7,117	1,705	1,539	-----	-----	3,244
Total	83,449	27,537	36,541	27,366	174,893	84,348	25,488	41,362	28,115	179,313
Zinc chloride [2]	-----	-----	W	W	14,073	-----	-----	W	W	11,632
Zinc sulfate	3,809	3,955	-----	10,701	18,465	5,503	5,342	-----	10,897	21,742

W Withheld to avoid disclosing individual company confidential data.
[1] Excludes zinc sulfide and lithopone; figures withheld to avoid disclosing individual company confidential data.
[2] Includes zinc content of zinc ammonium chloride and chromated zinc chloride.

Table 22.—Distribution of zinc oxide and leaded zinc oxide shipments, by industries

(Short tons)

Industry	1965	1966	1967	1968	1969
Zinc oxide:					
Rubber	103,057	104,866	94,388	111,797	115,988
Paints	30,249	27,100	24,547	25,864	25,170
Ceramics	10,009	12,147	9,850	10,226	9,469
Chemicals	11,365	13,678	17,509	22,769	22,775
Agriculture	977	1,559	5,048	5,044	4,007
Photocopying	W	11,405	14,039	21,564	27,566
Floor covering	363	W	W	W	W
Other	30,550	22,910	16,105	16,562	14,748
Total	186,570	193,665	181,486	213,826	219,723
Leaded zinc oxide:					
Paints	10,951	10,462	8,644	6,356	4,905
Rubber; Other and unspecified	899	1,095	1,662	1,639	2,051
Total	11,850	11,557	10,306	7,995	6,956

W Withheld to avoid disclosing individual company confidential data; included with "Other."

Table 23.—Distribution of zinc sulfate shipments, by industries

(Short tons)

Year	Rayon		Agriculture		Other		Total	
	Gross weight	Dry basis	Gross weight	Dry basis	Gross weight	Dry basis	Gross weight	Dry basis
1965	21,204	18,886	14,331	12,449	15,009	10,637	50,544	41,972
1966	18,659	16,562	19,334	16,891	13,705	9,372	51,698	42,825
1967	W	W	17,156	14,803	31,644	24,742	48,800	39,545
1968	W	W	20,472	17,631	39,748	36,470	60,220	54,101
1969	W	W	19,029	16,424	45,245	33,580	64,274	50,004

W Withheld to avoid disclosing individual company confidential data; included with "Other."

Table 24.—Stocks of zinc-reduction plants in the United States, Dec. 31

(Short tons)

	1965	1966	1967	1968	1969
At primary reduction plants	27,635	63,626	81,307	r 64,695	66,777
At secondary distilling plants	987	1,172	609	684	885
Total	28,622	64,798	81,916	r 65,379	67,662

r Revised.

Table 25.—Consumers stocks of slab zinc at plants, Dec. 31, by grades

(Short tons)

Date	Special high grade	High grade	Intermediate	Brass special	Prime western	Remelt	Total
Dec. 31, 1968	48,114	6,585	440	4,511	41,926	242	r 101,818
Dec. 31, 1969	39,069	7,993	552	8,643	44,035	200	100,492

r Revised.

Table 26.—Average monthly quoted prices of 60-percent-zinc concentrate at Joplin, and common zinc (prompt delivery or spot), East St. Louis and London [1]

Month	1968			1969		
	60-percent-zinc concentrates in the Joplin region (per ton)	Metallic zinc (cents per pound)		60-percent-zinc concentrates in the Joplin region (per ton)	Metallic zinc (cents per pound)	
		East St. Louis	London [2]		East St. Louis	London [2]
January	$84.00	13.50	12.03	$87.00	13.84	12.19
February	84.00	13.50	11.88	88.00	14.00	12.10
March	84.00	13.50	11.67	88.00	14.00	12.27
April	84.00	13.50	11.68	89.00	14.02	12.35
May	84.00	13.50	11.77	92.00	14.50	12.62
June	84.00	13.50	11.75	92.00	14.50	12.73
July	84.00	13.50	12.03	92.00	14.50	12.84
August	84.00	13.50	12.17	92.00	14.50	13.17
September	84.00	13.50	11.90	96.00	15.38	13.42
October	84.00	13.50	11.83	100.00	15.50	13.53
November	84.00	13.50	11.95	100.00	15.50	14.01
December	84.00	13.50	12.06	100.00	15.50	14.04
Average for year	84.00	13.50	11.89	93.00	14.65	12.96

[1] Joplin: Metal Statistics, 1970. East St. Louis: Metal Statistics, 1970. London: Metals Week.
[2] Conversion of English quotations into U.S. money based on average rates of exchange recorded by Federal Reserve Board. Average of daily mean of bid and asked quotations at morning session of London Metal Exchange.

Table 27.—U.S. exports of slab and sheet zinc, by countries

Destination	1967		1968		1969	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Slabs, pigs, and blocks:						
Australia	-----	-----	1	$1	20	$6
Brazil	188	$57	-----	-----	-----	-----
Canada	1,198	530	326	165	670	191
Chile	142	59	130	46	69	22
Colombia	93	30	5	2	2	1
Germany, West	451	118	4	2	17	8
India	13,724	3,122	32,345	9,507	8,409	2,337
Iran	-----	-----	12	4	-----	-----
Israel	-----	-----	3	3	-----	-----
Mexico	6	4	1	1	-----	-----
Netherlands	-----	-----	2	1	2	1
Philippines	350	105	122	35	5	3
Spain	25	15	-----	-----	-----	-----
Taiwan	42	24	23	11	-----	-----
Turkey	357	109	-----	-----	-----	-----
Venezuela	148	81	7	4	26	9
Vietnam, South	67	24	-----	-----	-----	-----
Other	18	9	30	15	78	34
Total	16,809	4,287	33,011	9,797	9,298	2,612
Sheets, plates, strips, or other forms, n.e.c.:						
Argentina	42	34	38	32	22	20
Australia	24	22	32	26	1	2
Brazil	7	6	20	18	7	6
Canada	1,934	1,528	1,976	1,414	1,188	909
Chile	59	51	35	27	27	21
Colombia	34	34	69	64	18	15
Denmark	34	30	12	10	2	2
Germany, West	18	18	115	84	27	20
India	-----	-----	1	1	361	164
Israel	39	30	36	26	5	4
Mexico	32	45	17	18	14	13
New Zealand	48	33	7	7	7	5
Pakistan	-----	-----	177	90	779	346
Philippines	12	7	9	7	1	1
South Africa, Republic of	113	98	87	76	1	1
Taiwan	3	5	47	34	33	22
Venezuela	118	127	103	94	87	81
Other	1,048	641	267	200	134	114
Total	3,565	2,709	3,048	2,228	2,714	1,746

Table 28.—U.S. exports of zinc by classes

Year	Slabs, pigs, or blocks		Sheets, plates, strips, or other forms, n.e.c.		Zinc scrap and dross (zinc content)		Semifabricated forms, n.e.c.	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1967	16,809	$4,287	3,565	$2,709	1,665	$530	2,161	$1,177
1968	33,011	9,797	3,048	2,228	2,293	886	15,000	3,840
1969	9,298	2,612	2,714	1,746	1,989	716	28,810	6,321

Table 29.—U.S. exports of zinc pigments

Kind	1968 Short tons	1968 Value (thousands)	1969 Short tons	1969 Value (thousands)
Zinc oxide	3,640	$1,202	3,779	$1,341
Lithopone	1,300	281	1,086	300
Total	4,940	1,483	4,865	1,641

Table 30.—U.S. imports of zinc, by countries

Country	1967 Short tons	1967 Value (thousands)	1968 Short tons	1968 Value (thousands)	1969 Short tons	1969 Value (thousands)
ORES						
Algeria	9,264	$1,258	-----	-----	-----	-----
Australia	4,336	701	2,267	$410	2,940	$628
Bolivia	9,576	1,450	[r] 6,011	[r] 1,004	2,069	347
Canada	289,387	42,045	310,586	46,625	367,529	54,213
Chile	9	1	74	15	421	76
Germany, West	6,248	941	5,942	881	-----	-----
Guatemala	-----	-----	-----	-----	525	79
Honduras	9,727	1,362	12,959	1,759	15,272	2,138
Mexico	119,135	13,839	142,313	16,352	143,747	17,001
Morocco	6,516	862	15,715	1,426	5,988	614
Netherlands	-----	-----	3,313	418	-----	-----
Peru	69,357	9,646	39,899	6,071	57,087	8,597
South Africa, Republic of	8,419	1,686	4,287	643	6,525	866
Other	1,618	219	-----	-----	17	1
Total	534,092	74,010	[r] 543,366	[r] 75,604	602,120	84,560
BLOCKS, PIGS, OR SLABS						
Angola	-----	-----	-----	-----	661	149
Australia	7,187	1,703	19,915	4,627	34,237	8,896
Belgium-Luxembourg	16,100	3,995	16,500	4,080	16,361	4,226
Canada	80,487	21,784	118,701	30,439	152,947	40,226
Congo (Kinshasa)	2,921	728	8,146	1,850	4,801	1,282
Germany, West	939	259	-----	-----	2	1
Japan	41,621	10,483	45,735	11,115	52,502	13,239
Mexico	18,673	4,385	19,034	4,150	12,092	2,642
Mozambique	1,394	340	1,098	267	1,256	301
Norway	3,753	951	6,272	1,555	4,481	1,206
Peru	33,568	8,873	53,729	13,655	30,204	8,201
Portuguese West Africa	-----	-----	-----	-----	1,874	447
Poland	9,870	2,607	9,454	2,366	9,495	2,498
Spain	2,094	564	2,877	691	-----	-----
United Kingdom	1,145	251	3,398	803	1,086	274
Yugoslavia	474	130	-----	-----	385	93
Zambia	505	124	277	63	3,817	953
Other	1,381	325	1,404	345	2,807	654
Total	222,112	57,502	306,540	76,006	329,008	85,288

[r] Revised.

Table 31.—U.S. imports for consumption of zinc, by countries

Country	1967 Short tons	1967 Value (thousands)	1968 Short tons	1968 Value (thousands)	1969 Short tons	1969 Value (thousands)
ORES						
Algeria	9,264	$1,258	727	$122	-----	-----
Australia	3,334	358	1,236	235	4,387	$700
Bolivia	137	13	r 8,619	r 1,455	9,407	1,489
Canada	274,854	38,584	301,306	44,459	326,929	48,552
Chile	206	3	126	29	1,025	213
Germany, West	24	5	-----	-----	3,701	658
Honduras	1,612	268	6,531	925	11,517	1,614
Mexico	83,653	9,228	101,554	11,204	141,720	16,036
Morocco	3,318	414	15,675	1,897	8,848	873
Netherlands	-----	-----	3,313	418	-----	-----
Peru	45,274	6,074	40,237	7,368	54,925	8,591
South Africa, Republic of	9,584	1,845	5,466	857	1,959	421
Sweden	-----	-----	-----	-----	593	65
Other	59	25	13	2	223	30
Total	431,319	58,075	r 484,803	r 68,971	565,234	79,242
BLOCKS, PIGS, OR SLABS						
Angola	-----	-----	-----	-----	661	149
Australia	7,187	1,703	19,915	4,627	34,237	8,896
Belgium-Luxembourg	15,989	4,016	16,611	4,109	16,361	4,226
Canada	80,482	21,791	118,701	30,439	151,895	40,042
Congo (Kinshasa)	2,921	728	8,146	1,850	4,801	1,282
Germany, West	939	259	-----	-----	2	1
Japan	41,621	10,483	45,735	11,115	52,502	13,239
Mexico	18,673	4,385	19,034	4,150	12,092	2,642
Mozambique	1,394	340	1,098	267	1,256	301
Norway	3,753	951	6,272	1,555	4,481	1,206
Peru	33,568	8,873	53,729	13,655	30,204	8,201
Poland	9,870	2,607	9,454	2,366	9,495	2,498
Portuguese West Africa	-----	-----	-----	-----	1,874	447
Spain	2,094	564	2,877	691	-----	-----
United Kingdom	1,145	250	3,398	803	1,086	274
Yugoslavia	474	130	-----	-----	385	93
Zambia	505	124	277	63	3,799	949
Other	1,387	327	1,404	345	2,718	651
Total	222,002	57,531	306,651	76,035	327,849	85,097

r Revised.

Table 32.—U.S. imports for consumption of zinc, by classes

Year	Ore (zinc content) Short tons	Ore (zinc content) Value (thousands)	Blocks, pigs, and slabs Short tons	Blocks, pigs, and slabs Value (thousands)	Sheets, plates, strips, and other forms Short tons	Sheets, plates, strips, and other forms Value (thousands)
1967	431,319	$58,075	222,002	$57,531	648	$276
1968	r 484,803	r 68,971	306,651	76,035	754	290
1969	565,234	79,242	327,849	85,097	966	418

Year	Old and worn out Short tons	Old and worn out Value (thousands)	Dross and skimmings Short tons	Dross and skimmings Value (thousands)	Zinc dust Short tons	Zinc dust Value (thousands)	Total value [1] (thousands)
1967	1,465	$240	2,498	$433	3,771	$1,211	$117,766
1968	878	119	581	63	8,100	2,443	r 147,921
1969	1,770	255	716	67	8,251	2,652	167,731

r Revised.

1 In addition, manufactures of zinc were imported as follows: 1967—$318,287; 1968—$446,555; 1969—$510,785.

Table 33.—U.S. imports for consumption of zinc pigments and compounds

Kind	1968		1969	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Zinc arsenate	2	$6	-----	-----
Zinc oxide	15,551	3,072	14,565	$3,059
Zinc sulfide	534	176	355	119
Lithopone	246	37	261	40
Zinc chloride	2,063	412	1,367	233
Zinc sulfate	2,196	235	6,236	675
Zinc cyanide	92	66	124	83
Zinc compounds, n.s.p.f.	154	148	610	267
Total	20,838	4,152	23,518	4,476

Table 34.—World mine production of zinc (content of ore), by countries

(Short tons)

Country [1]	1967	1968	1969 p
North America:			
Canada	1,248,977	1,273,260	1,316,416
Guatemala (exports)	478	-----	1,026
Honduras	14,425	16,295	17,644
Mexico	265,894	264,578	279,298
United States (recoverable)	549,413	529,446	553,124
South America:			
Argentina	29,987	28,975	e 34,900
Bolivia	18,468	12,371	28,875
Chile	1,238	1,383	1,629
Colombia e	560	700	466
Ecuador	177	126	229
Peru	335,983	321,218	346,954
Europe:			
Austria	12,302	13,955	15,690
Bulgaria	75,100	e 77,200	e 70,000
Czechoslovakia	8,332	10,885	e 11,000
Finland	67,020	72,100	78,471
France	27,183	24,030	21,826
Germany:			
East e	13,000	13,000	13,000
West	117,228	121,472	121,923
Greece e	11,500	11,700	10,158
Ireland	r 39,700	58,400	115,743
Italy	137,460	154,100	146,081
Norway	13,417	13,052	12,561
Poland	172,600	182,000	184,000
Portugal	560	r 400	1,712
Spain	r 63,797	82,230	89,066
Sweden	r 90,192	89,618	99,318
U.S.S.R. e	595,000	634,000	672,000
Yugoslavia	99,226	105,242	e 102,000
Africa:			
Algeria	r 8,980	e 23,900	e 24,500
Congo (Brazzaville)	7,020	1,024	992
Congo (Kinshasa)	133,982	139,474	e 140,500
Morocco	50,178	35,032	37,343
South-West Africa, Territory of e	44,000	66,000	77,000
Tunisia	4,577	5,675	e 5,800
Zambia	49,476	59,300	55,667
Asia:			
Burma e	r 5,200	5,200	5,400
China, mainland e	100,000	110,000	110,000
India	5,808	7,680	9,629
Iran [2] e	26,500	27,500	24,800
Japan	289,554	291,389	297,488
Korea:			
North e	125,000	130,000	138,000
South	15,045	21,319	24,341
Philippines	1,706	2,472	3,622
Thailand (in ore) e	1,500	1,200	800
Turkey	4,066	5,377	7,506
Oceania: Australia	448,591	465,604	556,253
Total [3]	r 5,330,400	5,509,882	5,864,751

e Estimate. p Preliminary. r Revised.

[1] Czechoslovakia produces concentrate for export, and Brazil, Hungary, Rumania, and North Vietnam also produce zinc, but data are not available.

[2] Year ended March 20 of year following that stated.

[3] Totals are of listed figures only.

Table 35.—World smelter production of zinc, by countries

(Short tons)

Country [1]	1967	1968	1969 [p]
North America:			
Canada	[r] 405,367	426,932	466,350
Mexico	78,111	88,227	88,477
United States	938,830	1,020,891	1,040,597
South America:			
Argentina [e]	25,400	23,100	27,100
Brazil	1,975	3,866	[e] 6,000
Peru	[r] 67,967	72,519	68,649
Europe:			
Austria [2]	15,605	16,859	17,121
Belgium [2]	250,586	280,317	288,359
Bulgaria [2]	81,500	82,800	[e] 85,200
Finland	-----	-----	1,195
France	204,686	228,700	280,500
Germany:			
East [e]	15,000	15,000	15,000
West	113,155	134,973	240,487
Italy	98,134	123,761	143,654
Netherlands	[r] 43,000	46,300	52,000
Norway	60,408	66,260	64,910
Poland [2]	216,000	223,000	228,700
Spain	77,610	83,100	88,513
U.S.S.R. primary [e]	[r] 595,000	634,000	672,000
United Kingdom	114,971	157,493	166,441
Yugoslavia [2]	58,630	87,058	89,352
Africa:			
Congo, (Kinshasa)	67,783	68,975	70,252
South Africa, Republic of	-----	-----	11,845
Zambia	49,035	58,575	55,286
Asia:			
China, mainland (refined) [e]	88,000	100,000	100,000
India	3,350	22,817	26,710
Japan	569,033	667,510	785,051
Korea:			
North [e]	88,000	88,000	66,000
South	2,809	2,705	2,546
Oceania: Australia	217,809	229,591	271,525
Total [3]	[r] 4,547,754	5,053,329	5,519,820

[e] Estimate. [p] Preliminary. [r] Revised.
[1] North Vietnam, and Rumania also produce zinc, but production data are not available.
[2] Includes production from reclaimed scrap.
[3] Totals are of listed figures only.

Zirconium and Hafnium

By Donald E. Eilertsen [1]

Domestic zircon production was slightly smaller in 1969 than in 1968, but imports, exports, and estimated consumption broke all previous records. Outputs of zirconium sponge metal and zirconium-bearing refractories increased substantially over those of 1968.

Legislation and Government Programs.—The Statistical Supplement to the Stockpile Report to the Congress showed the following excess materials on hand at yearend: 16,514 short tons of baddeleyite mineral concentrate, 1,720 tons of zircon, and 1 ton of zirconium metal powder. The U.S. Atomic Energy Commission (AEC) had yearend inventories of approximately 1,050 tons of zirconium sponge, 200 tons of Zircaloy, and 40 tons of hafnium crystal bar.

Table 1.—Salient zirconium statistics in the United States

(Short tons)

Product	1968	1969
Zircon:		
Production	W	W
Exports	2,026	5,395
Imports	59,900	95,414
Consumption [e]	143,000	160,000
Stocks, yearend, dealers and consumers [1]	46,000	52,000
Zirconium oxide:		
Production [2]	3,864	5,702
Producers' stocks, yearend [2]	1,077	1,005

[e] Estimate. W Withheld to avoid disclosing individual company confidential data.

[1] Excludes foundries.

[2] Excludes oxide produced by zirconium metal producers.

DOMESTIC PRODUCTION

Zircon was produced as a byproduct during the recovery of titanium-mineral-bearing sands at the Trail Ridge dredging and milling facilities of E. I. du Pont de Nemours & Co., Inc., near Starke, Fla., and by Humphreys Mining Co., for Du Pont, near Folkston, Ga. Zircon output was approximately at the same level as in 1968; the figure is being withheld from publication to avoid disclosing company confidential data.

Statistical data on the production of zirconium sponge, ingot, and scrap and on hafnium sponge and oxide are also withheld from publication to avoid disclosure of company confidential data. Zirconium powder and alloy productions were respectively 91 and 3,511 tons. Output of zirconium sponge metal increased substantially over that of 1968.

Four firms produced 44,800 tons of milled (ground) zircon, an increase of 1.6 percent over 1968 production. Production of zirconium oxide by four companies, excluding that produced by the producers of metal, totaled 5,702 tons. Production of zirconium-bearing refractories totaled 31,200 tons, an increase of almost 25 percent over that of 1968. Hafnium crystal bar output totaled 28 tons compared with 25 tons in 1968.

Zirconium Technology Corp., frequently known as Zirtech, announced the completion of a new modern $1.7 million plant at Albany, Oreg. The facility will produce precision tubing and bar products from special metals and alloys, the latter including zirconium alloy tubing for use in nuclear reactors.[2]

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[1] Physical scientist, Intermountain Field Operations Center, Denver, Colo.

[2] American Metal Market. Zirconium Technology Completes Modern Precision Tubing Plant. V. 76, No. 238, Dec. 17, 1969, pp. 14, 24.

Table 2.—Producers of zirconium and hafnium materials, 1969

Company	Location	Materials
ZIRCONIUM MATERIALS		
Amax Specialty Metals, Inc	Akron, N.Y	Ingot.
Do	Parkersburg, W. Va	Sponge metal.
The Carborundum Co	Falconer, N.Y	Refractories.
Corhart Refractories Co	Buckhannon, W. Va	Do.
Do	Corning, N.Y	Do.
Do	Louisville, Ky	Do.
Foote Mineral Co	Cambridge, Ohio	Alloys.
Do	Exton, Pa	Metal powder.
A.P. Green Refractories Co., Remmey Division	Philadelphia, Pa	Refractories.
Harbison-Walker Refractories Co	Mount Union, Pa	Do.
Harvey Aluminum, Inc	Torrance, Calif	Ingot.
M & T Chemicals, Inc	Andrews, S.C	Milled zircon.
National Lead Co., Titanium Alloy Manufacturing Div. (TAM)	Niagara Falls, N.Y	Milled zircon, chloride, oxide, other compounds, powder, alloys, refractories.
Norton Co	Huntsville, Ala	Oxide.
Ohio Ferro-Alloys Corp	Brilliant, Ohio	Alloys.
Frank Samuel & Co., Inc	Camden, N.J	Milled zircon.
Tizon Chemical Corp	Flemington, N.J	Oxide, other compounds.
The Charles Taylor Sons Co	Cincinnati, Ohio	Refractories.
Do	South Shore, Ky	Do.
Transelco, Inc	Dresden, N.Y	Various compounds, ceramics, alloys.
Union Carbide Corp	Alloy, W. Va., and Niagara Falls, N.Y	Alloys.
Ventron Corp	Beverly, Mass	Do.
Wah Chang Albany Corp	Albany, Oreg	Oxide, chloride, sponge metal, ingot, powder.
Walsh Refractories Corp	St. Louis, Mo	Refractories.
Zirconium Corp. of America	Cleveland, Ohio	Oxide and refractories.
Continental Mineral Processing Corp	Sharonville, Ohio	Milled zircon.
HAFNIUM MATERIALS		
Amax Specialty Metals, Inc	Akron, N.Y	Sponge metal, crystal bar.
Do	Parkersburg, W. Va	Oxide.
Nuclear Materials & Equipment Corp	Leechburg, Pa	Crystal bar.
Wah Chang Albany Corp	Albany, Oreg	Oxide, sponge metal, crystal bar, ingot.

CONSUMPTION AND USES

Zircon has many uses such as foundry sand (largest), refractories and as raw material for producing zirconium and hafnium metals, alloys, compounds, and zircon mineral products. Consumption of zircon concentrate and milled zircon is roughly estimated at 160,000 tons—117,000 tons as foundry sand, 25,000 tons for refractories, and 18,000 tons for other usage.

Preliminary Bureau of Census figures for 1969 show that shipments of zircon refractories and zirconia brick and shapes totaled 2.1 million brick valued at $6.6 million expressed in terms of equivalent 9-inch bricks. This compared to 1.7 million bricks valued at $5.5 million in 1968.[3]

Dealers and other firms indicated that they shipped milled zircon and concentrate to the following markets in 1969: Foundry use 63,400 tons, refractories and ceramics 51,200 tons, and metal, alloys, compounds, and other uses 5,900 tons. Zirconium metal is used in nuclear reactors, camera flash bulbs, and as construction materials for chemical plants to resist corrosion.

A 1,000-megawatt nuclear powerplant has more than 100 miles of zirconium alloy tubing to contain the uranium oxide fuel that powers the reactor, and an additional 25 miles of this tubing is used annually to refuel such a plant. The AEC estimated that the installed nuclear generating capacity in the United States will reach 150,000 megawatts by 1980, the equivalent of 150 plants of 1,000-megawatt size.[4]

[3] U.S. Department of Commerce, Bureau of the Census. Current Industrial Reports. Refractories. First Quarter 1969, Series MQ–32C(69)–1, July 3, 1969; Second Quarter 1969, Series MQ–32C(69)–2, Sept. 18, 1969; Third Quarter 1969, Series MQ–32C(69)–3, Dec. 29, 1969; Fourth Quarter 1969, Series MQ–32C(69)–4, Apr. 3, 1969. Each report 2 pp.
———. Refractories. Summary for 1968. Series MQ–32C(68)–5, Aug. 20, 1969, 6 pp.
[4] Work cited in footnote 2.

Zirconium compounds have uses in refractories, glazes, enamels, and polishing material for optical glass.

Hafnium metal, alloys, and compounds continued to have few uses. The metal was used in control rods for special nuclear reactors and in alloys for making high-temperature and high-strength special structural parts; compounds were used in insulators and cutting tools. Some uses for hafnium were similar to those developed for zirconium.

STOCKS

Table 3.—Yearend stocks of zirconium and hafnium materials

(Short tons)

Item	Yearend 1968	Yearend 1969
Zircon concentrate held by dealers and consumers, excluding foundries	r 39,700	45,000
Milled zircon held by dealers and consumers, excluding foundries	6,400	6,700
Zirconium:		
Oxide	r 1,716	1,835
Sponge	241	438
Ingot	r 158	241
Scrap	r 660	575
Powder	5	W
Alloys	r 980	635
Refractories	r 8,217	8,602
Hafnium:		
Oxide	W	218
Sponge	32	31
Crystal bar	5	5

r Revised. W Withheld to avoid disclosing individual company confidential data.

PRICES

Published prices of zircon, zirconium oxide, hydride, and various forms of wrought and unwrought zirconium and hafnium metals were steady throughout the year.

Table 4.—Published prices of zirconium and hafnium materials, 1969

Specification of material	Price
Zircon:	
Domestic, f.o.b. Starke, Fla., bags, per short ton [1]	$56–57
Imported sand containing 65 percent ZrO_2, c.i.f. Atlantic ports, in bags, per long ton [1]	70
Domestic, granular, 1- to 5-ton lots, from works, in bags, per pound [2]	.04875
Domestic, milled, 1- to 5-ton lots, from works, in bags, per pound [2]	.055
Zirconium oxide: [2]	
Chemically pure white ground, barrels or bags, works per pound	1.50
Milled, bags, 5-ton lots, from works, per pound	.645
Glass-polishing grade, 100 pound bags, 94–97 percent ZrO_2, works, per pound	.92
Opacifier grade, 100 pound bags, 85–90 percent ZrO_2, per pound	.41
Stabilizer oxide, 100 pound bags, 91 percent ZrO_2, milled, per pound	0.75–0.85
Zirconium hydride: [2]	
Electronic grade, powder, drums, from works, per pound	14.50–16
Zirconium: [3]	
Powder, per pound	12–13
Sponge, per pound	5.50–7
Sheets, strip, bars, per pound	13–16
Hafnium: [3]	
Sponge, per pound	75
Bar and plate, rolled, per pound	120

[1] Metals Week. V. 40, Nos. 1–52, January–December 1969.

[2] Oil, Paint and Drug Reporter. V. 195, Nos. 1–26, January–June 1969; v. 196, Nos. 1–26, July–December 1969.

[3] American Metal Market. V. 76, Nos. 148–247, Aug. 7–Dec. 31, 1969.

FOREIGN TRADE

Exports of zirconium ores and concentrates totaled 5,395 short tons valued at $589,840 and were made to 13 countries. The three major recipients were Canada, 75 percent; Mexico, 10 percent; and Italy, 6 percent.

Imports for consumptiom of zircon, 92 percent from Australia, smashed the previous record of 1968 by 59 percent. The average value of imported zircon at foreign ports was $40.43 per short ton compared with $33.62 per ton a year ago.

Table 5.—U.S. exports of zirconium-bearing products, 1969

Destination	Pounds	Value
Zirconium:		
Australia	3,578	$9,482
Germany, West	8,648	93,348
India	9,986	240,658
Italy	1,404	60,176
Japan	42,724	362,502
Pakistan	192	1,876
Portugal	1,170	12,870
South Africa, Republic of	50	1,320
Spain	192	1,876
Taiwan	144	2,750
Turkey	220	2,472
Total	68,308	789,330
Wrought zirconium and zirconium alloys:		
Belgium	1,002	36,584
Brazil	156	1,104
Canada	525,752	9,013,202
Denmark	176	12,060
France	1,184	15,348
Netherlands	3,412	22,080
Norway	892	26,654
Sweden	19,402	396,852
United Kingdom	52,188	349,694
Total	604,164	9,873,578
Zirconium waste and scrap:		
Australia	128	980
Brazil	5,680	23,100
Canada	2,742	12,286
France	72,766	374,878
Germany, West	29,014	207,766
Italy	2,200	13,068
Japan	12,446	67,120
Netherlands	4,340	19,812
Switzerland	2,048	9,176
Taiwan	1,500	14,800
United Kingdom	81,588	416,820
Total	214,452	1,159,806

Table 6.—Imports of zirconium and hafnium materials, 1969

Country	Pounds	Value
Wrought zirconium:		
France	10,567	$86,991
Germany, West	10,236	12,060
Japan	90	1,098
Netherlands	121	2,785
Sweden	73	1,144
Total	21,087	104,078
Zirconium waste and scrap:		
Canada	9,865	3,611
France	425,515	1,902,196
Japan	32,266	127,461
United Kingdom	6,432	3,088
Total	474,078	2,036,356
Unwrought zirconium alloys:		
Germany, West	1,282	11,178
United Kingdom	3,250	1,328
Total	4,532	12,506
Zirconium oxide:		
France	500	2,000
Germany, West	3,077	2,913
Switzerland	3	456
United Kingdom	273,146	110,132
Total	276,726	115,501
Other zirconium compounds:		
Germany, West	8,300	55,817
Japan	120,000	10,775
Netherlands	22	474
United Kingdom	1,457,652	445,455
Total	1,585,974	512,521
Unwrought hafnium:		
Germany, West	29	3,050
Peru	412	10,516
Total	441	13,566
Wrought hafnium: Canada	6	450

Table 7.—U.S. imports for consumption of zircon, by countries

Country	1967		1968		1969	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Australia	57,908	$1,873	58,812	$1,963	87,743	$3,510
Canada [1]	1,111	13	904	35	3,818	93
French Pacific Islands	------	------	------	------	3,358	60
Malaysia	56	2	------	------	112	3
South Africa, Republic of	------	------	28	8	383	192
Syrian Arab Republic	228	3	45	3	------	------
United Kingdom [1]	------	------	111	5	------	------
Total	59,303	1,891	59,900	2,014	95,414	3,858

[1] Believed to be country of shipment rather than country of origin.

WORLD REVIEW

Australia.—Associated Minerals Consolidated Ltd. began operating what is believed to be the world's largest mobile, mineral-sands concentrating plant on South Stradbroke Island off the eastern Australian coast. The floating dredge and mineral beneficiation complex was designed to mine zircon, rutile, ilmenite, and monazite from beach sands of the low, swampy, windswept, uninhabited island. The deposits are part of approximately 1,000 miles of coastline on which the Australian mineral sand industry is based. The mobile concentrating plant is capable of treating 1,500 tons (1,200 cubic yards) of sand per hour as it dredges its way forward and pumps tailings out behind and takes its small pond along with it. The treated concentrates are pumped ashore into storage for shipment to the mainland separator.[5]

A modified, German-made, bucket-wheel excavator will be used by Associated Minerals Consolidated Ltd. to mine zircon and rutile from beach sand on the northern coast of New South Wales.[6]

Greenland.—Zirconium occurs in deposits at Narssaq in southern Greenland. The Danish Sulphuric Acid and Superphosphate Factory has been testing the ores, which seem to be abundant, but economic exploitation is still undetermined. The rock, composed of layers of kakortokite and eudialyte, contains about 2 to 3 percent zirconium oxide and some rare-earth minerals.[7]

Uruguay.—The Government recently authorized the formation of an Uruguayan-foreign firm to exploit and process black sands located on the Atlantic coast at Aguas Dulces. The deposit, prospected and tested since 1950, has an average thickness of 6 meters, extends along the coast for 12 kilometers, and contains 3 million metric tons of heavy minerals with an average 2.5-percent concentration. The heavy minerals contain 5 percent zircon, 60 percent ilmenite, 1 percent rutile, and 0.6 percent monazite.[8]

Table 8.—Free world production of zirconium concentrates, by countries

(Short tons)

Country	1967	1968	1969 p
Australia	r 317,721	332,956	411,021
Brazil	2,934	3,083	3,874
Ceylon	130	28	75
Malagasy Republic	230	-------	--
Malaysia (zircon exports)	520	1,241	1,562
Thailand	1,687	3,549	276
United States	W	W	W
Total [1]	r 323,222	340,857	416,808

p Preliminary. r Revised.
W Withheld to avoid disclosing individual company confidential data.
[1] Total is of listed figures only.

TECHNOLOGY

The Bureau of Mines published several scientific reports concerning zirconium and hafnium. One pertained to research on joining refractory metal compounds to each other and to oxide ceramics by a vacuum hot press-diffusion-bonding method. Very satisfactory bonds were made of ZrC to ZrB_2, Zrn to Zrb_2, ZrC to ZrN, and of Zrc, ZrN, and ZrB_2 to AL_2O_3. The bonding material for each assembly consisted of 50 weight-percent each of the two end compounds. The joint areas of the ZrC, ZrN, and ZrB_2 were stronger and more shock resistant than the parent materials.[9]

Electrical resistivity measurements were reported on arc-melted, spin-cast, and hot-pressed columbium carbide-carbon and zirconium carbide-carbon materials at elevated temperatures, and the results were compared with work previously done on these materials and with hafnium carbide-carbon.[10]

Studies were conducted on hafnium-iridium phase relations by metallography, thermal analysis, electron-beam microprobe, and X-ray diffraction. Melting temperature, mode of formation, crystal system, and lattice parameters were deter-

[5] Engineering and Mining Journal. World Largest Mobile Mineral Sands Concentrator Operating in Australia. V. 170, No. 1, January 1969, p. 87.
[6] The Mining Journal (London). Bucketwheel for Beach Sands. V. 272, No. 6968, Mar. 7, 1969, pp. 201–202.
[7] Bureau of Mines. Mineral Trade Notes. V. 66, No. 6, June 1969, pp. 32–34.
[8] Pp. 25–26 of work cited in footnote 7.
[9] Kelley, John E., Donald H. Sumner, and Hal J. Kelly. Joining Refractory Metal Compounds by Hot Pressing. BuMines Rept. of Inv. 7225, 1969, 26 pp.
[10] Paulson, Denton L., and Gene Asai. Electrical Resistivity of Hyperstoichiometric Columbium and Zirconium Carbide Materials at Elevated Temperatures. BuMines Rept. of Inv. 7289, 1969, 30 pp.

mined for Hf_2Ir, Hf_5Ir_3, HfIr and $HfIr_3$.[11]

Investigations on the effect on microstructure on the superconductivity in selected columbium-hafnium alloys were made, and the results were compared with those predicted by other scientists on the interpretation of high-field superconductivity.[12]

The oxidation of 99.7- and 99.96-percent-pure hafnium specimens at various temperatures and pressures and in air and oxygen atmospheres was studied. The formation of hafnium oxide under various conditions and scaling were evaluated. Excessive scaling on the 99.7-percent-pure hafnium sample may have been caused by oxidation of the metal impurities present. Little or no scaling occurred on the high-purity specimen.[13]

The TaN–ZrB_2 system was investigated to develop improved ceramic materials for cutting tools. Densification, phase relations, mechanical properties, and wear resistance of hot-pressed compositions of TaN–ZrB_2 were examined and evaluated.[14]

Twenty-two zirconium alloys were studied for corrosion resistance in water at 360° C and 2,708 psi for periods up to 112 days. Determinations were made in weight gain and hydrogen content. The alloys included dilute and intermetallic alloys of zirconium with vanadium, chromium, nickel, iron, tin, and copper; intermediate alloys of zirconium with vanadium, chromium, nickel, iron, and copper; and Zircaloy -2 and -4.[15]

Comprehensive summaries of recent studies on zirconium and hafnium metals, alloys, and compounds, containing hundreds of references, were published during the year.[16]

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[11] Copeland, M. I., and D. Goodrich. The Hafnium-Iridium System. J. Less-Common Metals, v. 18, No. 4, August 1969, pp. 347–355.

[12] Siemens, R. E., L. L. Oden, and D. K. Deardorff. Effect of Microstructure on Superconductivity in the Columbium-Hafnium System. BuMines Rept. of Inv. 7258, 1969, 29 pp.

[13] Vahldiek, F. W. Hafnium II. Oxidation. J. Less-Common Metals, v. 19, No. 4, December 1969, pp. 305–314.

[14] Murata, Yorihiro, and E. Dow Whitney. Densification and Wear Resistance of Ceramic Systems: III. Tantalum Monoitride-Zirconium Diboride. Am. Ceram. Soc., v. 48, No. 7, July 1969, pp. 698–702.

[15] Gulbransen, E. A., and K. F. Andrew. Oxidation Studies on Zirconium Alloys in High-Pressure Liquid Water at 360° C. J. Electrochem. Soc., v. 116, No. 5, May 1969, pp. 659–664.

[16] Zr–Hf Newsletter. AMAX Speciality Metals Division, American Metal Climax, Inc., Akron, N.Y., January 1969, 16 pp.; April 1969, 12 pp.; July 1969, 16 pp.; and October 1969, 14 pp.

Minor Metals

By Staff, Bureau of Mines

CONTENTS

ARSENIC [1]

Domestic Production.—Arsenic trioxide was produced domestically, as a byproduct, only at the Tacoma, Wash., copper smelter of American Smelting and Refining Company. Source of the arsenic was copper ores and concentrates, and speiss, flue dust, and sludges from other mineral treatment plants that were treated for recovery of arsenic and other metals. Production figures cannot be published. Sales were substantially greater than in 1968.

Consumption and Uses.—The use pattern for arsenic was the same as in prior years. Approximately 97 percent of the arsenic content of compounds is sold to the consumer product manufacturer as arsenic trioxide (As_2O_3). The remaining 3 percent is used as metal for alloying with lead and copper.

Arsenic was used principally for its toxic qualities in insecticides and herbicides. Lead arsenate, calcium arsenate, sodium arsenite, and arsenic containing organic compounds were used in formulating pesticides. Arsenic compounds were used in herbicides to control grassy vegetation, in cattle and poultry feed to control intestinal parasites, in wood preservatives and dyes. A substantial quantity of arsenic was used in glass and enamels as a color modifier.

A small but growing market for high-purity arsenic is developing in the electronics industry, as indicated by imports of over 3 tons of this material in 1969 with a value of over $40 per pound.

Because of a change in reporting procedures at the U.S. Department of Agriculture, data on the consumption of arsenic wood preservatives in the United States will not be available after 1968. The table showing this information in the Minerals Yearbook has been deleted.

Prices.—The price of refined white arsenic, 99.5 percent, at New York docks, in barrels, small lots, was 6¼ to 6¾ cents per pound throughout the year. Refined white arsenic in bulk carload lots at Laredo, Tex., was $120 per ton, and crude white arsenic was quoted at $94 per ton at Tacoma, Wash.

The price of arsenic metal in London was £518 per long ton, equivalent to 55.6 cents per pound.

The yearend price of lead arsenate in 50-pound bags was 26 to 29 cents per pound. Sodium arsenate, 60 percent arsenic pentoxide, in 200-pound drums was quoted at 30 cents per pound; and sodium arsenite, 94 percent soluble pink powder, 75 percent arsenious acid, in 100-pound drums, was quoted at 23 cents per pound.

Foreign Trade.—U.S. imports of white arsenic declined 28 percent in quantity and 22 percent in value. The average value of 1969 imports was $113 per ton.

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[1] By John W. Cole, physical scientist, Washington, D.C.

Table 1.—U.S. imports for consumption of white arsenic (As_2O_3) content, by countries

Country	1967 Short tons	1967 Value (thousands)	1968 Short tons	1968 Value (thousands)	1969 Short tons	1969 Value (thousands)
Belgium-Luxembourg	1,107	$160	254	$41	17	$4
Canada	90	11	8	2	-----	-----
France	5,557	466	6,424	600	4,336	420
Germany, West	-----	-----	14	3	-----	-----
Japan	-----	-----	199	14	-----	-----
Mexico	11,453	1,017	7,159	716	7,361	875
Peru	18	1	644	52	255	19
South Africa, Republic of	968	82	1,134	105	121	13
Sweden	6,245	616	9,315	1,090	6,071	732
U.S.S.R.	1,626	149	44	3	-----	-----
United Kingdom	11	1	-----	-----	-----	-----
Western Africa, n.e.c	-----	-----	-----	-----	10	1
Total	27,075	2,503	25,195	2,626	18,171	2,064

Table 2.—U.S. imports for consumption of arsenicals by classes

(Thousand pounds and thousand dollars)

Class	1967 Quantity	1967 Value	1968 Quantity	1968 Value	1969 Quantity	1969 Value
White arsenic (As_2O_3)	54,149	$2,503	50,390	$2,626	36,341	$2,064
Metallic arsenic	590	301	819	583	692	568
Sulfide	578	35	50	12	19	5
Sheepdip	10	2	------	------	44	9
Sodium arsenate	253	22	75	6	110	11
Lead arsenate	------	------	------	------	45	6
Arsenic compounds, n.e.c	------	------	------	------	10	43

Metallic arsenic imports also declined—15 percent in quantity and 3 percent in value. The average value of 1969 imports was $0.82 per pound, but the value ranged from $0.45 to $162 per pound. Although Sweden supplied 99 percent of the quantity, the value was only 53 percent of the total. Imports from Canada consisted of 6,225 pounds valued at $255,000 or $41 per pound. Twenty pounds from Japan were valued at $162 per pound, and 20 pounds from the United Kingdom were valued at $150 per pound.

World Review.—Sweden continued to lead the world in production of arsenic; France was second. Production in Mexico dropped to less than 50 percent of its 1968 output.

Table 3.—World production of white arsenic (arsenic trioxide), by countries [1] [2]

(Short tons)

Country	1967	1968	1969 p
Brazil	245	344	331
Canada	378	345	350
France	r 15,432	e 15,432	15,432
Germany, West	583	1,128	1,102
Japan	709	789	786
Mexico	16,498	14,915	7,075
Peru	298	1,353	530
Portugal	278	202	221
South-West Africa [3]	e 331	534	551
Spain	142	143	110
Sweden	22,266	23,259	23,149
U.S.S.R. e	7,716	7,716	7,826
United States	W	W	W
Total [4]	r 64,876	66,160	57,463

e Estimate. p Preliminary. r Revised.
W Withheld to avoid disclosing individual company confidential data.
[1] Arsenic may be produced in Argentina, Austria, Belgium, China (mainland), Czechoslovakia, East Germany, Finland, Hungary, Southern Rhodesia, United Kingdom, and Yugoslavia, but there is too little information to estimate production.
[2] Including calculated trioxide equivalent for output reported as elemental arsenic and arsenic compounds.
[3] Output of Tsumeb Corp. Ltd. for fiscal years ending June 30.
[4] Total is of listed figures only.

CESIUM AND RUBIDIUM [2]

Domestic Production.—The source of all cesium and rubidium produced in the United States in 1969 was imported pollucite and ALKARB, a residue from past lithium compound production.

Cesium and rubidium compounds and rubidium metal were produced by Penn Rare Metals Division of Kawecki Berylco Industries, Inc., Revere, Pa.; American Potash & Chemical Corp., Trona, Calif.; and Rocky Mountain Research, Inc., Denver, Colo. MSA Research Corp., Callery, Pa., shipped cesium and rubidium metal, and rubidium compounds from stocks.

Consumption and Uses.—Statistical data on the consumption and uses of cesium and rubidium compounds are not available.

Various forms of cesium and rubidium had applications in pharmaceuticals, photomultipler tubes, photoelectric cells, spectrophotometers, scintillation counters, infrared lamps, semiconductors, and vacuum tubes. By far the largest consumption of cesium and rubidium was in research and development.

Prices.—Cesium metal, 99 percent +, was quoted at $100 to $375 per pound. Rubidium metal, 99.5 percent +, was quoted at $300 per pound.

Foreign Trade.—No pollucite was imported during the year. Imports of cesium compounds and rubidium metal as reported by the Bureau of Census were as follows:

Country of origin	Cesium chloride		Cesium compounds, n.s.p.f.	
	Pounds	Value	Pounds	Value
Austria	110	$2,000	-----	-----
Germany, West	1,453	53,372	3,029	$94,750
Switzerland	22	1,025	419	14,979
United Kingdom	249	4,124	50	566
Total	1,834	60,521	3,498	110,295

Technology.—The National Aeronautics and Space Administration (NASA) continued its long range development program involving the use of cesium for space power generation and energy conversion. Over the past 5 years, NASA has conducted experiments with cesium for thermionic converter applications. High-purity cesium has been studied for use as a conducting interelectrode gas and as a low-work function source of electrons. Other experimental applications include using cesium in magnetohydrodynamic power generation and in power switching thyratron tubes.

GALLIUM [3]

Domestic Production.—Gallium metal was produced as a byproduct of alumina production by the Aluminum Company of America at its Bauxite, Ark., plant. Gallium metal, oxide, and trichloride were produced as a byproduct of zinc production from sphalerite by Eagle-Picher Industries, Inc., at its Quapaw, Okla., plant.

Consumption and Uses.—The largest consumption of gallium is in electronic applications. When alloyed with Group V metals (phosphorus, arsenic, antimony, and bismuth), gallium forms versatile semiconducting materials. Gallium semiconducting compounds are used in transistors, diodes, as dopant for other semiconductor materials, and in Gunn devices. Gallium is used in the construction of high-temperature quartz tube thermometers. Minor uses for gallium are as a sealant for glass joints, as a constituent of solders, as backing for mirrors, as a low-temperature lubricant, as a component of dental alloys, and in research.

[2] By E. Chin, chemist, Washington, D.C.
[3] By E. Chin, chemist, Washington, D.C.

Prices.—Market prices (per gram) of gallium from bauxite sources were lowered substantially. Prices, effective as of January 1969, were as follows:

Quantity	99.99 percent	99.999 percent	99.9999 percent
Up to 999 grams	$1.00	$1.10	$1.20
1,000 to 4,999 grams	.80	.85	.95
5,000 to 24,999 grams	.70	.75	.85

Foreign Trade.—Imports of gallium-bearing products (unwrought, waste, and scrap) as reported by the Bureau of the Census were as follows:

Country of origin	Pounds	Value
Belgium-Luxembourg	288	$37,665
Canada	4	1,081
Germany, West	170	21,543
Japan	9	4,923
Netherlands	2	440
Switzerland	2,054	330,393
United Kingdom	129	15,210
Total	2,656	411,255

GERMANIUM [4]

Germanium demand was high during 1969, and a shortage of supplies caused the first rise in prices since September 2, 1966. The increased demand appears to have been caused by uses other than for semiconductors because production and shipments of germanium diodes and transistors was almost the same as in 1968. Germanium metal was imported from the U.S.S.R. for the first time.

Domestic Production.—Primary germanium output was derived from smelter residues resulting from retorting and refining of zinc concentrates from the Kansas-Oklahoma area and zinc concentrates from fluorspar-zinc-lead ores of the Kentucky-Illinois area. Eagle-Picher Industries, Inc., operated a refinery at Miami, Okla. Kawecki Berylco Industries, Inc., Revere, Pa., and Sylvania Electric Products, Inc., Towanda, Pa., operated refineries to produce germanium from primary materials and scrap. Several other laboratories operate facilities for producing intrinsic ingot from electronic-grade dioxide.

Prices.—The price of purified germanium ingot was raised on July 2 from $175.25 to $184.50 per kilogram and on October 13 was raised to $201.50. Germanium dioxide (electronic) was raised from $88.50 to $95 per kilogram on July 2, and to $105 on October 13.

Foreign Trade.—U.S. imports of germanium metal (unwrought, waste, and scrap) increased 93 percent in quantity and 127 percent in value. The first recorded imports of germanium from the U.S.S.R. were second only to Belgium-Luxembourg in quantity and value.

Table 4.—U.S. imports for consumption of germanium, by countries

Country	Pounds	Value
	Unwrought, and waste and scrap	
Belgium-Luxembourg	3,521	$704,766
Canada	42	2,000
Germany, West	220	7,350
Italy	220	7,350
Switzerland	2	333
U.S.S.R.	3,063	181,669
United Kingdom	774	46,296
Total	7,842	949,764
	Wrought	
Belgium-Luxembourg	9	5,154

World Review.—The Government of the Congo (Kinshasa) resumed production of germanium in 1969. Reported production was 11,000 kilograms of germanium in concentrates. The principal source was the Prince Leopold mine near Kipushi, where the germanium-containing mineral renierite is associated with copper and zinc minerals. The germanium concentrates are shipped to Belgium for recovery of refined germanium metal or dioxide.

[4] By John W. Cole, physical scientist, Washington, D.C.

INDIUM [5]

Domestic Production.—The American Smelting and Refining Company produced indium metal and chloride at its Perth Amboy, N.J., plant and indium metal at its Denver, Colo., plant. The Anaconda Company produced 62,970 troy ounces of indium at its Great Falls, Mont., plant, compared with 85,640 ounces in 1968. Anaconda discontinued indium production in November because of market conditions and the low level of indium contained in materials treated. Source material for indium was certain smelter flue dusts and residues in which the trace quantities of indium associated with zinc minerals were concentrated.

Uses.—Indium was used in electronic devices in a variety of ways, such as a component of solder for connecting lead wires to germanium in transistors, and as a property-modifying component of the intermetallic germanium semiconductor. The compounds, indium arsenide, indium antimonide, and indium phosphide were utilized for other semiconductor applications. Indium was also used in special solders, glass-sealing alloys, and dental alloys.

Stocks.—Producer stocks of indium increased significantly during the year and at yearend were in excess of total shipments for 1969.

Prices.—The market quotations for indium throughout the year were $2.50 per troy ounce for 30 to 90 ounces in stick shapes; ingots were $2.05 per troy ounce in 100-ounce lots; and $1.75 in plus 10,000-ounce lots.

Foreign Trade.—Imports for consumption of indium (unwrought, waste, and scrap) totaled 283,275 troy ounces valued at $425,859, compared with 280,421 ounces and $484,528 for 1968. Imports by country were Canada 165,095 ounces ($254,009), Japan 55,388 ounces ($78,685), Peru 21,051 ounces ($36,839), U.S.S.R. 13,088 ounces ($15,897), West Germany 12,908 ounces ($17,247), Belgium-Luxembourg 8,368 ounces ($9,805), United Kingdom 6,861 ounces ($12,602), and the Netherlands 516 ounces ($775).

RADIUM [6]

Radium is being used less and less in the United States principally because of cheaper substitute material and increasingly greater control of its hazardous aspects.

Legislation and Government Programs.—The U.S. Department of Health, Education and Welfare has issued pamphlets and booklets [7] which review the status of various health programs with respect to radium and radioisotope usage and control, the evaluation of radium contamination, and the use and hazards of certain radioactive elements including radium.

Most of the publications are available through the Office of Public Information and Education, Environmental Control Administration, Consumer Protection and Environmental Health Service, U.S. Department of Health, Education and Welfare, Rockville, Md. 20852.

The depletion allowance for mining domestic and foreign radium-bearing raw materials was lowered from 15 to 14 percent. The new rate was effective with taxable years beginning after Oct. 9, 1969.

Domestic Production.—No primary radium was produced in the United States in 1969 nor has it been for many years. The principal dealer continued to be Radium Chemical Co., Inc., New York, N.Y., which received its supplies of radium salts from Union Minière S.A. This latter Belgian company, formerly Union Minière du Haut-Katanga, recovered radium from Congolese (Kinshasa) ores. Canadian Radium and Uranium Division, Canrad Precision Industries, Inc., New York, and Nu-

[5] By Harold J. Schroeder, physical scientist, Washington, D.C.

[6] By John G. Parker, physical scientist, Denver, Colo.

[7] Bureau of Radiological Health. Report of State and Local Radiological Health Programs. Fiscal Year 1968. U.S. Department of Health, Education and Welfare, July 1969.
Public Health Service. Evaluation of Radium Contamination in Aircraft Instrument Repair Facilities. Pub. No. 999–RH–36. U.S. Government Printing Office, Washington, D.C., May 1969. 37 pp.
Robinson, Earl W. The Use of Radium in Consumer Products. MORP 68–5. Public Health Service, National Center for Radiological Health, U.S. Department of Health, Education and Welfare, November 1968, 25 pp.
Williams, Kenneth D., and Joseph D. Sutton. Survey of the Use of Radionuclides in Medicine: Preliminary Report. Public Health Service, National Center for Radiological Health, U.S. Department of Health, Education and Welfare, July 1968.

clear Radiation Development Corp., Grand Island, N.Y., which took over radium activities from United States Radium Corp., Morristown, N.J., are the only two other domestic firms having an interest in radium sales and shipments.

The principal interest of both Canrad and U.S. Radium is in radioactive isotopes (radioisotopes), especially those such as tritium (hydrogen 3) which have certain fluorescent properties. Radium Chemical Co., Inc., still offers a reencapsulation service—removing radium from old sources and placing it in new, doubly encapsulated platinum containers.

Uses.—Much of the radium formerly used in self-luminous light sources has been replaced by tritium and krypton-85 luminous compounds which have less external gamma radiation.

The continuing use of radium in the therapeutic treatment of cancer is due primarily to the penetrative power of its gamma radiation. Here it is used in the form of encapsulated radium sulfate in interstitial or intracavitary treatment. These containers are checked periodically for leakage of radon gas. Leakage requires their return to the leasor or laboratories for reencapsulation. Other radioisotopic substitutes for radium in medical usage are cesium-137, iridium-192, and gold-198. Also, californium-252, a newly developed radioisotope, available as yet in very limited quantities, has been suggested for therapeutic usage. Cobalt-60 is used principally in large teletherapy machines.

Beryllium neutron sources with radium are being replaced gradually by sources with little or no gamma radiation, such as those containing plutonium-238 and curium-244. In turn, it is said that californium-252, a spontaneous neutron emitter that has a 2.65-year half-life, can be fabricated into small-sized sources which need less free space for decay helium. The Bureau of Mines is evaluating Cf-252 as a neutron source in its process control program to reduce air pollution from coal utilization. Other potential uses for californium-252 were investigated.[8]

Prices.—Radium prices have not been quoted for several years, at which times they were listed as high as $21.50 per milligram for new material. In some European countries, some small lot sales were made at prices as low as $2 per milligram. The price situation in this country is rather unsettled because of efforts made by the Environmental Control Administration, U.S. Department of Health, Education and Welfare, and in various State and local radiological health programs to license and limit the use of radium. This has led to former users offering significant quantities of radium salts, sometimes at low asking prices, just to dispose of the material.

Foreign Trade.—Radium has been included for several years in an export and import classification which prevents disclosure of pertinent data. Under arrangements with the U.S. Atomic Energy Commission, the Bureau of the Census released trade statistics on radium in 1967, but no data were available on the subject in 1968 or 1969. Imports of radium along with certain radioisotopes and compounds, were exempt from duty.

RHENIUM[9]

The demand for rhenium increased as a result of the increased requirement for rhenium-platinum catalysts by the petroleum industry. By the yearend, rhenium was in short supply and there was a significant increase in price.

Domestic Production.—Rhenium continued to be recovered as a byproduct from the molybdenite (MoS_2) contained in Southwestern porphyry copper ores by Kennecott Copper Corp. at its molybdenum roasting facility near Garfield, Utah. Shattuck Chemical Co., Denver, Colo., continued to recover rhenium salts from rhenium-bearing domestic and imported molybdenite. Cleveland Refractory Metals (CRM), Solon, Ohio, a division of Chase Brass & Copper Co. (a subsidiary of Kennecott Copper Corp.), received its supply of rhenium-bearing crude materials from the Garfield, Utah, roasting plant of its parent company, and from Shattuck Chemical Co. CRM increased its capacity for rhenium metal in anticipation of the increased demand.

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[8] U.S. Atomic Energy Commission. Californium-252. Its Use and Market Potential. Savannah River Operations Office, Aiken, S.C. May 1969, 26 pp.

[9] By Meherwan C. Irani, metallurgist, Pittsburgh, Pa.

Porphyry copper deposits in Chile, Congo (Kinshasa), the United States, and the U.S.S.R. represented the only significant sources of rhenium. Rhenium metal was recovered at molybdenite roasting plants in Belgium, the Soviet Union, the United Kingdom, the United States, and West Germany.

Consumption and Uses.—Approximately 75 percent of the rhenium consumed was used in the development of rhenium and rhenium-platinum catalysts and in the development of ductile, high-temperature tungsten and molybdenum-base alloys. Other applications of rhenium continued to be in high temperature thermocouples, flashbulb filament wire, electrical contacts, and coatings. Development of rhenium-platinum catalysts used in the cracking of petroleum hydrocarbons emerged as the major use of rhenium. It is estimated by CRM that, by 1972, more than half of the anticipated market of 20,000 pounds per year will be for the manufacturer of catalysts.

Prices.—In July 1969, Cleveland Refractory Metals (CRM) increased prices for rhenium materials. The new published prices, for minimum order of $100, were as follows:

	Per pound
Ammonium perrhenate (NH_4ReO_4), up to 5 pounds	$680
Ammonium perrhenate, over 5 pounds, but less than 20 pounds	$645
Ammonium perrhenate, over 20 pounds	$610
Rhenium metal powder, up to 5 pounds	$700
Rhenium metal powder, over 5 pounds, but less than 20 pounds	$665
Rhenium metal powder, over 20 pounds, but less than 50 pounds	$630

The prices were nominal towards the yearend because there was little or no uncommitted metal available for sale by CRM. Owing to a shortage of supply, rhenium was sold at the yearend on the open market at prices in excess of $1,000 per pound. Most of this rhenium is believed to be of foreign origin.

CRM, using special patented processes, recycled rhenium-bearing scrap materials to recover the rhenium content. High-purity rhenium metal was produced from a mixture of rhenium salts and rhenium scrap starting materials.

Foreign Trade.—Imports of unwrought rhenium metal in 1969 increased 86 percent to about 811 pounds. It was imported from West Germany (32 percent), the U.S.S.R. (27 percent), Sweden (27 percent), and France (13 percent). A small amount was imported from the United Kingdom. The rhenium from France and West Germany is believed to have been obtained from molybdenite recovered from porphyry copper ores in Chile. The rhenium from the Soviet Union is presumed to have been recovered from the flue dusts of molybdenite roasters. The source of the rhenium imported from Sweden is unknown but may have been from the Soviet Union. The average price of unwrought rhenium imports during the year, excluding U.S. duty of 8 percent ad valorem, was $588 per pound (West Germany), $487 per pound (France), $338 per pound (Sweden), and $323 per pound (U.S.S.R.). There were no imports of wrought rhenium during 1969.

Technology.—A patent was granted covering the recovery of rhenium from aqueous solutions obtained by leaching rhenium-containing ore, flue dust, or other metallurgical material.[10] The aqueous solution is contacted, at a specified pH value, with a kerosine solution of a secondary or tertiary amine. The resulting extract phase is purified and subjected

[10] Ziegenbalg, S. and S. Gerish. (assigned to Eorschungsinstitut fuer Ne-Metalle, Freiberg, Germany). Method for Extracting Rhenium from Aqueous Solutions. U.S. Pat. 3,495,934, Feb. 17, 1970.

Table 5.—U.S. imports for consumption of rhenium, by countries

Country	1967		1968		1969	
	Pounds	Value	Pounds	Value	Pounds	Value
France	23	$10,206	17	$6,722	109	$53,045
Germany, West	72	31,142	419	142,217	[1] 261	153,358
Sweden	---	-----	---	-----	215	72,681
U.S.S.R.	---	-----	---	-----	222	71,660
United Kingdom	1	1,164	(2)	269	4	1,364
Total	96	42,512	436	149,208	811	352,108

[1] Adjusted by the Bureau of Mines.
[2] Less than ½ unit.

to reextraction to transfer the values into an aqueous solution. The rhenium compound is obtained from the solution by crystallization.

A Soviet paper published during the year described extraction and separation of rhenium.[11] It describes an electrolytic process for separating rhenium and molybdenum from their disulfides. It was found that complete extraction of milligram-amounts of rhenium, in the presence of 1,000 times its amount of molybdenum, can be achieved in 1 hour. In the process, a 5 percent solution of ammonium chloride acidified by hydrochloric acid to pH 2.5 is used as electrolyte. At a current density of 100 mA/cm^2, 70 to 80 percent of the molybdenum is extracted from the solution. Molybdenum precipitated on the cathode and the rhenium remained in solution. A German patent describing recovery of rhenium from impure oxidized acidic solutions was issued to Kennecott Copper Corp.[12] In the process, rhenium is recovered from solution by contacting it with a solution of tridecyl alcohol in kerosine. Rhenium is selectively extracted into the organic phase from which it is transferred into an aqueous solution of ammonium sulfocyanide.

SCANDIUM [13]

Scandium, obtained as a byproduct from uranium processing, is replacing that recovered from imported Norwegian thortveitite, a rare scandium-yttrium silicate. Most of the byproduct scandium comes from Australia and Canada.

Domestic Production.—The domestic firms concerned with production, refining, or sales of scandium in 1969 were Alfa Inorganics, Inc., Beverly, Mass.; Atomergic Chemetals Co., Division of Gallard-Schlessinger Chemical Manufacturing Corp., Carle Place, N.Y.; King Products, Inc., Arlington, N.J.; Research Chemicals, a division of Nuclear Corporation of America, Phoenix, Ariz.; Semi-Alloys, Inc., Mount Vernon, N.Y.; and Semi-Elements, Inc., Saxonburg, Pa.

In addition to being found in and recovered from uranium waste solutions, research in the past has proved the feasibility of recovering scandium from phosphate rock and tungsten concentrate.

Uses.—Some advances seem to have been made in translating the various properties of scandium, discovered in laboratory scale experimental work, into actual commercial usage.

A high-pressure discharge light called Metalarc, containing mercury with lesser quantities of scandium and sodium oxides, was developed by Sylvania Electric Products, Inc. It is being used in several sports stadiums and indoor coliseums in the United States where its output quality is claimed to be virtually the same as that of natural sunlight.

Prices.—Only a few quotations on scandium, its salts and oxide, were forthcoming during the year. Depending upon lot size, purity, and form (such as ingot, powder, chips, and distilled), the metal was quoted at from $2,000 to $6,800 per pound, the latter being distilled, high-purity material. The oxide, on a similar basis, was priced from $1,000 to $1,500 per pound; salts, such as chlorides, nitrates, sulfates, oxalates, and acetates, from $750 to $800 per pound. Larger quantities of some items were available at lower prices.

Technology.—Some evaluations were made for the National Aeronautics and Space Administration on magnesium-scandium alloys.[14] The Dow Chemical Co. investigated alloys with 10 to 20 percent scandium and ternary additions of lithium, silver, cadmium, and yttrium.

Researchers are using scandium metal in the development of fast breeder reactors. The metal acts as a neutron filter, permitting only two keV neutrons to pass through. Insertion of a 33-inch-long piece of scandium metal in a beam hole in Idaho Nuclear Corp.'s materials testing reactor permits designers to determine how the safety of a fast reactor is affected as the temperature increases.

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[11] Simson, T. F., Z. B. Rozhdestvenskaya, O. A. Songina, A. V. Koval. Electrolytic Separation of Rhenium and Molybdenum From Their Disulfide. Kazakh State Univ. Alma-Ata, U.S.S.R. Zh. Anal. Khim., 24: 1352–6, September 1969 (in Russian).

[12] Prater, John D., and Ronald N. Platz (assigned to Kennecott Copper Corp., New York). Rhenium Production by Ion Exchange. Ger., Offen. 1,808,707 June 12, 1969, U.S. Appl. Nov. 13, 1967, 20 pp.

[13] By John G. Parker, physical scientist, Denver, Colo.

[14] Materials Engineering. Rare Earths May be Key to Stronger Magnesium Alloys. V. 69, No. 1, January 1969, p. 25.

SELENIUM [15]

Demand for selenium continued strong throughout the year and record production and shipments were recorded. At yearend, producers were reported to have back orders covering 2 years' output, and stocks reached a record low.

No changes were made in Government stocks. Total inventories at yearend were 475,000 pounds, equal to the objective set by the Office of Emergency Preparedness (OEP) April 17, 1964.

Domestic Production.—Of the five plants in the United States reporting production of selenium, four were at major electrolytic refineries as follows: American Metal Climax, Inc., Carteret, N.J.; American Smelting and Refining Co., Baltimore, Md.; International Smelting & Refining Co., Perth Amboy, N.J.; and Kennecott Copper Corp., Garfield, Utah. The fifth producer, Kawecki Berylco Industries, Inc., Boyertown, Pa., produced selenium from purchase material from primary and secondary sources. Phelps Dodge Refining Corp., Maspeth, N.Y., sells a crude selenium product to other companies for refining.

Table 6.—Salient selenium statistics

(Thousand pounds of contained selenium)

	1965	1966	1967	1968	1969
United States:					
Production	540	620	598	633	1,229
Shipments to consumers	824	845	659	941	1,410
Imports for consumption	251	286	301	583	546
Stocks, Dec. 31, producers	1,021	797	736	428	247
Price per pound, commercial grade	$4.50–$6	$4.50–$6	$4.50–$6	$4.50–$6	$7–$8.50
World: Production	1,799	1,973	2,051	2,012	2,759

Consumption and Uses.—Selenium was used for modifying the color and imparting color to glasses and enamels. It was used in bottle glass to neutralize the green color imparted by iron. The large increase in the production of one-use bottles contributed to the increased demand for selenium. Selenium was used to tint gray or "black" glass used in the window of modern office buildings. Its use in xerography is believed to have increased. As indicated by reported premium prices paid for selenium in Europe, foreign demand was strong.

Prices.—The price of commercial grade and high-purity selenium were raised from $4.50 and $6 per pound, respectively, to $5 and $6.25 March 10; to $5.50 and $6.75 early in July; and to $7 and $8.50 per pound December 1.

Late in the year commercial-grade selenium was reported to have been traded at a high premium price in Europe.

Foreign Trade.—Imports of selenium decreased slightly from 1968 levels. Canada was the principal supplier as shown in the listing that follows:

U.S. imports for consumption of selenium, by countries

(Thousands of pounds and dollars)

Country	Quantity	Value
	Unwrought, and waste and scrap	
Canada	516	$3,206
Peru	2	10
Germany, West	3	14
Japan	4	18
Total	525	$3,248
	Selenium oxide (selenium content)	
Canada	16	$75
Other	5	24
Total	21	$99

In addition to selenium and selenium dioxide, a small quantity of unspecified selenium salts was imported from Canada.

World Review.—The United States, Canada, and Japan, in that order, continued to lead in production of selenium with 89 percent of free world output.

[15] By John W. Cole, physical scientist, Washington, D.C.

Table 7.—World production of selenium by countries

(Thousand pounds of contained selenium)

Country	1967	1968	1969 p
Australia e	4	4	4
Belgium-Luxembourg (exports)	72	54	55
Canada	725	636	711
Finland	15	16	15
Japan	422	399	435
Mexico	5	2	42
Peru	11	13	15
Sweden	r 132	e 176	176
United States	598	633	1,229
Yugoslavia	10	22	20
Zambia [1] e	57	57	57
Total [2]	r 2,051	2,012	2,759

e Estimate. p Preliminary. r Revised.
[1] Contained in copper refinery slimes exported for treatment.
[2] Total is of listed figures only.

TELLURIUM [16]

Domestic Production.—Production of tellurium during 1968 was reported by the following companies: American Metal Climax, Inc., Carteret, N.J.; American Smelting and Refining Company, Baltimore, Md.; International Smelting & Refining Co., Perth Amboy, N.J.; United States Smelting Lead Refinery, Inc., East Chicago, Ind.; and Kawecki Berylco Industries, Inc., Boyertown, Pa. Phelps Dodge Refining Corp., Maspeth, N.Y., sells a crude tellurium product to other refineries.

Table 8.—Salient tellurium statistics

(Thousand pounds of contained tellurium)

	1965	1966	1967	1968	1969
United States:					
Production, primary and secondary	195	199	135	121	234
Shipments to consumers	146	215	172	201	245
Stocks, Dec. 31, producers	212	195	186	157	191
Imports	18	18	91	71	112
Price per pound, commercial grade	$6	$6	$6	$6	$6
World: Production	321	334	270	258	427

Consumption and Uses.—A report prepared by a panel of industry and Government specialists convened by the National Materials Advisory Board (NMAB) described the "Usage Patterns for Tellurium." Total domestic consumption is 200,000 to 250,000 pounds. The metallurgical industry consumes 79 percent as a carbide stabilizing agent in the production of white cast iron, as a machinability additive for steel and copper and as an additive to lead to improve corrosion resistance. The chemical and pharmaceutical industries consume 19 percent, principally as a secondary vulcanizing agent in the rubber industry. Thermoelectric and electronic devices each consume about 1 percent.

Foreign Trade.—Imports of consumption of tellurium were as follows:

Source	Thousand pounds and thousand dollars	
	Quantity	Value
Canada	70	$369
Peru	39	209
Japan	3	18
Total	112	596

World Review.—The United States produced 55 percent of free world production of tellurium; Canada produced 24 percent; Japan produced 12 percent; and Peru produced 9 percent.

[16] By John W. Cole, physical scientist, Washington, D.C.

Table 9.—Free world production of tellurium by countries

(Thousand pounds of contained tellurium)

Country [1]	1967	1968	1969 [p]
Canada	73	71	104
Japan	30	31	51
Peru	[r] 32	35	38
United States	135	121	234
Total [2]	[r] 270	258	427

[p] Preliminary. [r] Revised.
[1] Small quantity also recovered in Australia by Electrolytic Refining and Smelting Co. of Australia Pty. Ltd.
[2] Total is of listed figures only.

THALLIUM [17]

Domestic Production.—The American Smelting and Refining Company at Denver, Colo., was the only domestic producer of thallium and thallium compounds. The company produced and consumed more of the metal but shipped much less than in 1968. Thallium compound production was larger than in 1968 but shipments were smaller.

Uses.—High-purity thallium is used principally for metallurgical research. Thallium has a significant use in electronic applications such as thallium-activated sodium iodide crystals in photomultiplier tubes. Other uses of thallium were in low-melting alloys and in optical glass.

Price.—The quoted price for thallium in less-than-100-pound lots has been unchanged at $7.50 per pound since December 1957.

Foreign Trade.—Imports for consumption of thallium (unwrought, waste, and scrap) were 601 pounds, valued at $2,155, from Belgium-Luxembourg.

Technology.—During the past 20 years there has been considerable interest and activity in organometallic chemistry, but only recently has there been much study of the chemistry of the organothallium compounds. An article was published summarizing the use of such compounds in organic synthesis.[18]

[17] By Gertrude N. Greenspoon, mineral specialist, Washington, D.C.

[18] Taylor, Edward C., and Alexander McKillop. Organothallium Chemistry—New Horizons in Synthesis. Aldrichimica acta, v. 3, No. 1, 1970, pp. 4–9.

Minor Nonmetals

By William G. Park [1]

CONTENTS

GREENSAND

Domestic production of greensand (glauconite) increased 12 percent in quantity and 23 percent in value over that of 1968. Only two firms, Iversand Co. of New Jersey and Kaylorite Corp. of Maryland, produced greensand; information on production and sales for 1969 is withheld to avoid disclosing individual company confidential data. For the 5-year period 1965–69, average annual production was 3,156 short tons valued at $198,000. The material was marketed for use as a soil conditioner and water softener.

The Bureau of Mines, under a cooperative agreement with the Delaware Geological Survey, began evaluation of glauconite for potential utilization as a ceramic material in structural clay products or lightweight aggregate. Samples from formations in Delaware were tested by Morse Laboratories, Sacramento, Calif.

IODINE [2]

Consumption of crude iodine established a record high in 1969 for the second year in a row. Domestic output increased, but imports decreased in quantity from those of 1968. Increases in quoted prices for crude iodine and most iodine compounds were announced in 1969.

Japan continued to be the world's largest producer of crude iodine.

Legislation and Government Programs.—On December 31, 1969, the Government

[1] Physical scientist, Bureau of Mines, Dallas, Tex.
[2] By Keith S. Olson, Industry economist, Bureau of Mines, Minneapolis, Minn.

Table 1.—Crude iodine consumed in the United States

Products	1968			1969		
	Number of plants	Crude iodine consumed		Number of plants	Crude iodine consumed	
		Thousand pounds	Percent of total		Thousand pounds	Percent of total
Resublimed iodine	6	136	3	8	410	8
Potassium iodide	8	1,715	39	9	1,893	39
Sodium iodide	2	W	W	4	W	W
Other inorganic compounds	15	862	19	15	733	15
Organic compounds	25	1,739	39	26	1,866	38
Total	[1] 38	[2] 4,451	100	[1] 40	4,902	100

W Withheld to avoid disclosing individual company confidential data; included with "Other inorganic compounds."
[1] Nonadditive total because some plants produce more than 1 product.
[2] Data do not add to total shown because of independent rounding.

strategic stockpile contained 2,955,692 pounds of crude iodine and the supplemental stockpile 5,056,147 pounds for a total of 8,011,839 pounds. The stockpile objective for iodine, established by the Office of Emergency Preparedness, is 8 million pounds. There were no deliveries of iodine to the Government stockpiles in 1969.

Depletion allowances for domestic iodine producers were changed under terms of the Tax Reform Act of 1969. Effective with taxable years beginning after October 9, 1969, the depletion allowance for iodine from both domestic and foreign production is 14 percent of gross income, not to exceed 50 percent of net income without the depletion deduction. The previous rate was 15 percent of gross income with the same restriction as to net income.

Domestic Production.—The Dow Chemical Co., the only domestic producer, recovered crude iodine from well brines at Midland, Mich., as a coproduct with bromine, calcium and magnesium compounds, and potash. Output increased in quantity and value over that of 1968.

Consumption and Uses.—Approximately 4.9 million pounds of crude iodine was consumed by 40 firms in 14 States. In 1968, nearly 4.5 million pounds of crude iodine was consumed by 38 firms. Leading iodine-consuming States in 1969, in descending order of magnitude, were Missouri, New York, New Jersey, and Pennsylvania. Collectively, these four States represented 83 percent of the total crude iodine consumption. Increases were reported in the amount of crude iodine consumed in producing resublimed iodine, potassium iodide, sodium iodide, and organic iodine-containing compounds. Major uses of iodine included photographic chemicals, household and industrial disinfectants, pharmaceutical preparations, and animal and fowl feeds. Lesser amounts of iodine were consumed in making high-purity metals, motor fuels, iodized salt, smog inhibitors, swimming pool sanitizers, lubricants, and catalysts in chemical processes.

Stocks.—Yearend stocks of crude iodine, held by consumers, were nearly 972,000 pounds valued at approximately $1.1 million, an increase of 32 percent in quantity and 39 percent in value over those of 1968.

Prices.—Early in 1969, quoted prices for several iodine compounds were increased following an increase of 6 cents per pound in the price of crude iodine late in 1968. Increases of an additional 6 cents per pound were announced late in 1969, by Chilean Nitrate Sales, Inc., and The Dow Chemical Co., and took effect on November 3, 1969 and on January 1, 1970, respectively. Several producers of iodine compounds also increased their prices. Quoted prices for iodine and iodine compounds at yearend were as follows:

	Per pound
Crude iodine, drums	$1.24-$1.30
Resublimed iodine, U.S.P., drums, f.o.b. works	2.20- 2.42
Calcium iodate, drums, delivered	1.45- 1.60
Calcium iodide, 25-pound jars, f.o.b. works	4.27
Potassium iodide, U.S.P., crystals, drums, 500 pounds or more, delivered	1.60
Potassium iodide, U.S.P., crystals, drums, smaller lots, delivered	1.62
Sodium iodide, U.S.P., 300-pound drums, freight equalized	2.19

Source: Oil, Paint and Drug Reporter.

Foreign Trade.—Crude iodine imported into the United States in 1969 decreased 3 percent in quantity, but increased 3 percent in value over that of 1968. The average value of imported crude iodine increased from $0.95 per pound in 1968 to $1.01 per pound, corresponding to the 6-cent-per-pound increase in quoted price for crude iodine. More than 5.7 million pounds of crude iodine was imported, 60 percent of which was from Japan and 40 percent from Chile. Imports of resublimed iodine were 10,720 pounds, of which Japan supplied 10,500 pounds and Sweden the remainder.

On January 1, 1969, tariff rates were lowered from 9 to 8 cents per pound on resublimed iodine and from 22 to 20 cents per pound on potassium iodide. These reductions were part of a program to reduce the tariffs on resublimed iodine and potassium iodide to 5 and 12 cents per pound, respectively, by January 1, 1972. Crude iodine enters the United States duty free.

World Review.—*Chile.*—Production of crude iodine in 1969 was 2,700 short tons (preliminary), compared with 2,120 tons in 1968. The increase was due to a greater output by the Chilean nitrate industry, which produces iodine as a byproduct.

Japan.—Japan continued to lead the world in production of crude iodine. Output in 1969 was 5,092 short tons, compared with 3,958 tons in 1968.[3] Most of the io-

[3] U.S. Embassy, Tokyo, Japan. State Department Airgram A-414, Apr. 14, 1970, p. 3.

Table 2.—U.S. imports for consumption of crude iodine, by countries

(Thousand pounds and thousand dollars)

Country	1967		1968		1969	
	Quantity	Value	Quantity	Value	Quantity	Value
Canada	30	$29	-----	-----	-----	-----
Chile	2,174	1,834	r 2,426	r $2,080	2,308	$2,215
Germany, West	-----	-----	r 3	1	-----	-----
Japan	1,255	1,314	3,454	r 3,513	3,397	3,538
Sweden	(1)	(1)	-----	-----	-----	-----
Total	3,459	3,177	r 5,883	5,594	5,705	5,753

r Revised.

1 Less than ½ unit.

dine was produced from well brines associated with natural gas production by six firms operating plants on the Chiba Peninsula east of Tokyo. About one-half of Japan's iodine output is exported, mainly to the United States.

Technology.—Research on seeding hurricanes with silver iodide in an attempt to lessen their destructive effects was continued by the Environmental Science Service Administration and the U.S. Navy.[4] In August, 1969, Hurricane Debbie was treated with silver iodide crystals with little, if any, effect upon that storm.

A process for the preliminary hydrogenation of coal tar in producing gasoline-refinery feedstock material using elemental iodine or hydrogen iodide as the catalyst was patented.[5]

LITHIUM

Domestic output of lithium minerals including lithium carbonate from brines declined, but value increased slightly over 1968, reflecting a higher average unit price. Imports for consumption of lithium ore were about one-eighth of the quantity imported in 1968.

Domestic Production.—Foote Mineral Co., the leading producer of regular and ceramic grade spodumene, mined and beneficiated by flotation the mineral at Kings Mountain, N.C. Lithium Corp. of America, a subsidiary of Gulf Resources and Chemical Corp., began operating a heavy media concentrating mill adjoining its open pit spodumene mine near Bessemer City, N.C., in February.[6] Small quantities of lepidolite and amblygonite were mined by Keystone Chemical Corp., Keystone, S. Dak. Lithium carbonate was recovered from brines by Foote Mineral Co. at Silver Peak, Nev., and by American Potash and Chemical Corp. at Trona, Calif.

Processors of lithium raw materials to lithium primary products were Foote Mineral Co., Sunbright, Va., and Silver Peak, Nev.; American Potash and Chemical Corp., Trona, Calif.; and Lithium Corp. of America, at Bessemer City, N.C. Production data were not available for publication.

Legislation and Government Programs.—Ad valorem tariffs of lithium metal were 20 percent and on lithium compounds 8 percent during 1969; lithium mineral concentrates are imported duty free. At yearend, 6,490 short tons of lithium hydroxide monohydrate were held by General Service Administration under the Federal Property Act; although a small quantity was offered for sale during 1969, none was sold.

Consumption and Uses.—Numerous chemicals with wide varieties of application were made from domestic spodumene flotation concentrate and lithium carbonate extracted from brines. Lithium is used primarily in compounds for greases, air conditioning, ceramics, metallurgy, welding and brazing, organic synthesis, swimming pool sanitation, and the production of hydrogen.

4 Oil, Paint and Drug Reporter. Silver Iodide Lining Planned for Hurricane Clouds. V. 196, No. 6, Aug. 11, 1969, p. 5.

5 Friedman, Louis and Ralph Eddinger (assigned to FMC Corp., New York). Hydrogenation of Coal Tar. U.S. Pat. 3,453,202, July 1, 1969.

6 Industrial Minerals (London). Spodumene Production Started by Lithcoa. No. 20, May 1969, p. 36.

Prices.—The Oil, Paint and Drug Reporter quoted prices for lithium metal and compounds at yearend as follows:

	Per pound
Lithium metals, 1,000-pound lots or more, delivered	$7.75
Lithium carbonate, carlots, truck loads, delivered, in drums	.46
Lithium chloride, anhydrous, carlots, truck loads, delivered, in drums	.85
Lithium fluoride, 2,000-10,000 pound lots, delivered	1.70
Lithium hydride, carlots, truck loads, delivered	7.50
Lithium hydroxide, monohydrate, carlots, truck loads, delivered, in drums	.55
Lithium nitrate, technical 100-pound lots, in drums	1.25-1.55
Lithium stearate, 50-pound cartons, carlots, works, freight allowed	.55
Lithium sulfate, 100-pound lots, in drums	1.20-1.30

Foreign Trade.—Quantitative data on U.S. exports of lithium minerals and lithium metal, alloys, and compounds were not available for 1969. U.S. imports of lithium minerals were 88 percent less than in 1968. The Republic of South Africa supplied almost all of the mineral imports. As a result of trade sanctions, there were no domestic imports from Southern Rhodesia, the only supplier of lithium minerals in 1968.

Imports of organic lithium salts, principally from Japan with minor quantities from Canada and West Germany, were 26,951 pounds valued at $12,195.

There was 57,898 pounds of lithium compounds valued at $140,993 imported primarily from France (88 percent) with small amounts from the Netherlands, West Germany, United Kingdom, and Switzerland.

Table 3.—U.S. imports for consumption of lithium ore, by country of origin and U.S. customs district

Country and customs district	1968		1969	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Canada: Pembina	------	----	200	$2
Rhodesia, Southern: Baltimore	11,016	$360	-----	--
South Africa, Republic of: Baltimore	377	22	1,188	64
Total	11,393	382	1,388	66

World Review.—*Canada.*—Tantalum Mining Corporation of Canada carried out pilot plant tests on low-iron spodumene concentrates from a pegmatite at Bernic Lake.[7] The deposit contains an estimated 5 million short tons of spodumene and 107,700 short tons of lepidolite.

[7] Canadian Mining Journal. Manitoba's "New" Metals. V. 90, No. 11, November 1969, pp. 47–51.

Table 4.—Free world production of lithium minerals, by countries

(Short tons)

Country	Mineral produced	1965	1966	1967	1968	1969p
Argentina	Lithium minerals	686	298	272	140	NA
Australia	do	347	1,112	747	827	794
Brazil [1]	do	7,540	110	r 6,800	------	NA
Canada	Spodumene (Li_2O content)	507	127	r 218	------	------
Mozambique	Lepidolite	83	NA	276	824	461
Rhodesia, Southern	Eucryptite	e 705	NA	NA	NA	NA
	Lepidolite	e 17,747	NA	NA	NA	NA
	Petalite	e 29,873	NA	NA	NA	NA
	Spodumene	e 15,322	NA	NA	NA	NA
South Africa, Republic of	Lithium minerals	958	337	------	40	e 44
South-West Africa	Amblygonite	39	30	NA	NA	NA
	Lepidolite	298	365	NA	NA	NA
	Petalite	1,332	1,344	NA	NA	NA
Uganda	Amblygonite	22	[1] 78	49	49	NA
United States	Lithium minerals	W	W	W	W	W

e Estimate. p Preliminary. r Revised. NA Not Available. W Withheld to avoid disclosing individual company confidential data.

[1] Exports.

Technology.—Three new magnesium-lithium alloys that have much greater tensile and yield strength for use at cryogenic temperatures were reported.[8] According to several articles in the Journal of the Electrochemical Society, research continues on the use of lithium in various ways in battery and fuel cell generation of electrical power.

During 1969, more than 24 patents were issued which involved lithium; these covered a wide range of applications including new compounds, processes in various industries, and other uses of lithium.

MEERSCHAUM

United States consumers of meerschaum (the mineral sepiolite) continued to rely on imports for their raw materials in 1969. Meerschaum imports for consumption totaled 21,365 pounds in 1969, a 78-percent increase from 1968. A much lower average unit price however, resulted in only 9-percent increase in value to $41,853. The Somali Republic replaced Turkey as the major supplier of the imports. Deposits near El Bur in the Mudugh region of the Somali Republic reportedly contained large reserves of meerschaum which have been under increased development in recent years.

The primary use of meerschaum continued to be in pipes and cigarette holders.

QUARTZ CRYSTAL

ELECTRONIC-GRADE

The consumption of raw quartz crystal, both natural and manufactured, declined 24 percent from that of 1968. The consumption of manufactured quartz increased slightly. The production of quartz crystal as finished and blank units decreased about 20 percent.

Table 5.—Salient electronic-and optical-grade quartz crystal statistics

	1967	1968	1969
Imports of electronic- and optical-grade quartz crystal thousand pounds	220	286	237
Value thousands	$498	$339	$278
Consumption of raw electronic-grade quartz crystal thousand pounds	332	247	188
Production, piezoelectric units, number thousands	23,340	24,586	19,562

Domestic Production.—No domestic production of natural electronic-grade quartz crystal was reported to the Bureau of Mines in 1969. At yearend, five companies reported production of manufactured quartz for use by the electronic industry. These companies were Sawyer Research Products, Inc., Eastlake, Ohio; Thermo Dynamics Corp., Shawnee Mission, Kans.; P. R. Hoffman Co., Carlisle, Pa.; Western Electric Co., Inc., North Andover, Mass.; and Quality Crystals, Inc., Cortland, Ohio. The major producers were Sawyer Research Products, Inc., and Thermo Dynamics Corp.; Sawyer reported sales of 58,000 pounds of manufactured quartz. Western Electric Co., Inc., continued to produce quartz for its own affiliated companies use.

Legislation and Government Programs.—There were no active Government programs for the acquisition of quartz crystal during 1969, and the General Services Administration was disposing of surplus stockpile material. At yearend, there were 4,711,370 pounds of stockpile-grade and 456,465 pounds of nonstockpile-grade quartz crystal in the Defense Materials Inventory.

Consumption and Uses.—Consumption of raw quartz crystal declined from 246,673 pounds in 1968 to 187,605 pounds in 1969. The consumption of manufactured quartz increased slightly from 83,945 pounds in 1968 to 84,261 pounds in 1969. About 16.9 million finished quartz crystal units and

[8] Light Metal Age. Magnesium-Lithium Alloys Developed for Low Temperature Use. V. 27, No. 1, 2, February 1969. p. 14.

2.6 million blank units were produced from raw quartz crystal consumed during the year.

The data reported in table 5 are based on reports received in 1969 from 28 crystal cutters in 12 States. Finished piezoelectric units were produced by 24 of the cutters; the others produced only semifinished blanks. Of these cutters, three cut natural quartz only, 12 cut synthetic only, and 13 cut both natural and synthetic.

Fourteen consumers in four States accounted for 80 percent of the total raw quartz consumption. Pennsylvania was the leading quartz-consuming State with 43 percent of the total, followed by Illinois, Kansas, and Missouri. Piezoelectric units were manufactured by 39 producers in 16 States. Fifteen of these producers worked from partially processed quartz crystal blanks and did not consume raw material. Fourteen plants in four States supplied nearly 75 percent of the total output of finished crystal units. Oscillator plates comprised 68 percent of production. The remainder included filter plates, telephone resonator plates, transducer crystals, and miscellaneous items.

Prices.—According to the Engineering and Mining Journal, December 1969, quartz crystal price for piezoelectric and optical use ranged from $2.50 to $50 per pound depending upon size and grade. Buyer and seller negotiate final selling price for specific quality quartz crystal.

Foreign Trade.—Both quantity and value of imported electronic- and optical-grade quartz crystal (valued at more than $0.50 per pound) declined in 1969. These imports totaled 237,224 pounds valued at $277,649 and averaged $1.17 per pound. Brazil continued to be the major world producer and supplied almost 95 percent of the U.S. imports; the remainder, 12,507 pounds, came from Argentina, West Germany, and the United Kingdom.

Imports of lasca totaled 1,053,779 pounds valued at $199,272. Although quantity increased 18 percent, value decreased 26 percent because of cheaper lasca imports from France, which suppled 56 percent of the total. Primary uses of lasca are in the manufacture of fused quartz and as nutrients for manufactured quartz crystal.

U.S. exports of both natural and manufactured raw quartz increased 19 percent from 172,352 pounds in 1968 to 204,986 pounds in 1969. Value increased 31 percent to $2,160,858. Hong Kong, the United Kingdom, Canada, and Japan received 71 percent of the material.

World Review.—*Guatemala.*—Minnesota Mining and Manufacturing Co. discovered quartz deposits with estimated reserves of 1 million tons.[9]

Technology.—An experimental program proved that, by changing only the crystallographic orientation of the seed upon which quartz is deposited, a higher and more uniform crystal Q factor can be obtained and fabrication of larger high-frequency plates can be economically practical.[10] Fiber optics technology utilizing fused quartz fibers clad with a lower index of refraction material has a potential use in fire and explosion detection systems.[11]

STAUROLITE

Staurolite, a complex silicate of iron and aluminum, was produced only in Florida in 1969. E. I. du Pont de Nemours & Co., Inc. (plants at Highland and Trail Ridge) recovered staurolite as a byproduct from ilmenite and rutile sands in Clay Country. Quantity and value of marketed production increased 20 and 23 percent, respectively, over 1968. The principal use of the mineral was as a sand blast abrasive. Certain portland cement mixes utilized staurolite as an ingredient, and some twinned crystals are of value as semiprecious stone.

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[9] The Mining Journal (London). Guatemalan Quartz Discovery. V. 273, No. 6985, July 4, 1969, p. 8.

[10] The Western Electric Engineer. Growth of Synthetic Quartz for Use in High Frequency Monolithic Crystal Filters. V. 13, No. 2, April 1969, pp. 23–27.

[11] American Ceramic Society. Fused Quartz Fiber Optics for Ultraviolet Transmission. V. 48, No. 2, February 1969, pp. 211–219.

STRONTIUM

Domestic Production.—For the tenth consecutive year no strontium minerals were produced in the United States. However, domestic deposits of celestite (strontium sulfate) were under evaluation by several companies. For the second straight year imports of strontium minerals more than doubled, reflecting the continuing strong rise in demand for strontium compounds. Firms that produced various compounds from imported celestite included E. I. du Pont de Nemours & Co., Inc., Grasselli, N.J.; Foote Mineral Co., Exton, Pa.; and FMC Corp., Modesto, Calif.

Table 6.—U.S. imports for consumption of strontium minerals,[1] by countries

Country	1968		1969	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Italy	17	$5	------	----
Mexico	3,879	51	21,402	$404
Spain	4,443	97	2,252	45
United Kingdom	4,557	137	4,149	146
Total	12,896	290	27,803	595

[1] Strontianite or mineral strontium carbonate and celestite or mineral strontium sulfate.

Legislation and Government Programs.—The Government sold 1,575 short tons of stockpile-grade and 10,958 short tons of nonstockpile-grade celestite during 1969. Government stockpiles contained 13,541 tons of stockpile-grade and 16,767 tons of nonstockpile-grade celestite at yearend.

Consumption and Uses.—The principal uses of strontium continue to be for pyrotechnics and signals, which utilize the brilliant crimson color that strontium imparts to a flame. In vacuum-tube manufacture, strontium metal and alloys of strontium were used as getters for the removal of gas. Miscellaneous chemical applications for strontium compounds included greases, ceramics, plastics, medicines, paint filler, welding rod coatings, and in making high-purity zinc. Quantitative information concerning consumption was not available.

Increased use of strontium carbonate in the manufacture of glass for color television tubes is expected because of its advantages of lighter weight and better radiation shield than the barium carbonate now used.[12] Also, strontium carbonate allows use of higher voltages for better picture brilliance and less distortion.

Prices.—At year end prices quoted in the Oil, Paint and Drug Reporter were as follows: Strontium carbonate—pure, drums, 5-ton lots or more, works, at 35 cents per pound, and technical, drums, works, at 13 to 21 cents per pound; strontium nitrate—bags, carlots, works, at $12 per 100 pounds. No price quotations were published for strontium sulfate. Final prices of strontium compounds are negotiated between buyer and seller. The average value of imported strontium minerals at foreign ports was about $21 per ton.

World Review.—Kaiser Aluminum and Chemical Corp. acquired large celestite ore reserves on Cape Breton Island, Nova Scotia, from Cape Chemical Corp. of Montreal.[13] Plans for development include a preconcentration plant at the mine site, and a processing plant 35 miles from the mining operation at Point Edward, which will produce approximately 30,000 tons of strontium compounds annually along with about 70,000 tons of byproducts.

Table 7.—Free world production of strontium minerals, by countries
(Short tons)

Country [1]	1967	1968	1969 [p]
Argentina	33	77	NA
Italy	728	858	[e] 860
Mexico	2,803	3,806	19,926
Pakistan	418	716	[e] 661
United Kingdom	[r] 7,481	[e] 8,818	[e] 8,818
Total [2]	[r] 11,463	14,275	30,265

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.
[1] Strontium minerals are produced in Germany, Poland, Spain, and the U.S.S.R., but data on production are not available.
[2] Total is of listed figures only.

[12] Oil, Paint and Drug Reporter. Strontium Carbonate Growing as More Color TV Sets Turn On. V. 195, No. 26, June 30, 1969, pp. 4, 27–28.
[13] World Mining. Nova Scotia. V. 5, No. 13, December 1969, p. 62.

WOLLASTONITE

Wollastonite sales increased 3 percent in quantity and in value over 1968. The principal domestic supply was from Essex County, N.Y., where paint- and ceramic-grade wollastonite was mined and processed. Smaller quantities of the mineral were produced from deposits in Riverside county, Calif.

Wollastonite, principally used in ceramics, was rapidly finding uses in other products. These new uses included fillers, reinforcing agents, fluxes, glazes, and bricks.[14] Other potential markets include insulation, fertilizer, paper, fiberglass, asbestos shingles, and linoleum.

During mid-1969, Interpace Corp. of Parsippany, N.J., a manufacturer of pipe, ceramic, and precast products, purchased the minerals division of Cabot Corp. Included in the acquisition was the wollastonite mine and milling plant in Essex County.

Nominal per-ton prices for wollastonite were reported in Oil, Paint and Drug Reporter, unchanged from October 1960 through December 1969, as follows: Fine, paint-grade, bags, carlots, ex warehouse $51; medium, paint-grade, bags, carlots, works $29; less than carlots ex warehouse $39. As is customary for most industrial minerals, actual sales were negotiated at prices agreed upon by buyer and seller without public disclosure.

World sources of wollastonite are few. Countries mining and marketing wollastonite during 1969 besides the United States included Mexico, Finland, and Kenya. Several deposits known in South Africa have been mined intermittently, but little value can be assigned these resources until production of a salable product and markets have been established.[15] Other smaller or lower purity deposits are known in France, Italy, and Switzerland. Discovery of large wollastonite deposits near Khila in the Indian State of Rajasthan in 1969 is believed to be the first find of the mineral in Asia.[16]

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[14] Industrial Minerals. Versatile Wollastonite. No. 19, April 1969, pp. 16–20.

[15] Industrial Minerals. Wollastonite Comes of Age. No. 19, April 1969, pp. 8–13.

[16] The Mining Journal (London). Indian Wollastonite Find. V. 273, No. 6991, Aug. 15, 1969, p. 138.