Minerals yearbook: Metals and minerals (except fuels) 1959. Year 1959, Volume I 1960

Bureau of Mines
Washington, D. C.: Bureau of Mines : United States Government Printing Office, 1960

MINERALS YEARBOOK

1959

Volume 1 of Three Volumes

METALS AND MINERALS

(Except Fuels)

U.S. DEPARTMENT OF THE INTERIOR
March 3, 1849

Prepared by the staff of the
BUREAU OF MINES
DIVISION OF MINERALS
Charles W. Merrill, Chief
Richard H. Mote, Assistant Chief
Donald R. Irving, Assistant to the Chief

UNITED STATES DEPARTMENT OF THE INTERIOR

FRED A. SEATON, Secretary

BUREAU OF MINES

MARLING J. ANKENY, Director

OFFICE OF THE DIRECTOR:

THOMAS H. MILLER, *Deputy Director*
PAUL ZINNER, *Assistant Director—Programs*
JAMES WESTFIELD, *Assistant Director—Health and Safety*
HENRY P. WHEELER, *Assistant Director—Helium*
PAUL T. ALLSMAN, *Chief Mining Engineer*
EARL T. HAYES, *Chief Metallurgist*
CARL C. ANDERSON, *Chief Petroleum Engineer*
LOUIS L. NEWMAN, *Chief Coal Technologist*
JOHN E. CRAWFORD, *Chief Nuclear Engineer*
WILLIAM A. VOGELY, *Chief Economist*
REXFORD C. PARMELEE, *Chief Statistician*
ALLAN SHERMAN, *Chief, Office of Mineral Reports*

DIVISIONS:

CHARLES W. MERRILL, *Chief, Division of Minerals*
T. REED SCOLLON, *Chief, Division of Bituminous Coal*
JOSEPH A. CORGAN, *Chief, Division of Anthracite*
R. A. CATTELL, *Chief, Division of Petroleum*
ELMER W. PEHRSON, *Chief, Division of Foreign Activities*
W. E. RICE, *Chief, Division of Administration*

REGIONAL OFFICES:

MARK L. WRIGHT, *Regional Director, Region I, Albany, Oreg.*
R. B. MAURER, *Regional Director, Region II, San Francisco, Calif.*
R. W. GEEHAN, *Regional Director, Region III, Denver, Colo.*
ROBERT S. SANFORD, *Acting Regional Director, Region IV, Bartlesville, Okla.*
EARLE P. SHOUB, *Regional Director, Region V, Pittsburgh, Pa.*

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1960

**For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington 25, D.C. - Price $4.50 (cloth)**

FOREWORD

THE THREE-VOLUME Minerals Yearbook for 1959 is being issued in this, the 50th anniversary year of the Bureau of Mines. Although the Bureau of Mines was established in 1910, the Minerals Yearbook is much older, having appeared originally in 1867 as "Reports Upon the Mineral Resources of the United States" under the seal of the Department of the Treasury. Over the years, the series has appeared variously as "Mineral Resources West of the Rocky Mountains," as part of the "Annual Report of the Geological Survey," and as "Mineral Resources of the United States." Under the last-named title, the series first appeared under Bureau of Mines authorship. That was in 1927, and the statistical coverage was for the year 1924.

In 1933, the publication assumed its new and present title of "Minerals Yearbook." Beginning with the 1952 edition, the presentation became a three-volume issue to meet the expanded and specialized needs of the mineral industries and others.

The three-volume issues of the Yearbook follow this pattern:

Volume I includes chapters on metal and nonmetal mineral commodities except mineral fuels. In addition, it includes a chapter reviewing these mineral industries, a statistical summary, chapters on mining and metallurgical technology and employment and injuries, and a new chapter on technologic trends.

Volume II includes chapters on each mineral fuel, an employment and injuries presentation, and a mineral-fuels review chapter that summarizes developments in the fuel industries.

Volume III contains chapters covering each of the 50 States, plus chapters on island possessions in the Pacific Ocean and the Commonwealth of Puerto Rico and island possessions in the Caribbean Sea, including the Canal Zone. Volume III also has a statistical summary chapter, identical with that in Volume I, and a chapter on employment and injuries.

The data in the Minerals Yearbook are based largely upon information supplied by mineral producers, processors, and users, and acknowledgment is made of this indispensable cooperation given by industry. Information obtained from individuals through confidential surveys has been grouped to provide statistical aggregates. Data on individual producers are presented only if available from published or other nonconfidential sources, or when permission of the individuals concerned has been granted.

MARLING J. ANKENY,
Director.

ACKNOWLEDGMENTS

The Bureau of Mines has been assisted in collecting mine-production data and the supporting information appearing in this volume of the MINERALS YEARBOOK by the following cooperating organizations:

Alabama: Geological Survey of Alabama.
Alaska: Department of Mines.
Arkansas: Arkansas Oil and Gas Commission.
California: Division of Mines.
Delaware: Delaware Geological Survey.
Florida: Florida Geological Survey.
Georgia: Geological Survey of Georgia.
Idaho: Bureau of Mines and Geology.
Illinois: State Geological Survey.
Indiana: Indiana Department of Conservation.
Iowa: Iowa Geological Survey.
Kansas: Conservation Division, State Corporation Commission, State Geological Survey, University of Kansas.
Kentucky: Kentucky Geological Survey.
Louisiana: Louisiana Department of Conservation.
Maine: Geological Survey of Maine.
Maryland: Department of Geology, Mines, and Water Resources.
Michigan: Michigan Department of Conservation.
Mississippi: Mississippi State Oil and Gas Board; Oil and Gas Severance Tax Division, Mississippi State Tax Commission.
Missouri: Geological Survey and Water Resources.
Montana: Montana Bureau of Mines and Geology.
Nevada: Nevada Bureau of Mines.
New Hampshire: New Hampshire State Planning and Development Commission.
New Jersey: Bureau of Geology and Topography.
New York: New York State Science Service.
North Carolina: Geological Survey of North Carolina.
North Dakota: North Dakota Geological Survey.
Oklahoma: Oil and Gas Conservation Department, Oklahoma Corporation Commission; Gross Production Tax Department, Oklahoma Tax Commission.
Oregon: State Department of Geology and Mineral Industries.
Pennsylvania: Bureau of Topographic and Geological Survey.
Puerto Rico: Mineralogy and Geology Section, Economic Development Administration, Commonwealth of Puerto Rico.
South Carolina: Geological Survey of South Carolina.
South Dakota: State Geological Survey.
Tennessee: Tennessee Department of Conservation.
Texas: Oil and Gas Division, Railroad Commission of Texas; Oil and Gas Division, State Comptroller of Public Accounts.
Utah: Utah Geological and Mineralogical Survey.
Virginia: Division of Mineral Resources.
Washington: Division of Mines and Geology.
West Virginia: West Virginia Geological and Economic Survey.
Wisconsin: Wisconsin Geological Survey.
Wyoming: Geological Survey of Wyoming.

Except for the four review chapters, this volume was prepared by the staff of the Division of Minerals. The following persons supervised preparation of the various chapters: Thomas E. Howard, chief, Branch of Mining Research; Henry G. Iverson, chief, Branch of Metallurgy Research; Charles T. Baroch, chief, Branch of Nonmetallic Minerals; Frank J. Cservenyak, chief, Branch of Ferrous Metals; and Paul F. Yopes, chief, Branch of Nonferrous Metals. Preparation of this volume was supervised and the chapters were coordinated with those in volume III by Donald R. Irving, assistant to the chief, Division of Minerals.

The manuscripts upon which this volume is based have been reviewed to insure statistical consistency between the tables, figures, and text, between this volume and volume III and between this volume and those for former years, by a staff supervised by Kathleen J. D'Amico, who was assisted by Julia Muscal, Hope R. Anderson, Helen L. Gealy, Helen E. Tice, Anita C. Going, Dorothy Allen, and Joseph Spann.

Minerals Yearbook compilations are based largely on data provided by the mineral industries. Acknowledgment is made of the willing contribution both by companies and individuals of these essential data.

CHARLES W. MERRILL,
Chief, Division of Minerals.

CONTENTS

Review of the Mineral Industries[1]

(Metals and Nonmetals Except Fuels)

By William A. Vogely[2]

❖

Contents

STRIKES in the steel and copper industries adversely affected production in the minerals industry in 1959. Because of an excellent first half of the year and rapid recovery of production after the steel settlement, most statistical indicators were higher than the recession-recovery year 1958.

Domestic production of metals declined by 9 percent, but nonmetals (except fuels) increased by 8 percent. Ferrous-metal mine production was down 8 percent, and base-metal mine production was off 11 percent. Employment was high during the first half of the year, but averaged lower than in 1958. Stocks continued to decline as a whole, but crude metal ore stocks actually increased. The indexes of stocks at yearend were still high as compared with 1955. Prices were firm throughout the year. A new index of average unit mine value is presented for the first time in this review; it showed a very slight decline in average mine realization for 1959. The percentage share of supply from imports increased in some commodities, due in large part to the shutdown of domestic iron, steel, and copper industries.

Activity under the Defense Mobilization Program was at low level. The Tariff Commission rejected applications by the fluorspar, tungsten, and cobalt industries for relief under the national security clause.

World mineral markets followed closely those in the United States. Ocean freight rates rose during the last half of 1959.

---

[1] Some fuels are covered in this chapter but only where specifically indicated and in general where mining-industry data were not available for both nonfuels and fuels components.

[2] Assistant chief economist.

DEFENSE MOBILIZATION

Prepared by Gabrielle Sewall[3]

Defense Production Act.[4]—Of the $2.1 billion authorized borrowing authority under the Defense Production Act (DPA) all had been allocated to the delegate agencies at the end of 1959 except $316,000, which remained available for new programs ($724,000 available at the end of 1958). The volume of deliveries under existing contracts necessitated cash payments exceeding the $2.1 billion. Accordingly, Congress appropriated an additional $108 million to meet the estimated cash requirements through 1960 and at the end of 1959 the authorized borrowing authority stood at $2,208 million. Gross transactions certified for all programs, $8.3 billion, were 1 percent lower than at the end of 1958; gross transactions contracted (or consummated) were reduced during the year by less than 0.05 percent from the $8.0 billion of the previous year; $6.5 billion of the amount was completed, canceled, or terminated. For the metals and minerals programs, $4.1 billion was contracted for, an increase of 18 percent over the year before. Deliveries to the Government were $2.6 billion ($2.5 billion in 1958). The remaining $1.5 billion ($1.4 billion for 1958) represented obligations that the Government was not required to accept, due largely to sales of contractors to purchasers other than the Government, nonexercise of some contractors' "put" options, and cancellation or reduction of some contracts. The probable ultimate net cost of the metals and minerals program covering purchases, loans, and grants as of the end of 1959 was $804 million, a 6-percent decrease from 1958, accounted for mostly by reductions in the copper and aluminum programs.

National Strategic Stockpile Program.[5]—Deliveries to the strategic stockpile during 1959 were about $38 million, of which about $29 million exceeded stockpile objectives. Commitments for deliveries of nearly $17 million of strategic materials were canceled during the year. New procurement was limited to amosite asbestos, small diamond dies, and jewel bearings. On October 29, chrysotile asbestos was substituted for amosite. The latter was transferred to the list for acquisition through barter for delivery to the supplemental stockpile inventory. Early in the year, when mica requirements decreased, active procurement of foreign mica was curtailed.

Supply-requirements studies for interim objectives by the Office of Civil and Defense Mobilization (OCDM) resulted in several changes in the status of stockpile commodities. Ruby, sapphire, and corundum were transferred from Group II to Group I (those for which there are official objectives) and objectives established for them. Kyanite-mullite was returned to the List of Strategic and Critical Materials for Stockpiling after an absence of 5 years. Mineral commodities removed from the list were abrasive-grade bauxite, natural cryolite (not stockpiled since World War II), diamond dies (other

---

[3] General economist.

[4] Executive Office of the President, Office of Civil and Defense Mobilization, Report on Borrowing Authority: Dec. 31, 1958, pp. 11–15, and 1959, pp. 10–15.

[5] Executive Office of the President, Office of Defense Mobilization, Stockpile Report to the Congress, January–June, 1959, pp. iii–11 and July–December, 1959, pp. iv–14.

TABLE 1.—Summary of Government inventories of raw materials, at acquisition cost and at market value, December 31 [1]

(Million dollars)

Type of acquisition	Inventory, December 31, 1958			Inventory, December 31, 1959		
	Total		Excess over stockpile objective	Total		Excess over stockpile objective
	Acquisition cost [2]	Market value [3]	Acquisition cost	Acquisition cost [2]	Market value	Acquisition cost
National stockpile (Public Law 520):						
Stockpile grade	5,947	5,777	2,218	5,897	6,127	1,925
Nonstockpile materials	244	--------	244	313	151	313
Total	6,191	--------	2,462	6,210	6,278	2,238
DPA inventory (Public Law 744):						
Stockpile grade	861	632	750	951	756	826
Nonstockpile materials	412	--------	412	459	132	459
Total	1,273	--------	1,162	1,410	888	1,285
Supplemental stockpile (Public Law 480):						
Stockpile grade	320	327	303	618	609	462
Nonstockpile materials	17	--------	17	27	18	27
Total	337	--------	320	645	627	489
Department of the Interior (Public Law 733):						
Stockpile grade	22	13	22	(4)	(4)	(4)
Nonstockpile materials	4	--------	4	(4)	(4)	(4)
Total	26	--------	26	(4)	(4)	(4)
Commodity Credit Corporation inventory (Public Law 608):						
Stockpile grade	243	245	230	125	131	63
Nonstockpile materials	2	--------	2	10	4	10
Total	245	--------	232	135	135	73
Federal Facilities Corporation (Public Law 608): Stockpile grade tin	10	9	10	10	9	10
Subtotals:						
Stockpile grade	7,403	7,003	3,533	7,601	7,632	3,286
Nonstockpile materials	679	--------	679	809	304	809
Total	8,082	7,003	4,212	8,410	7,937	4,095

[1] GSA Summary of Raw Materials inventories, December 31, 1958, and December 31, 1959, DM-76-OC, Pt. A.

[2] Acquisition cost of inventories includes open-market purchases at contract prices, intradepartmental transfers at market prices prevailing at time of transfer, transportation to first permanent storage location, beneficiating and processing costs, but does not cover cost of research, administrative and interest expenses, accessorial cost, storage and handling.

[3] Because of mixed nature of individual commodities (types, quality, and grades) and lack of active trading in these materials, the market value of commodities not meeting stockpile specification and of inventory not having stockpile objectives was not calculated.

[4] Transferred to supplemental stockpile after termination of Public Law 733.

than small), ground steatite talc, and titanium sponge (none in the strategic stockpile).

During the year 16 basic objectives were increased, and 20 decreased; 17 maximum objectives were increased, and 18 decreased. Other revisions involved upgrading Government-owned materials to include advanced forms for use in emergency, such as oxygen-free copper, tungsten carbide powder, molybdic oxide, ferromolybdenum, and ferrovanadium. For the 75 materials on the strategic stockpile list as of December 31, 1959, inventories of 54 met or exceeded maximum objectives, and another 10 inventories at least met basic objectives. Quantities of materials in other Government-owned inventories, if transferred to the strategic stockpile, would have increased to 62 the number of maximum objectives and to 70 the number of basic objectives met by total Government inventories.

TABLE 2.—National stockpile objectives and inventory[1]

(Value in million dollars at market prices)

Objectives	Objectives		Inventory	
	In effect Dec. 31		On hand Dec. 31	
	1958	1959	1958	1959
Basic	2,900	2,400	2,800	2,300
Maximum	1,600	2,300	900	2,000
Total objectives	4,500	4,700	3,700	4,300
Excess over objectives			2,000	1,800
Outstanding commitments			67	15

[1] Executive Office of the President, OCDM, Stockpile Report to the Congress, July–December 1958 and July–December 1959.

Surplus Disposal.[6]—As a result of the downward revisions of the stockpile brought about by Defense Mobilization Order (DMO) V–7, issued June 30, 1958, many commodities proved to exceed objectives, and the stockpile situation changed from one of mainly acquisition to one of disposal of excess materials. OCDM was responsible for approving plans for disposing of surplus materials after consultation with other interested agencies. The proposed plans for sale were worked out by the General Services Administration (GSA) in accordance with the provisions contained in the Strategic and Critical Materials Stock Piling Act (Public Law 520), the Defense Production Act (DPA), and the disposal policies set forth in Defense Mobilization Orders DMO V–3 and DMO V–7. In general these provisions were intended to protect producers, processors, and consumers against disruption of usual markets, and when the quantity was substantial a public announcement well in advance of sale was required. Sales from the strategic stockpile required Congressional approval unless the materials were either obsolete or subject to deterioration.

On September 9, 1959, Congress approved the disposal of diamond gems, platinum-group metals, and zircon. Materials not requiring Congressional approval were prepared for release: alumina, aluminum, cadmium-magnesium scrap, chromite, synthetic cryolite, kyanite-mullite (subspecification grade), quartz crystal, rare earths and thorium fractions, alloy tin, titanium, zinc oxide, and zirconium ore. In April approximately 136,000 tons of surplus copper from the DPA inventories was proposed for sale at the rate of 5,000 tons per month. Opposition came from copper producers, and the Senate passed Resolution 101, restraining sale until some later date.

---

[6] Joint Committee on Defense Production Activities, 9th Ann. Rept., House Rept. 1193, 86th Cong., 2d sess., Jan. 13, 1960, pp. 48–49; work cited in footnote 5, July–December 1959, p. 1.

On December 10, 1959, a revised edition of DMO V-7 was issued, which canceled DMO V-3, and elaborated on the 3-year emergency period by stating that "Until such time as the essential needs of the nation in the event of a nuclear attack (including reconstruction) can be determined, the maximum objective shall not be less than 6-months' usage by industry in the United States in periods of active demand." For many materials the strategic-stockpile inventories alone were adequate to meet the maximum objectives in effect at the end of 1959.

Change in the DMO provided that settlements for cancellation or reduction of commitments could (1) include payment of the premium portion of premium-price contracts; (2) be made by payment-in-kind, a means of reducing the cash outlay as well as the quantities on hand in the Government inventory; and (3) also be made by converting cash contracts involving excess materials to barter contracts with surplus agricultural commodities. Excess materials were to be used by Government agencies. The new order included interagency concurrence in disposals and certain administrative controls for disposal of DPA inventories not otherwise subject to restriction.

TABLE 3.—Commodities delivered under U.S. Government purchase regulations[1]

Commodity	Quantity delivered as of December 31		Total authorized purchases
	1958	1959	
Public Law 206, 83d Congress:			
Beryl ore short tons	2,144	2,487	4,500
Manganese ore, domestic small producers, carload program thousand long ton units	22,134	28,070	28,000
Mica: Block, film, and hand-cobbed (hand-cobbed equivalent) short tons	16,172	19,479	25,000
Defense Production Act: Mercury (76-pound flasks, prime virgin):			
Domestic	24,320	26,891	155,000
Mexican	2,153	3,274	95,000
Public Law 733, 84th Congress: Fluorspar, acid grade short tons	139,886	156,603	175,815

[1] GSA Report of Purchases under Purchase Regulations, as of December 31, 1958, and December 31, 1959. Only commodities listed for which purchases were made during 1959.

Tax Amortization Program.[7]—All goals in the metals and minerals expansion program continued closed at the beginning of 1959, including the goal for uranium, on which action had been suspended by AEC. In March OCDM Regulation 1-B was issued to announce that primary uranium-processing facilities were eligible for certification. During the year four certificates of necessity, totaling $9 million, were certified.

Except for some aluminum and iron ore projects, all metals and mineral facilities that had been expanded through the 5-year tax writeoff program were completely installed by the end of 1959, including those for uranium begun before 1959. Value reported in place was 96 percent of the total goal certified for aluminum and 88 percent for iron ore.

---

[7] Unpublished records of Defense Materials Service, GSA, Bureau of the Census, U.S. Department of Commerce.

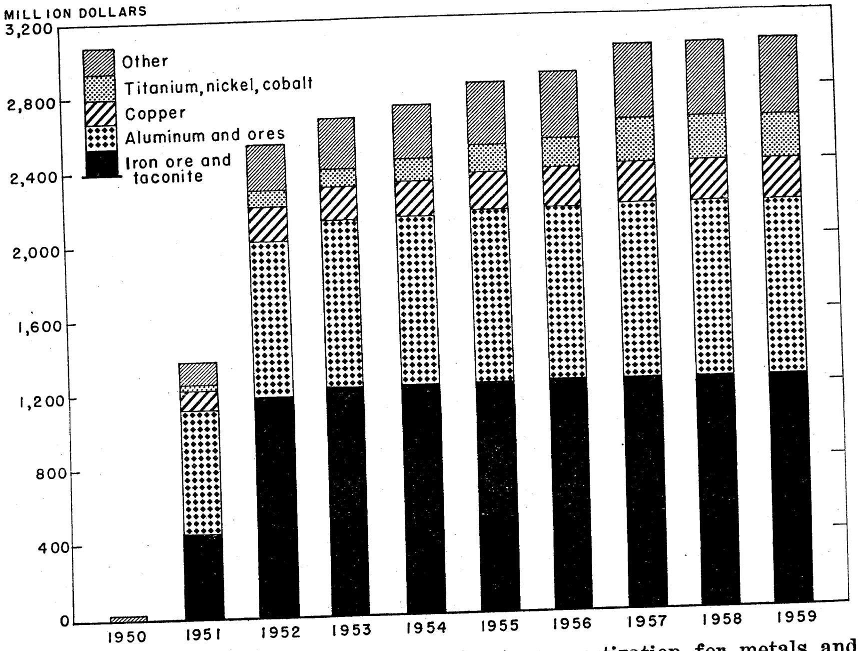

FIGURE 1.—Cumulated amount certified for tax amortization for metals and minerals, 1950–59, by commodities.

Office of Minerals Exploration (OME).[8]—Exploration for new sources of strategic and critical materials continued to be encouraged by Government assistance under the program set in motion early in the year, although the program under DPA was closing out. Of 69 applications received by OME under the new program for matching Government funds by the end of the year, 13 contracts were executed for copper, lead, zinc, mercury, fluorspar, and mica projects in 9 States.

By the end of the year only 33 contracts executed under the Defense Minerals Exploration Administration remained in force, compared with 106 in force a year earlier. Of the 1,159 contracts executed by DMEA, discoveries or developments were certified on 386 by the end of 1959. The 36 projects certified in 1959 covered antimony, asbestos, cobalt, columbium, manganese, rutile, tantalum, tin, tungsten, and uranium in 17 States. With respect to 381 projects certified and terminated, the total contract value was $26.1 million; the Government contractual share was $16.2 million of which $13.2 million, was spent. Comparable amounts for the 340 at the end of 1958 were: Contract value, $22 million; Government share, $13.9 million; Government expenditure, $11.4 million. The potential ore reserves of all 386 certified projects were estimated to have a net recoverable value of $800 million at prevailing market prices.

Barter Program.[9]—The list of minerals eligible at the beginning of

---

[8] OME, monthly reports.
[9] Work cited in footnote 6 pp. 45–48; U.S. Department of Agriculture reports on barter contracts.

the year for barter on an equivalent basis with CCC-owned (Commodity Credit Corporation) surplus agricultural commodities (primarily wheat and corn) was reduced, as quotas were reached, from 39 mineral products to 24 by May and further reduced to 16 by September. At the same time, other changes in the program were announced by the U.S. Department of Agriculture. The commodity-country destinations were increased to include 105 destination areas as barter outlets for the surplus agricultural commodities, instead of the 85 on the list in November 1958. These modifications were made to direct barter efforts increasingly toward countries less able to pay cash and toward those that had not been major markets historically for agricultural commodities.

By December there were 14 minerals considered eligible for barter, a list that at any one time was dependent on such factors as U.S. national interest, requirements, existing commitments, and market conditions: antimony, refractory bauxite, beryl, bismuth, refractory chromite, columbite, metallurgical fluorspar, metallurgical manganese, mica (muscovite block, film, and splittings), nickel, tantalite, and tin. As of December 31, 1959, strategic materials acquired through barter and held in CCC inventory pending transfer to the stockpiles were valued at $103.4 million.

TABLE 4.—Barter operations by the Commodity Credit Corporation [1] [2]

(Million dollars)

Period	Materials delivered			Contracts negotiated			Exports
	Strategic	Nonstrategic	Total	Strategic	Nonstrategic	Total	
July 1, 1949–December 31, 1957	637.6	72.7	710.3	849.2	134.2	983.4	898.8
1958	159.6	32.3	191.9	95.5	----------	95.5	65.0
1959:							
First quarter	23.5	9.7	33.2	59.6	----------	59.6	33.5
Second quarter	54.9	7.4	62.3	60.0	2.5	62.5	58.1
Third quarter	42.3	7.9	50.2	34.4	----------	34.4	53.2
Fourth quarter	49.6	2.8	52.4	35.2	----------	35.2	31.7
Total	170.3	27.8	198.1	189.2	2.5	191.7	176.5
July 1, 1949–December 31, 1959	967.5	132.8	1,100.3	1,133.9	136.7	1,270.6	[3] 1,140.3

[1] U.S. Department of Agriculture reports on barter operations.

[2] All quantities and exchange values based on operating records are subject to adjustment upon final accounting.

[3] July 1, 1954–December 31, 1959, from inception of Public Law 480.

Research and Development.[10]—In compliance with a request of OCDM for reports from interested Federal agencies on developments that might have a bearing on the demand-supply situation for high-temperature and other special-property materials, reports were received during the year from four agencies—Business and Defense Services Administration, Department of Defense, Department of the Interior, and Materials Advisory Board of the National Academy of Sciences. In February, the National Academy of Sciences also appointed a special committee on scope and conduct of materials research, to review the total materials research needs of the country, to ascertain the adequacy of present research programs to meet the needs, to appraise

---

[10] Work cited in footnote 6, pp. 18–28.

the available manpower resources and facilities, and to make recommendations for overcoming deficiencies. Committee report and recommendations were submitted in the fall of 1959.

DOMESTIC PRODUCTION

Value of Mineral Production.—The production value of metals, nonmetals, and mineral fuels was 4 percent higher than in 1958. This increase was registered despite a decline in metals resulting from the long steel and copper strikes, which also reduced the market for fuels, especially coal. Virtually all the changes in total value resulted from physical volume changes, as unit prices were steady compared with 1958.

TABLE 5.—Value of mineral production in United States by mineral group [1]

(Millions)

Mineral groups	1950–54 (average)	1955	1956	1957	1958	1959	Change in 1959 from 1958 (percent)
Metals and nonmetals except fuels:							
Nonmetals	$2,209	$2,957	$3,266	$3,267	$3,346	$3,720	+11
Metals	1,594	2,055	2,358	2,137	1,593	1,570	−1
Total	3,803	5,012	5,624	5,404	4,939	5,290	+7
Mineral fuels	9,652	10,780	11,741	12,709	11,589	11,794	+2
Grand total	13,455	15,792	17,365	18,113	16,528	17,084	+3

[1] Beginning with 1953 Alaska and Hawaii are included.

Volume of Mineral Production.—The Bureau of Mines index of physical volume of mineral production increased almost four points in 1959, a 3-percent rise. The index was at the same point achieved in 1955 after the 1954 low, but still well below the record of 1957. Rise in the index was caused entirely by nonmetals and fuels, as metal production declined 9 percent, compared with 8 and 3 percent increases in nonmetals and fuels, respectively. The Federal Reserve Board (FRB) indexes showed a similar rise overall. These indexes (table 7) have been completely revised and rebased on 1957. Revision of the FRB index resulted in generally higher increases since 1947–49 than had been indicated by the earlier version. Weight differences between this index and that of the Bureau of Mines, as well as some differences in coverage, can result in differential movements between the indexes, but the newly revised FRB index follows that of the Bureau more closely than did the earlier version.

The major advantage of the Bureau's index is that it is available on a comparable basis since 1880. However, FRB indexes are available monthly and on a seasonally adjusted basis. The monthly indexes clearly reflect the work stoppages beginning at midyear in the metal mining industry and indicate that nonmetals enjoyed increasing production throughout most of the year, continuing recovery from the 1957–58 recession.

TABLE 6.—Indexes of the physical volume of mineral production in the United States, by groups and subgroups [1]

(1947–49=100)

Year	All minerals	Metals						Nonmetals				Fuels
		Total	Ferrous	Nonferrous				Total	Construction	Chemical	Other	
				Total	Base	Monetary	Other					
1950	102.6	108.8	106.1	110.7	109.0	117.4	113.9	116.1	117.9	112.9	110.0	100.1
1951	112.6	117.2	126.6	110.6	110.0	100.8	149.7	127.3	128.3	123.9	130.0	110.1
1952	110.9	112.7	109.5	114.9	109.4	97.4	251.8	132.1	134.6	127.7	124.2	107.8
1953	112.6	119.1	133.3	109.2	103.0	98.3	236.7	135.2	137.5	133.6	118.5	108.8
1954	107.9	97.6	95.5	99.0	93.2	93.6	205.2	146.4	152.4	140.9	107.8	104.0
1955	119.0	115.0	122.8	109.5	106.8	95.3	194.0	161.0	170.1	146.2	127.5	113.8
1956	125.8	117.1	116.6	117.4	116.1	94.9	206.8	[2] 172.6	[2] 179.9	163.5	135.8	120.5
1957	126.1	118.8	122.2	116.4	113.7	93.0	229.9	175.7	189.3	153.5	124.4	120.3
1958	115.5	90.8	79.3	99.0	98.2	87.9	144.7	176.2	195.7	142.7	111.7	110.2
1959 [3]	119.2	82.2	72.8	88.9	87.0	80.7	142.6	190.7	211.5	153.7	125.5	114.0

[1] For description of index see Minerals Yearbook 1956, vol. I, Review of the Mineral Industries, pp. 2–5.
[2] Revised figure.
[3] Preliminary figures.

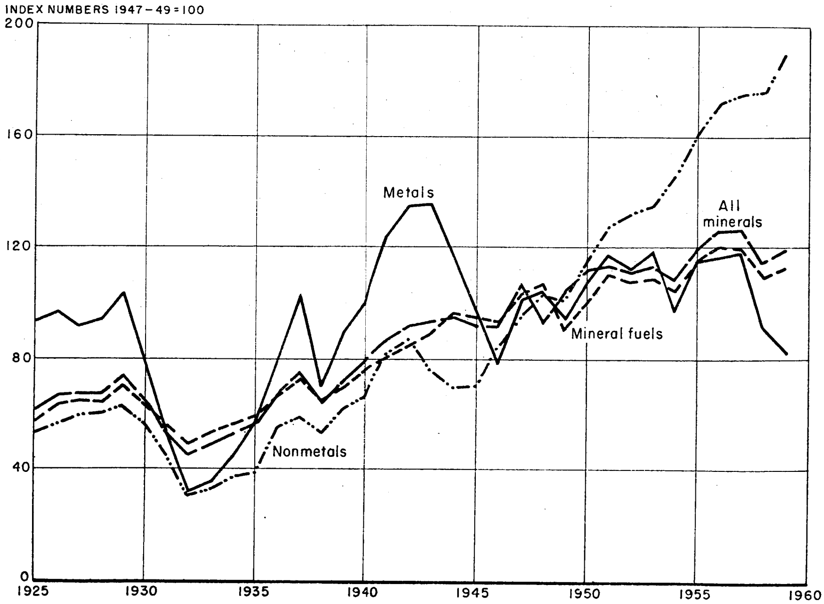

FIGURE 2.—Indexes of physical volume of mineral production in the United States, 1925–59, by groups.

TABLE 7.—Indexes of production of metal and mineral mining, metals, nonmetallic products, and total industrial production[1]

(1957=100)

Year	Metal, stone, and earth minerals	Iron and steel	Primary metals	Clay, glass and stone products	Total industrial production
1952	76	88	88	86	84
1953	82	102	100	88	91
1954	79	80	81	85	85
1955	91	106	106	97	96
1956	98	103	104	102	99
1957	100	100	100	100	100
1958	91	75	78	95	93
1959	94	86	89	110	105

[1] Federal Reserve Bulletin, February and May 1960, and Selected Advance Work Tables of Revised Monthly Industrial Production Indexes for Industry Groupings, 1957=100, April 1960.

TABLE 8.—Monthly indexes of production, metal mining, and stone and earth minerals, seasonally adjusted[1]

(1957=100)

Month	Metal mining			Stone and earth minerals		
	1958	1959	Change from 1958 (percent)	1958	1959	Change from 1958 (percent)
January	98	102	+4.1	97	101	+4.1
February	94	101	+7.4	89	101	+13.5
March	91	101	+11.0	91	103	+13.2
April	78	99	+26.9	93	109	+17.2
May	69	102	+47.8	96	109	+13.5
June	74	94	+27.0	98	109	+11.2
July	75	73	−2.7	101	111	+9.9
August	76	48	−36.8	100	111	+11.0
September	81	39	−51.9	104	109	+4.8
October	85	42	−50.6	104	108	+3.8
November	90	68	−24.4	105	110	+4.8
December	93	80	−14.0	101	113	+11.9
Annual average	84	79	−6.0	98	108	+10.2

[1] Federal Reserve Bulletin, February and May 1960; and Selected Advance Work Tables of Revised Monthly Industrial Production Indexes for Industry Groupings, 1957=100, April 1960.

NET SUPPLY

Net Supply.—The net supply[11] of minerals and metals generally increased in 1959. Even though the domestic iron mines were shut down during much of the productive season, the net supply was larger than during the 1958 recession. Recovery from that recession is evident in most of the principal commodities shown in table 9. The declines that occurred can be explained by the special circumstances of the steel strike and the lead-zinc import-quota program. The net-supply analysis clearly indicates that the recovery begun in 1958 carried strongly through 1959, in spite of the widespread labor-management difficulties.

---

[11] Sum of primary shipments, secondary production, and imports, minus exports.

TABLE 9.—Net supply of principal minerals in the United States and components of gross supply [1]

(Thousand short tons unless otherwise stated)

Commodity	Net supply			Components as a percent of gross supply (gross supply=100)						Exports as a percent of gross supply	
				Primary shipments [2]		Secondary production [3]		Imports [4]			
	1958	1959	Change from 1958 (percent)	1958	1959	1958	1959	1958	1959	1958	1959
Ferrous ores, scrap, and metals:											
Iron (equivalent) [5]	[6] 84,526	92,977	+10	[6] 48	40	[6][7] 29	[7] 33	23	27	3	2
Manganese (content)	1,329	1,272	−4	14	11	----	----	[8] 86	[8] 89	(9)	1
Chromite (Cr_2O_3 content)	602	674	+12	10	6	----	----	90	94	(9)	4
Cobalt (content) thousand pounds	[6] 20,336	24,418	+20	[6] 24	12	[10] 2	[10] 1	[6] 74	87	----	----
Molybdenum (content) do	30,284	32,656	+8	100	100	----	----	(9)	(9)	29	37
Nickel (content)	108	131	+21	[6] 14	11	4	4	82	85	(9)	----
Tungsten ore and concentrate (W content) short tons	5,135	4,810	−6	34	36	----	----	[8] 66	[8] 64	2	1
Other metallic ores, scrap, and metals:											
Copper (content)	[6] 1,483	1,718	+16	52	44	22	25	[8] 26	[8] 31	21	9
Lead (content)	[6] 1,237	1,107	−11	[6] 22	23	[6][11] 32	[11] 41	[6][8] 46	[8] 36	(9)	(9)
Zinc (recoverable content)	[6] 1,067	1,066	(9)	[6] 39	39	6	7	[8] 55	[8] 54	(6 9)	1
Aluminum (equivalent) [12]	[6] 2,353	2,505	+6	[13] 12	[13] 14	3	3	[14] 85	[14] 83	[14] 3	[14] 6
Tin (content) long tons	59,252	66,827	+13	----	(9)	23	20	77	80	2	1
Antimony (recoverable content) [15] short tons	[6] 36,591	40,237	+10	[6] 5	3	[6][11] 53	[11] 50	[6][8] 42	[8] 47	(9)	(9)
Beryl ore (BeO content) do	5,062	8,366	+65	9	4	----	----	91	96	----	(9)
Cadmium (content) [16] do	5,064	4,667	−8	37	33	----	----	[8] 63	[8] 67	5	9
Magnesium (content)	34,824	35,928	+3	[17] 86	[17] 83	14	16	(9)	1	1	4
Mercury 76-pound flasks	[6] 73,186	65,273	−11	[6][17] 51	[17] 47	[6] 7	7	[6][8] 42	[8] 46	2	2
Platinum-group metals thousand troy ounces	[6] 719	1,130	+57	2	1	[18] 11	[18] 12	87	87	6	3
Titanium concentrate:											
Ilmenite and slag (TiO_2 content)	517	581	+12	57	59	----	----	43	41	----	----
Rutile thousand troy ounces	35	26	−26	5	27	----	----	95	73	3	15
Nonmetals:											
Asbestos	685	754	+10	6	6	----	----	94	94	(19 9)	(19 9)
Barite, crude	1,132	1,542	+36	53	58	----	----	47	42	----	----
Boron minerals and compounds, finished products (gross weight)	293	366	+25	100	100	----	----	(9)	----	45	41
Bromine and bromine in compounds million pounds	166	186	+12	100	100	----	----	(9)	(9)	6	5
Clays	[6] 43,462	49,070	+13	100	100	----	----	(9)	(9)	1	1
Fluorspar, finished	732	726	−1	43	26	----	----	[8] 57	[8] 74	(6 9)	(9)
Gypsum, crude	13,782	16,735	+21	[20] 71	[20] 63	----	----	29	37	----	----
Mica (except scrap) thousand pounds	11,742	12,724	+8	5	5	----	----	95	95	8	8
Phosphate rock (P_2O_5 content) thousand long tons	3,720	3,999	+8	99	99	----	----	1	1	20	21
Potash (K_2O equivalent)	[6] 2,281	2,373	+4	92	91	----	----	8	9	10	12
Salt (common)	[6] 22,160	25,764	+16	97	96	----	----	3	4	2	2
Sulfur, all forms (content) [21] thousand long tons	[6] 5,271	5,917	+12	89	90	----	----	11	10	23	22
Talc and allied minerals	658	748	+14	97	97	----	----	3	3	8	7

See footnotes on following page.

[1] Net supply is sum of primary shipments, secondary production, and imports, minus exports. Gross supply is total before subtraction of exports.

[2] Primary shipments are mine shipments or mine sales (including consumption by producers) plus byproduct production. Shipments more nearly represent quantities marketed by domestic industry and as such are more comparable to imports. Use of shipments data rather than production data also permits uniform treatment among more commodities.

[3] From old scrap only.

[4] Imports for consumption except where otherwise indicated; scrap is excluded wherever possible both in imports and exports but included are all other sources of mineral through refined or roughly comparable stage, except where commodity description indicates earlier stage. Exports of foreign merchandise (reexports), if any, are included when imports are general.

[5] Iron ore reduced to estimated pig-iron equivalent; reported weights used for all other items of supply.

[6] Revised figure.

[7] Receipts of purchased scrap.

[8] General imports; corresponding exports are of both domestic and foreign merchandise.

[9] Less than 0.5 percent.

[10] Consumption of purchased scrap.

[11] Includes recovery from old scrap, dross, and residues, which are a part of so-called new scrap.

[12] Includes 87.5 percent of bauxite mine production (rather than shipments) and imports, and 92 percent of alumina imports, both converted to estimated aluminum equivalent (3.925 long tons bauxite and 1.922 short tons of alumina to 1 short ton aluminum) in 1958; 87 and 92 percent in 1959 (3.832 and 1.913 conversion factors). These percentages are based on estimated proportions used in the production of metal. To avoid a duplicate adjustment for nonmetallic use, exports of bauxite to Canada were excluded from exports.

[13] Mine production of bauxite.

[14] Includes ingot equivalent (weight×0.9) of imports of scrap, largely scrap pig. Some duplication occurs because of small amount of loose scrap imported, which is also reflected in secondary production. See also footnote 12.

[15] Based on recovery from all forms as a byproduct from domestic and foreign sources.

[16] Primary shipments are estimated as a percentage of total primary production of metal, decreasing with increasing imports of lead and zinc; imports are represented by sum of remaining percentage of such production plus imports of metal. In 1959 the ratio was 39:61; in 1958, 41:59. Primary compounds not made from metal, data for which cannot be disclosed, are excluded for both years. Secondary includes recovery from both old and new scrap. Secondary data cannot be disclosed and are included with primary.

[17] Primary production of metal.

[18] Recovery from both old and new scrap.

[19] Exports of foreign merchandise (that is, reexports) are included.

[20] Estimated by adjusting production, excluding byproduct, for changes in producers' stocks.

[21] For pyrites, includes sulfur content (48 percent) of production.

Sources of Supply.—Imports continued to increase in importance as a source of supply, most markedly in the ferrous group. Copper, antimony, beryl, cadmium, and mercury imports also increased significantly. Of the commodities shown in table 9, the import contribution of 16 increased, 8 decreased, and 8 showed no change.

Sources of Imports.—Canada and Mexico increased their share of the market in 12 principal commodities, lost in 7, and maintained their position in 5. The "Other free world" showing declines in 9 commodities and gains in 12 also increased in importance. The largest shifts were in iron (equivalent), tungsten, tin, beryl, mercury, and potash. The U.S.S.R. bloc became a significant supplier of chromite, maintained its position in cadmium, but lost most of its potash sales.

TABLE 10.—Percentage distribution of imports of principal minerals consumed in the United States, by country group of origin [1]

Commodity	Canada and Mexico		East and South Pacific [2]		Other Western Hemisphere		Other free world		U.S.S.R. bloc [3]	
	1958	1959	1958	1959	1958	1959	1958	1959	1958	1959
Ferrous ores, scrap, and metals:										
Iron (equivalent) [4]	29	37	17	17	44	41	10	5	------	(5)
Manganese (content)	8	9	2	2	26	25	64	64	------	------
Chromite (Cr_2O_3 content)	------	------	4	------	3	3	93	92	------	5
Cobalt (content)	7	3	------	------	------	------	93	97	------	------
Nickel (content)	77	79	------	------	21	18	2	3	------	------
Tungsten ore and concentrate (W content)	10	1	33	32	49	21	8	46	------	------
Other metallic ores, scrap, and metals:										
Copper (content)	29	31	42	44	4	3	26	23	------	------
Lead (content)	33	39	45	38	2	1	20	22	------	------
Zinc (recoverable content)	68	65	18	21	1	(5)	13	14	------	(5)
Aluminum (equivalent) [6]	11	6	(5)	(5)	86	85	3	11	------	------
Tin (content)	(5)	1	(5)	1	10	(5)	90	98	------	------
Antimony (recoverable content) [7]	19	21	10	13	(5)	2	70	64	------	------
Beryl ore (BeO content)	------	------	------	------	36	66	64	34	------	------
Cadmium (content) [8]	78	78	7	3	------	------	16	19	------	------
Mercury	41	12	4	5	(5)	------	54	83	------	------
Platinum-group metals	18	25	(5)	(5)	3	3	65	59	14	13
Titanium concentrates: Rutile, ilmenite and slag (TiO_2 content)	33	43	14	17	(5)	------	53	40	------	------
Nonmetals:										
Asbestos	91	92	1	1	(5)	(5)	8	7	------	(5)
Barite, crude	62	57	14	18	1	(5)	23	25	------	------
Fluorspar, finished	65	61	------	------	------	------	35	39	------	------
Gypsum, crude	82	91	------	------	18	9	(5)	(5)	------	------
Mica (except scrap)	(5)	(5)	------	------	15	16	85	84	------	------
Potash (K_2O equivalent)	(5)	2	1	2	------	------	85	93	14	3
Sulfur (content)	100	100	------	------	------	------	(5)	(5)	------	------

---

[1] Data are based on imports for consumption and are classified like net new supply shown in table 9.

[2] West coast of South America (Salvador, Chile, Bolivia, Peru, and Ecuador), New Zealand, New Caledonia and Australia.

[3] U.S.S.R., Bulgaria, East Germany, Albania, Czechoslovakia, Hungary, Estonia, Latvia, Lithuania, Poland, Rumania, China, and North Korea.

[4] Includes iron ore, pig iron, and scrap.

[5] Less than 0.5 percent.

[6] See footnotes 12 and 14, table 9.

[7] Excludes antimony from foreign silver and lead ores.

[8] Metal and flue dust only.

CONSUMPTION

Patterns.—Consumption of minerals increased across the board in 1959, marking the recovery of the economy. All commodities listed in tables 11 and 12 showed increases. Percentage increases of 30 percent or more were recorded in 8 commodities, 10 to 29 percent in 18, and less than 10 percent in the remainder. The steel-associated minerals, generally, increased less than the others. The consumption analysis clearly indicates that the 1959 recovery was general and widespread, covering the entire range of mineral commodities.

TABLE 11.—Reported consumption of principal metals and minerals in the United States

Commodity	1958	1959	Change from 1958 (percent)
Antimony[1] ---- thousand short tons	11,880	13,317	+12
Barite, crude ---- do	1,196	1,396	+17
Bauxite ---- thousand long tons, dried equivalent	7,034	8,621	+23
Beryl ---- short tons, BeO content	6,002	8,173	+36
Chromite ---- thousand short tons, gross weight	1,221	1,337	+10
Cobalt ---- thousand pounds	7,542	9,899	+31
Copper, refined ---- thousand short tons	1,251	1,463	+17
Fluorspar, finished ---- do	494	590	+19
Iron ore ---- thousand long tons, gross weight	91,900	93,662	+2
Lead ---- thousand short tons	986	1,091	+11
Magnesium, primary ---- short tons	35,352	41,200	+17
Manganese ore ---- thousand short tons, gross weight	1,498	1,603	+7
Mercury ---- 76-pound flasks	52,617	54,895	+4
Mica splittings ---- thousand pounds	5,329	7,223	+36
Molybdenum, primary products[3] ---- thousand pounds, Mo content	24,231	32,350	+34
Nickel, exclusive of scrap ---- short tons	[2] 79,017	112,661	+43
Platinum-group metals (sales to consumers) ---- thousand troy ounces	690	896	+30
Tin ---- long tons	72,585	77,373	+7
Titanium concentrate:			
Ilmenite and slag ---- thousand short tons, estimated TiO_2 content	[2] 462	578	+25
Rutile ---- do	21	22	+5
Tungsten concentrate ---- short tons, W content	2,660	4,918	+85
Zinc, slab ---- thousand short tons	868	956	+10

[1] Includes antimony content of antimonial lead produced at primary lead smelters and antimony content of alloys imported.

[2] Revised figure.

[3] Comprises ferromolybdenum, molybdic oxide, and molybdenum salts and metal.

TABLE 12.—Apparent consumption of metals and minerals in the United States[1]

Commodity	1958	1959	Change from 1958 (percent)
Aluminum[2] ---- thousand short tons	[5] 2,092	2,487	+19
Asbestos, all grades[3] ---- do	685	754	+10
Boron minerals and compounds[4] ---- thousand short tons, gross weight	293	366	+25
Bromine and bromine in compounds ---- million pounds	166	186	+12
Cadmium, primary ---- thousand pounds, Cd content	8,177	11,474	+40
Clays ---- thousand short tons	[5] 43,462	49,070	+13
Gypsum, crude ---- do	13,782	16,735	+21
Phosphate rock ---- thousand long tons, P_2O_5 content[6]	3,760	4,079	+8
Potash ---- thousand short tons, K_2O equivalent	2,281	2,373	+3
Salt, common ---- thousand short tons	[5] 22,160	25,761	+16
Sulfur (all forms) ---- thousand long tons, S content	[5] 5,263	5,917	+12
Talc and allied minerals ---- thousand short tons	694	782	+13

[1] Covers commodities for which consumption is not reported.

[2] Includes shipments to Government in 1958, 323,000 short tons and in 1959, 73,000 short tons.

[3] No adjustments for national stockpile acquisitions.

[4] Reported as finished products.

[5] Revised figures.

[6] Estimated at 31 percent of gross weight.

Sales and Orders.—Seasonally adjusted sales of primary metals increased sharply until midyear, when the steel strike occurred. Nevertheless, the year showed sales up 16 percent over 1958, an increase of $3.6 billion. Sales of the stone, clay, and glass manufacturing industry were up 13 percent despite a decline in the last 5 months of the year. As expected because of the strike, new orders in the primary-metal industry were higher than deliveries during most of the year, trailing sales only in May, June, July, and December. New orders increased 29 percent, or $6.5 billion, over 1958.

TABLE 13.—Sales, primary metal industry and stone, clay, and glass industry, and new orders, primary metal industry [1]

(Million dollars)

Year and month	Primary metal		Stone, clay, and glass
	Sales	Net new orders	Sales
1956	28,339	29,028	8,982
1957	27,852	25,504	8,489
1958	22,949	22,504	7,658
1959	26,567	28,978	8,687
1959: [2]			
January	2,230	2,727	668
February	2,421	3,236	677
March	2,580	2,681	731
April	2,792	2,826	756
May	2,858	2,479	766
June	2,916	2,578	768
July	2,104	2,018	805
August	1,227	1,689	751
September	1,212	1,957	718
October	1,186	1,870	704
November	1,956	2,141	662
December	2,802	2,682	729

[1] U.S. Department of Commerce, Office of Business Economics, Survey of Current Business: Vol. 40, March 1960.

[2] Seasonally adjusted data; therefore will not add to 1959 total.

STOCKS

Indexes of Stocks.—Bureau of Mines indexes of physical stocks held by mineral manufacturers, consumers, and dealers at yearend and stocks held by primary producers at yearend declined in 1959 as compared with 1958. Crude mineral stocks of primary producers decreased quite substantially. The total minerals index fell 12 points; the decline was caused by a sharp drop in nonmetal stocks; crude metal ore stocks actually increased. Mineral stocks of manufacturers, consumers, and dealers also fell, but not as substantially as crude stocks. Also, unlike the crude metal stock index, metal stocks declined slightly.

The indexes were developed by the author. The following commodities are included in the index of stocks of manufacturers, consumers, and dealers: Aluminum, arsenic, bauxite, bismuth, cadmium, cement, chromite, copper, ferrous scrap and pig iron, fluorspar, iron ore, lead, manganese ore and ferromanganese, mercury, molybdenum primary products, nickel, platinum-group metals, tin, titanium concentrates, tungsten concentrates, and zinc. The index of stocks of primary producers includes the following commodities: Antimony, bauxite, fluorspar, gypsum, iron ore, mercury, molybdenum, phosphate rock, potassium salts, sulfur, titanium concentrates, and tungsten.

TABLE 14.—Indexes of stock of minerals of mineral manufacturers, consumers, and dealers as of yearend

(1955=100)

Yearend	Total metals and nonmetals [1]	Metals					Nonmetals [1]
		Total	Iron	Other ferrous	Base	Other nonferrous	
1950	81	81	78	72	84	89	77
1951	75	75	79	68	72	70	102
1952	90	90	94	86	87	[2] 88	97
1953	[2] 105	105	105	108	106	103	112
1954	99	99	101	[2] 117	95	[2] 101	94
1955	100	100	100	100	100	100	100
1956	111	111	102	98	117	136	128
1957	130	129	[2] 126	122	122	182	[2] 161
1958 [3]	[3] 130	[3] 129	131	[3] 130	122	161	168
1959	[3] 128	[3] 126	127	[3] 155	116	158	173

[1] Excluding fuels.
[2] Revised figure.
[3] Figure not strictly comparable; tungsten concentrate figure omitted to avoid revealing individual company data.

TABLE 15.—Index of stocks of crude minerals at mines or in hands of primary producers as of year end

(1955=100)

Yearend	Total minerals	Metals				Nonmetals
		Total	Iron ore	Other ferrous	Other	
1950	87	116	134	128	63	75
1951	91	121	131	149	83	79
1952	99	121	129	197	72	90
1953	105	135	133	326	73	93
1954	114	146	165	163	87	100
1955	100	100	100	100	100	100
1956	[1] 123	123	128	152	[1] 98	124
1957	144	158	[1] 158	405	[1] 72	138
1958 [1]	[2] 137	[2] 142	164	[2] 207	63	135
1959	[3] 125	[3] 147	172	[2] 149	[4] 75	117

[1] Revised figure.
[2] Figure not strictly comparable; tungsten concentrate figures omitted to avoid revealing individual company data.
[3] Figure not strictly comparable; tungsten concentrate and antimony ore and concentrate figures omitted to avoid revealing individual company data.
[4] Figure not strictly comparable; antimony ore and concentrate figures omitted to avoid revealing individual company data.

Primary market prices of each commodity were used as weights in the first index; average mine value was used in the second.

The indexes measure changes in the physical volume of stocks. The importance of any commodity in the index is a result of the physical stock of that commodity valued at 1955 prices. Movements in the indexes, therefore, reflect movements in the physical volume of stocks. These indexes are the same type as the indexes of physical volume of mineral production presented earlier in this review.

Value of Inventories.—The value of inventories held by firms in the primary-metal industry and in the stone, clay, and glass industry, seasonally adjusted, was stable throughout the year, standing slightly above December 1958 at yearend.

TABLE 16.—Seasonally adjusted book value of inventory, primary metal industry and stone, clay, and glass, December 1956–58 and monthly 1959 [1]

(Million dollars)

Year and month	Primary metal	Stone, clay, and glass	Year and month	Primary metal	Stone, clay, and glass
1956: December	3,975	1,171	1959—Continued		
1957: December	4,269	1,270	May	4,312	1,254
1958: December	[2] 4,111	1,200	June	4,201	1,276
1959: December	4,120	1,357	July	4,108	1,270
January	4,180	1,207	August	3,980	1,261
February	4,267	1,207	September	3,923	1,277
March	4,341	1,216	October	3,870	1,320
April	4,368	1,235	November	3,986	1,336

[1] U.S. Department of Commerce, Office of Business Economics, Survey of Current Business: Vol. 40, February and March 1960.

[2] Revised figure.

LABOR AND PRODUCTIVITY

Employment.—Total employment in the mineral industries declined in 1959 because of strikes in the iron and copper mining industries. By midyear, employment had come within 13,000 employees of the 1957 high, but dropped sharply in metal mining the last half of the year. Nonmetal mining employment increased rather steadily during the year and averaged slightly higher than in 1958. The same pattern was evident in mineral manufacturing. Employment in the fertilizer and cement industries increased slightly; that in the primary metals was substantially lower.

The following tabulation shows major changes in average employment in 1959 as compared with 1958:

	Percent
All industries	+3
Mining (including fuels)	−6
Metals and minerals (except fuels)	−6
Metal mining	−14
Nonmetal mining and quarrying	+1
Fuels	−6
Mineral manufacturing	−3

For the second successive year the mineral industries fared poorly, compared with all industries, but for very different reasons. Except for the strike during the second half of the year, these industries would have shown substantially better employment increases than that for all industries.

Hours and Earnings.—Average weekly hours of production workers in the mining industry reversed a 3-year downward trend and increased in 1959. Hourly earnings also increased, so that average weekly earnings in 1959 were 6.5 percent above 1958.

All categories of mining showed similar rises in average hours and earnings; copper mining had the greatest increase in weekly earnings (12 percent). Mineral manufacturing industries also registered increases in hours and earnings, led by the 13-percent rise in weekly earnings in blast furnaces, steelworks, and rolling mills.

TABLE 17.—Total employment in the mineral industries (nonfuel) in the continental United States, by industry[1]

(In thousands)

Year and month	Mining					
	Total	Nonmetallic mining and quarrying	Metal			
			Total[2]	Iron	Copper	Lead and zinc
1956	224.0	115.2	108.8	35.1	33.3	17.4
1957	224.5	113.3	111.2	38.9	32.6	16.7
1958	202.4	109.3	[3] 93.1	30.8	28.6	12.9
1959:						
January	196.2	102.6	93.6	30.9	30.2	12.7
February	194.9	101.4	93.5	31.1	30.5	12.5
March	197.8	104.3	93.5	32.5	29.3	12.5
April	205.3	109.6	95.7	33.9	30.5	12.3
May	208.8	112.3	96.5	34.9	30.7	12.3
June	210.9	113.2	97.7	35.4	31.1	12.6
July	211.2	113.8	97.4	35.2	31.0	12.7
August	177.7	115.7	62.0	10.6	20.1	12.9
September	161.9	115.2	46.7	9.7	8.9	11.5
October	160.7	114.2	46.5	9.7	8.7	11.4
November	181.4	114.2	67.2	30.0	8.0	12.0
December	181.1	111.6	69.5	32.3	8.1	12.1
Year (average)	190.7	110.7	80.0	27.2	22.3	12.3

Year and month	Mineral manufacturing				
	Fertilizers	Cement, hydraulic	Blast furnaces, steel works, and rolling mills	Smelting and refining of nonferrous metals	
				Primary	Secondary
1956	36.0	43.6	630.2	67.8	14.0
1957	35.8	42.0	642.7	68.1	13.2
1958	35.6	42.0	[3] 536.7	56.2	11.5
1959:					
January	35.2	39.4	569.3	54.9	11.9
February	36.7	38.5	591.7	54.9	12.0
March	41.9	40.6	618.4	54.7	12.1
April	46.4	42.0	633.5	54.1	12.2
May	45.6	42.6	643.4	54.9	12.3
June	34.1	43.2	651.8	56.3	12.5
July	31.6	43.5	630.8	56.9	12.5
August	32.4	43.6	242.2	55.7	12.8
September	35.0	43.2	229.0	45.2	12.0
October	34.8	41.1	222.8	44.9	11.9
November	34.1	41.8	597.3	44.3	12.0
December	35.0	41.4	634.1	49.7	12.4
Year (average)	36.9	41.7	522.0	52.2	12.2

[1] U.S. Department of Labor, Bureau of Labor Statistics. Published in Monthly Labor Review, Employment and Earnings. Data are based on reports from cooperating establishments covering both full- and part-time employees who worked during or received pay for any part of pay period ending nearest 15th of month. Data are for "all employees," those for "production and related workers" also available in above publications.

[2] Includes other metal mining, not shown separately.

[3] Revised figure.

Labor Turnover.—Work stoppages in iron and copper mining during the second half of 1959 clouded the analysis of labor-turnover rates. However, the higher annual average accession rate in lead-zinc and total metal mining and lower average separation and layoff rates, indicate that recovery of the mining industry in 1959 was substantial, compared with 1958.

TABLE 18.—Average hours and gross earnings of production and related workers in the mineral industries (nonfuel) in continental United States, by industries [1]

Year	Mining								
	Total [2]			Metal					
				Total [3]			Iron		
	Weekly—		Hourly earnings	Weekly—		Hourly earnings	Weekly—		Hourly earnings
	Earnings	Hours		Earnings	Hours		Earnings	Hours	
1955	[4] $86.52	43.4	$2.00	$92.42	42.2	$2.19	$92.86	40.2	$2.31
1956	[4] 91.06	[4] 43.4	[4] 2.10	96.83	42.1	2.30	96.71	39.8	2.43
1957	[4] 93.21	[4] 42.4	[4] 2.21	98.74	40.8	2.42	103.49	39.5	2.62
1958	[4] 92.62	[4] 41.3	[4] 2.26	[4] 96.22	[4] 38.8	2.48	[4] 100.27	[4] 36.2	2.77
1959	98.66	42.3	2.34	103.31	40.2	2.57	107.34	37.4	2.87

Year	Metal—Continued						Nonmetallic mining and quarrying		
	Copper			Lead and zinc					
1955	$95.70	44.1	$2.17	$83.82	41.7	$2.01	$80.99	44.5	$1.82
1956	100.28	43.6	2.30	89.24	41.7	2.14	85.63	44.6	1.92
1957	97.75	40.9	2.39	88.97	41.0	2.17	87.80	43.9	2.00
1958	[4] 94.62	39.1	[4] 2.42	[4] 85.93	[4] 39.6	2.17	[4] 89.63	[4] 43.3	2.07
1959	106.17	42.3	2.51	90.63	40.1	2.26	95.48	43.8	2.18

Year	Mineral manufacturing								
	Fertilizer			Cement, hydraulic			Blast furnaces, steel works, and rolling mills [5]		
1955	$63.90	42.6	$1.50	$78.85	41.5	$1.90	$95.99	40.5	[4] $2,37
1956	67.68	42.3	1.60	83.84	41.3	2.03	102.06	40.5	2.52
1957	71.83	42.5	1.69	87.91	40.7	2.16	104.79	39.1	2.68
1958	[4] 74.03	[4] 42.3	[4] 1.75	92.92	40.4	2.30	[4] 108.00	37.5	2.88
1959	78.12	43.4	1.80	98.98	40.9	2.42	122.28	39.7	3.08
	Electrometallurgical products			*Other*			Primary smelting and refining of nonferrous metals [5]		
1955	$87.14	41.3	$2.11	[4] $96.39	40.5	$2.38	$84.66	40.7	$2.08
1956	88.22	40.1	2.20	102.47	40.5	2.53	91.46	41.2	2.22
1957	93.26	40.2	2.32	105.18	39.1	2.69	95.82	40.6	2.36
1958	99.79	[4] 40.4	[4] 2.47	[4] 108.09	[4] 37.4	2.89	[4] 99.05	[4] 40.1	[4] 2.47
1959	104.64	40.4	2.59	122.67	39.7	3.09	105.93	40.9	2.59
	Primary smelting and refining of copper, lead, and zinc			*Primary refining of aluminum*			Secondary smelting and refining of nonferrous metals		
1955	$81.61	40.6	$2.01	$89.28	40.4	[4] $2,21	$81.45	42.2	$1.93
1956	88.81	41.5	2.14	95.34	40.4	2.36	85.04	42.1	2.02
1957	89.91	40.5	2.22	103.68	40.5	2.56	87.53	40.9	2.14
1958	[4] 90.12	[4] 39.7	2.27	[4] 111.91	[4] 40.4	[4] 2.77	[4] 88.84	40.2	2.21
1959	95.94	41.0	2.34	117.68	40.3	2.92	94.16	41.3	2.28

---

[1] U.S. Department of Labor, Bureau of Labor Statistics, Employment and Earnings: Ann. Supp. Issue, vol. 6, No. 11, May 1960, pp. 112–113.

[2] Weighted average of data for metal mining and nonmetallic mining and quarrying, computed by author of chapter, using figures for production workers as weights.

[3] Includes other metal mining, not shown separately.

[4] Revised figure.

[5] Italicized titles are components of this industry.

TABLE 19.—Monthly labor-turnover rates in the mineral industries 1958 average, and 1959 by months[1]

(Per 100 employees)

Turnover rate	All manufacturing	Hydraulic cement products	Blast furnaces, steel works, and rolling mills	Primary smelting and refining of nonferrous metals: copper, lead, zinc	Metal mining			
					Total metal mining	Iron mining	Copper mining	Lead and zinc mining
Total accession rate:								
1958 average	3.0	2.1	2.9	1.8	2.6	2.6	[2]2.8	2.1
1959:								
January	3.3	2.0	4.1	1.8	3.6	4.6	2.9	1.9
February	3.3	2.5	5.3	1.0	2.0	2.2	1.9	1.8
March	3.6	3.7	4.5	2.0	3.1	4.7	2.4	2.1
April	3.5	3.9	3.1	2.5	3.9	5.8	2.6	2.3
May	3.6	2.1	2.3	2.7	2.9	2.3	3.7	3.0
June	4.4	3.5	2.2	3.1	3.4	2.3	3.0	4.9
July	3.3	1.9	(3)	1.7	2.3	(3)	2.8	3.8
August	3.9	1.7	(3)	1.8	2.2	(3)	(3)	3.1
September	3.9	1.1	(3)	1.6	1.8	(3)	(3)	2.8
October	3.1	1.1	(3)	2.0	2.7	(3)	(3)	2.9
November	3.0	2.1	(3)	1.2	2.1	(3)	(3)	2.7
December	3.8	.9	2.1	2.1	2.9	3.2	(3)	2.7
Average	3.6	2.2	[4]3.4	1.9	2.7	[4]3.6	[4]2.8	2.8
Total separation rate:								
1958 average	3.6	2.9	3.4	2.5	3.9	4.2	3.7	3.7
1959:								
January	3.1	3.8	1.4	1.6	2.9	2.6	2.5	3.9
February	2.6	1.4	1.1	1.4	1.7	.9	1.7	2.0
March	2.8	1.3	1.2	1.3	2.8	2.9	2.0	3.7
April	3.0	1.3	1.3	2.2	2.9	2.4	2.5	3.8
May	2.9	1.5	1.2	1.8	2.8	1.2	2.6	2.5
June	2.8	1.2	1.6	2.1	2.7	2.3	3.2	3.1
July	3.3	1.2	(3)	2.2	2.6	(3)	3.0	2.3
August	3.7	2.0	(3)	1.7	2.7	(3)	(3)	4.5
September	4.3	3.7	(3)	2.9	4.3	(3)	(3)	3.5
October	4.7	3.0	(3)	1.3	1.8	(3)	(3)	2.1
November	4.1	2.1	(3)	1.0	2.2	(3)	(3)	1.8
December	3.1	2.7	1.8	1.7	2.2	1.9	(3)	1.4
Average	3.4	2.1	[4]1.4	1.8	2.6	[4]2.0	[4]2.5	2.9
Layoff rate:								
1958 average	2.3	2.0	2.8	1.5	2.2	3.6	[2]2.1	2.2
1959:								
January	1.7	3.2	.7	.5	.9	1.2	.4	2.3
February	1.3	.8	.3	.6	.3	.2	.2	.4
March	1.3	.4	.3	.2	.8	1.2	.2	1.7
April	1.3	.3	.3	.1	.3	.1	.2	.2
May	1.1	.3	.2	.2	.1	.1	.2	.1
June	1.0	.3	.4	.4	.7	.8	.9	.4
July	1.4	.2	(3)	.6	.2	(3)	.1	.2
August	1.4	.5	(3)	.2	.8	(3)	(3)	2.3
September	1.5	1.1	(3)	.5	1.6	(3)	(3)	.4
October	2.8	2.0	(3)	.2	.3	(3)	(3)	.3
November	2.6	1.3	(3)	.1	.9	(3)	(3)	.2
December	1.7	1.9	.4	.4	.4	.7	(3)	.1
Average	1.6	1.0	[4].4	.3	.6	[4].6	[4].3	.7

[1] Department of Labor, Bureau of Labor Statistics, Monthly Labor Review, and unpublished reports.
[2] Revised figure.
[3] Not available, because of work stoppage.
[4] 7-month average.

TABLE 20.—Wages and salaries in the mineral industries in the United States [1]

(Million dollars)

Industry	1958	Change from 1957 (percent)	1959	Change from 1958 (percent)
All industries	239,673	+.5	258,206	+7.7
All mining	3,774	−10.9	3,834	+1.6
Nonfuel mining	1,043	−9.7	1,067	+2.3
Metal mining	493	−18.7	479	−2.8
Nonmetallic mining and quarrying	550	+.2	588	+6.9
Fuel mining	2,731	−11.4	2,767	+1.3
Manufacturing	76,701	−4.9	84,723	+10.5
Primary metal industries	6,516	−12.9	7,237	+11.1

[1] U.S. Department of Commerce, Office of Business Economics, Survey of Current Business: Vol. 40, No. 7, July 1960, p. 28, table V1-2.

TABLE 21.—Average annual earnings in mining and primary metal industries [1]

Industry	1958		1959	
	Average	Change from 1957 (percent)	Average	Change from 1958 (percent)
All industries	$4,347	+3.4	$4,553	+4.7
All mining	5,220	+.1	5,540	+6.1
Nonfuel mining	5,318	+1.0	5,444	+6.0
Metal mining	5,418	−.8	5,841	+7.8
Nonmetallic mining and quarrying	4,911	+3.8	5,158	+5.0
Fuel mining	5,252	−.3	5,579	+6.2
Manufacturing	4,939	+3.3	5,214	+5.6
Primary metal industries	5,854	+3.0	6,321	+8.0

[1] U.S. Department of Commerce, Office of Business Economics, Survey of Current Business: Vol. 40, July 1960, p. 29, table V1-15.

Productivity.—Productivity generally increased in metal mining except for declines in recoverable metal per man-hour and production worker in iron ore mining. Indexes for lead-zinc and copper reached record highs.

In 1956 an index of lead-zinc production per man-hour was derived to fill a void left when the Bureau of Labor Statistics ceased publication of that index. They have now published the index through 1957 on a 1947 base.[12] The following comparison between the index computed by the author for this chapter and the Bureau of Labor Statistics index converted to a 1949 base shows little difference between the two. The computed index, since it is timely, will continue to be used in this review.

---

[12] U.S. Department of Labor, Bureau of Labor Statistics, Indexes of Output per Man-Hour for Selected Industries, 1919 to 1958: April 1959, p. 3.

Year:	*Bureau of Mines index*	*Bureau of Labor Statistics index*
	(1949=100)	
1949	100	100.0
1950	110	110.7
1951	101	101.4
1952	98	96.9
1953	100	101.1
1954	100	99.9
1955	103	101.7
1956	102	102.1
1957	105	107.2
1958	[1] 111	(2)
1959	115	(2)

[1] Revised figure.
[2] Not available.

TABLE 22.—Labor-productivity indexes for copper- and iron-ore mining[1]

(1947–49=100)

Year	Copper		Iron	
	Crude ore mined per—		Crude ore mined per—	
	Production worker	Man-hour	Production worker	Man-hour
1950–54 (average)	120.9	118.7	115.4	118.0
1955	134.2	134.3	132.7	133.4
1956	135.4	137.2	133.1	135.3
1957	138.1	149.0	131.4	134.4
1958 [2]	142.7	161.2	116.6	129.8
1959 [3]	167.5	174.7	125.3	135.4
	Recoverable metal [4] per—		Recoverable metal [4] per—	
	Production worker	Man-hour	Production worker	Man-hour
1950–54 (average)	115.0	112.8	107.9	104.8
1955	121.8	122.0	118.2	118.9
1956	116.1	117.6	[2] 109.7	[2] 111.5
1957	118.0	127.3	107.0	109.5
1958 [2]	124.5	140.6	88.8	99.4
1959 [3]	136.0	141.9	88.3	95.4

[1] U.S. Department of Labor, Bureau of Labor Statistics, Monthly Labor Review: February 1956, vol. 79, No. 2.
[2] Revised figures.
[3] Preliminary.
[4] Figures refer to usable ore rather than recoverable metal. For iron, usable ore is that product with the desired iron content (by selective mining, mixtures of ores, washing, jigging, concentrating, sintering).

PRICES AND COSTS

Index of Mine Value.—Table 23 gives, for the first time, an index of average unit mine value of minerals produced in the United States. It is believed that this index fills an important gap in mineral economic statistics. It differs from other mineral-price indexes and from the Bureau's value of mineral-production series in that it attempts to reflect actual mine value and not refined value of recoverable metal for copper, lead, zinc, gold and silver. These indexes were developed by estimating the changing differential smelter overtime so as to reflect the actual value of the ore as it leaves the milling stage.

The average unit mine value of all minerals (including fuels) was slightly lower in 1959. However, decline in the total mineral index was due entirely to a decline in the fuels index. Both the metals and nonmetals index showed increases above 1958. These increases were general in both groups; every subgroup also increased except monetary metals, which were unchanged.

TABLE 23.—Index of average unit mine value of minerals produced in the United States, by group and subgroup

(1947–49=100)

Year	All minerals	Metals						Nonmetals				Fuels
		Total	Ferrous	Nonferrous				Total	Construction	Chemical	Other	
				Total	Base	Monetary	Other					
1925	61	61	64	60	57	70	101	73	70	81	88	59
1926	64	59	64	57	55	63	102	77	75	85	89	63
1927	55	55	63	52	49	61	108	75	72	86	87	52
1928	53	56	62	54	51	62	109	76	73	86	83	49
1929	54	63	66	61	62	56	108	77	74	85	81	50
1930	51	53	67	47	46	52	104	74	71	85	77	48
1931	40	45	66	36	31	50	93	74	71	84	75	36
1932	40	39	62	30	22	52	79	71	68	81	73	37
1933	38	46	68	37	26	66	80	73	70	80	70	33
1934	47	56	68	51	30	100	88	72	69	81	72	43
1935	47	57	65	53	32	102	83	70	67	79	70	42
1936	49	60	67	57	37	103	85	70	66	80	71	45
1937	52	67	75	64	49	99	90	71	68	81	73	48
1938	51	61	73	56	38	97	80	71	67	80	75	47
1939	48	64	75	59	42	99	89	68	64	78	73	43
1940	48	64	67	63	47	99	115	67	63	78	74	44
1941	53	67	71	66	51	98	120	70	67	78	74	49
1942	56	69	70	69	57	97	115	75	73	82	76	52
1943	60	74	71	75	66	97	115	79	78	84	78	55
1944	62	75	71	78	71	98	107	83	82	85	80	58
1945	63	76	72	78	72	98	113	84	82	88	85	59
1946	70	84	79	86	83	100	105	89	88	90	87	66
1947	87	95	87	100	100	101	97	97	97	97	96	85
1948	107	103	99	106	107	99	102	101	101	102	101	109
1949	105	103	114	95	93	100	100	102	103	101	103	106
1950	105	109	126	98	98	101	91	104	104	104	108	105
1951	109	128	140	120	124	100	121	109	107	111	122	107
1952	110	132	155	117	119	103	114	111	108	113	127	107
1953	115	137	171	113	114	104	122	116	111	125	124	112
1954	115	140	175	116	117	106	132	117	110	130	126	111
1955	116	156	180	138	144	104	144	119	111	135	131	111
1956	120	171	195	154	163	104	148	122	114	136	142	114
1957	127	157	207	121	121	109	161	124	115	138	148	123
1958	123	150	213	105	102	111	147	124	115	137	146	120
1959	122	158	216	117	116	111	152	126	119	135	147	118

Since 1925, the average unit mine value of minerals has increased somewhat more rapidly than all wholesale prices. The Wholesale Price Index has increased from 67.3 in 1925 to 119.7 in 1959—a 78-percent rise; the average mine value index has increased by 100 percent. The long-term increases are especially marked in ferrous metals, which increased by 238 percent.

The difference between this index and others currently published is illustrated by the monetary-metal index. Treasury price of gold and silver does not change from year to year, but this index varies. The variations are caused by movements in the differential between smelter purchase price for ore and refined metal prices. It is believed that this index reflects more accurately the actual per-unit mine returns. The index is provisional, and work is being continued to strengthen the underlying estimating procedures involved.

Prices.—Prices of mineral commodities were higher in 1959, except for the continued decline in iron ore and a slight drop in fertilizer minerals. Nonferrous metals and iron and steel scrap showed the greatest increase in annual average prices; the former showed the greatest increase January to December 1959. All commodities listed except bituminous binders showed greater variations in price than the average for all commodities, but the variations were much smaller than they have been in recent years.

Costs.—Most cost items increased in 1959 as compared with 1958. The increases were especially marked in gas fuels and in lumber. Slight declines occurred in coal and in petroleum and its products.

TABLE 24.—Price relatives for selected metals and mineral commodities, January and December 1959, and annual averages[1]

(1947–49=100)

Commodity	1959		Change from January (percent)	Annual average		Change from 1958 (percent)
	January	December		1958	1959	
Iron ore	172.9	168.4	−2.6	[2] 177.0	169.9	−4.0
Iron and steel scrap	101.6	103.3	+1.7	93.7	100.2	+6.9
Iron and steel	172.0	172.2	+.1	168.8	172.0	+1.9
Nonferrous metals	133.2	140.7	+5.6	127.7	136.1	+6.6
Clay products	159.3	160.7	+.9	156.5	160.2	+2.4
Gypsum products	133.1	133.1	----------	132.1	133.1	+.8
Concrete ingredients	140.2	140.4	+.1	139.0	140.3	+.9
Building lime	141.4	143.1	+1.2	135.5	142.8	+5.4
Insulation material	103.5	102.9	−.6	104.0	103.1	−.8
Asbestos-cement shingles	160.8	167.0	+3.9	160.8	166.1	+3.2
Bituminous binders	100.0	100.0	----------	100.0	100.0	----------
Fertilizer materials	107.6	107.0	−.6	108.0	106.9	−1.0
All commodities (minerals and all other)	119.5	118.9	−.5	119.2	119.5	−.2

[1] U.S. Department of Labor, Bureau of Labor Statistics, Wholesale Price Index: Annual and monthly releases; also published currently in Monthly Labor Review.
[2] Revised figure.

TABLE 25.—Price relatives for selected cost items in nonfuel mineral production, January and December 1959 and annual averages, 1958–1959[1]

(1947–49=100)

Commodity	1959		Change from January (percent)	Annual average		Change from 1958 (percent)
	January	December		1958	1959	
Coal	125.3	124.1	−1.0	122.9	122.7	−.2
Coke	163.1	170.4	+4.5	161.9	169.8	+4.9
Gas fuels	112.7	115.5	+2.5	101.7	110.9	+9.0
Petroleum and products	118.2	114.3	−3.3	117.7	116.6	−.9
Industrial chemicals	124.0	124.0	----------	123.5	123.8	+.2
Lumber	121.0	125.9	+4.0	118.0	127.1	+7.7
Explosives	140.0	145.1	+3.6	139.6	143.6	+2.9
Construction machinery and equipment	170.7	172.9	+1.3	[2] 166.1	172.0	+3.6

[1] U.S. Department of Labor, Bureau of Labor Statistics, Wholesale Price Index: Annual and monthly releases; some commodities also published currently in Monthly Labor Review.
[2] Revised figure.

Relative Labor Costs.—The index of labor costs per pound of recoverable metal increased in copper, lead-zinc, and iron-ore mining in 1959, but because of an increase in copper and lead-zinc prices, labor costs per dollar of recoverable metal declined in these two industries. The declines, however, were from the very high levels of 1958, and the indexes were very high in 1959 as compared with the last 10 years. The 131 index for iron-ore mining is the highest reached since the index has been computed, while that for lead-zinc is exceeded only by the 1958 index.

Index of Metal Mining Expenses.—This index, presented for the first time in the 1958 Review chapter, does not represent changes in total unit costs of metal mining since it excludes capital costs and contract work. It does, however, gage the impact of labor costs and productivity changes as well as changes in prices of supplies and fuels used by the mining industry. Reflecting the increased costs of supplies and labor (adjusted for productivity), the index increased sharply in 1959 to a new high. This marked the fourth straight increase from the 1955 low. The 10-point increase in labor expense accounted for most of the increase in the total index.

TABLE 26.—Indexes of relative labor costs, copper-, lead-zinc-, and iron-ore mining

(1949=100)

Year	Labor costs per pound of recoverable metal [1]			Value of recoverable metal per man-hour [2]			Labor costs per dollar of recoverable metal [3]		
	Copper	Lead-zinc	Iron ore	Copper	Lead-zinc	Iron ore	Copper	Lead-zinc	Iron ore
1949	100	100	100	100	100	100	100	100	100
1950	91	93	96	128	109	114	83	94	90
1951	97	112	100	146	130	132	77	87	88
1952	108	124	115	146	116	130	86	105	95
1953	122	122	129	160	89	150	82	137	97
1954	126	120	153	166	89	130	82	135	113
1955	119	124	128	233	102	168	62	125	93
1956	129	133	143	254	106	170	60	128	96
1957	124	133	158	194	96	176	81	144	101
1958	[4] 115	[4] 124	184	[4] 190	[4] 87	159	[4] 85	[4] 159	118
1959	117	125	203	226	93	148	73	155	131

[1] Index computed by author from data in tables 18 and 22.

[2] Index computed by author from data in table 22, multiplied by price of electrolytic copper, average lead and zinc, and iron ore, and rebased.

[3] Index computed by author using above index of value and data in table 18.

[4] Revised figure.

TABLE 27.—Index of principal metal mining expenses [1]

(1947–49=100)

Year	Total	Labor	Supplies	Fuels
1950	96	94	100	101
1951	106	101	116	102
1952	113	114	114	102
1953	120	125	114	104
1954	128	136	115	104
1955	120	124	117	102
1956	129	136	121	101
1957	133	140	127	105
1958	138	[2] 146	129	106
1959	144	156	130	106

[1] Indexes constructed by author, using weights derived from the 1954 Census of Mineral Industries.

[2] Revised figure.

INCOME

National Income Originated.—Income originated in metal mining dropped by 5 percent in 1959 as compared with 1958, the third consecutive yearly decrease. However, the declines in 1957 and 1958 were caused by the recession in general business conditions; that in 1959 was attributable to the long steel and copper strikes. Metal mining was the only group listed in table 28 to show a decline. Nonmetal industries increased by 9 percent, the same as for all industries.

TABLE 28.—National income originated in the mineral industries in the United States, 1957–1959 [1]

Industry	1957 [2]	1958 [2]	1959	Change from 1958 (percent)
	Million dollars			
All industries	366,943	367,686	399,648	+9
Metal mining	951	757	716	−5
Nonmetallic mining and quarrying	789	771	844	+9
Total mining except fuels	1,740	1,528	1,560	+2
Total mining including fuels	6,238	5,357	5,471	+2
Primary metal industries	11,293	9,052	10,326	+14
Stone, clay, and glass products	3,871	3,775	4,492	+19
	Percent			
All industries	100.00	100.00	100.00	------------
Metal mining	.26	.21	.18	------------
Nonmetallic mining and quarrying	.22	.21	.21	------------
Total mining except fuels	.47	.42	.39	------------
Total mining including fuels	1.70	1.46	1.37	------------
Primary metal industries	3.08	2.46	2.58	------------
Stone, clay, and glass products	1.05	1.03	1.12	------------

[1] U.S. Department of Commerce, Office of Business Economics, Survey of Current Business, July 1960, p. 13, table I-10. To arrive at national income, depletion charges are not deducted; this affects data for mining industries.

[2] Revised figures.

Profits and Dividends.—The annual rate of profit in 1959 on stockholder's equity (after corporate income taxes) was sharply higher than in 1958 for the mineral manufacturing corporations. Although dividends distributed by these corporations also increased, they did not rise as sharply as did profits. The annual profit rate of 8 percent in primary metals was not as high as the 10.8 percent reached in 1957. These data are summarized in table 29.

Business Failures.—Mining failures continued to increase, but current liabilities of the firms that failed decreased by one half. The decline was the first recorded since 1955.

TABLE 29.—Annual average profit rates on shareholder's equity, after taxes, and total dividends, mineral manufacturing corporations[1]

Corporations	Annual profit rate (percent)			Total dividends (million dollars)		
	1958	1959	Percent change 1959 from 1958	1958	1959	Percent change 1959 from 1958
All manufacturing	8.6	10.4	+21	7,383	7,908	+7
Primary metals	6.8	8.0	+18	878	941	+7
Primary iron and steel	7.2	8.0	+11	608	638	+5
Primary nonferrous metals	6.0	8.0	+33	270	302	+12
Stone, clay, and glass products	10.1	12.7	+26	269	297	+10

[1] Federal Trade Commission and Securities and Exchange Commission, Quarterly Financial Reports for Manufacturing Corporations, 1st Quarter 1959 and 1st Quarter 1960, tables 4 and 8.

TABLE 30.—Industrial and commercial failures and liabilities[1]

Industry	1957	1958	1959
Mining:[2]			
Number of failures	75	86	91
Current liabilities ... thousand dollars	11,588	17,619	8,363
Manufacturing:			
Number of failures	2,336	2,594	2,374
Current liabilities ... thousand dollars	185,253	227,979	199,373
All industrial and commercial industries:			
Number of failures	13,739	14,964	14,053
Current liabilities ... thousand dollars	615,293	728,258	692,808

[1] Dun & Bradstreet, Inc., Monthly Business Failures: New York, N.Y., Jan. 19, 1960.

[2] Including fuels.

INVESTMENT

New Plant and Equipment.—Expenditures for new plant and equipment by fuel- and nonfuel-mining firms rose $46 million in 1959 compared with 1958, but were still $256 million under 1957. This increase of 5 percent did not quite match the slightly more than 5-percent rise in all manufacturing. Reflecting the good business conditions in 1959, expenditure in the mining industry rose steadily during the year. However, metal-manufacturing firms as well as all manufacturing firms showed declines in the third quarter because of the widespread work stoppages, and the annual total was lower for metal manufacturing firms. The largest increase in expenditure was by firms in the stone, clay, and glass products industry, a gain of $130 million, or 33 percent.

Issues of Mining Securities.—The mining industry (including fuels) was the source of 1.7 percent of all new corporate securities offered in 1959, well below the 2.1 percent recorded in 1958 and 1957. The percentage distribution between types of securities remained unchanged for mining as compared with 1957, but the other groups shifted towards common-stock financing. The total gross proceeds from corporate offerings were down by $1,810 million, compared with 1958; mining proceeds dropped $86 million. The 35-percent decline in proceeds in mining greatly exceeded the 16-percent drop in total corporate but was not as high as the 41-percent drop in manufacturing.

TABLE 31.—Expenditures on new plant and equipment by firms in mining and selected mineral manufacturing industries[1]

(Million dollars)

Industry	1957	1958	1959	1959			
				January-March	April-June	July-September	October-December
Mining[2]	1,243	941	987	213	243	256	275
Manufacturing	15,959	11,433	12,067	2,456	3,021	3,019	3,571
Primary iron and steel	1,722	1,192	1,036	208	273	219	336
Primary nonferrous metals	814	441	313	71	86	70	86
Stone, clay, and glass products	572	399	529	113	135	133	148
Chemicals and allied products	1,724	1,320	1,235	260	302	310	363
Petroleum and coal products	3,453	2,431	2,491	518	619	629	725

[1] U.S. Department of Commerce, Office of Business Economics, Survey of Current Business: Vol. 40, No. 3, March 1960, p. 16.
[2] Including fuels.

Prices of Mining Securities.—The index of common-stock annual average of mining securities increased in 1959, as did the composite and manufacturing indexes. Increase in the mining index reversed a 3-year decline. When compared with 1958, the indexes increased 3 percent in mining, 22 percent in manufacturing, and 23 percent in the composite.

TABLE 32.—Estimated gross proceeds of new corporate securities offered for cash in the United States in 1959[1]

Type of security	Total corporate		Manufacturing		Mining[2]	
	Million dollars	Percent	Million dollars	Percent	Million dollars	Percent
Bonds	7,190	74	1,519	73	86	54
Preferred stock	531	5	103	5	2	1
Common stock	2,027	21	451	22	73	45
Total	9,748	100	2,073	100	161	100

[1] U.S. Securities and Exchange Commission, Statistical Bulletin, vol. 19, No. 5, May 1960, p. 3. Substantially all new issues of securities offered for cash sale in the United States in amounts over $100,000 and with terms to maturity of more than 1 year are covered in these data.
[2] Including fuels.

TABLE 33.—Indexes of common-stock annual average prices[1]

(1939=100)

Year	Composite[2]	Manufacturing	Mining[3]
1955	304.6	374.4	312.9
1956	345.0	438.6	357.5
1957	331.4	422.1	342.3
1958	340.9	426.4	313.8
1959	420.2	521.7	321.8

[1] Council of Economic Advisers, Economic Indicators (prepared for the Joint Committee on the Economic Report): May 20, 1960, p. 32. Indexes are yearly averages of weekly closing-price indexes of common stock on New York Stock Exchange, published currently in U.S. Securities and Exchange Commission Monthly Statistical Bulletin.
[2] In addition to mining and manufacturing, covers transportation, utilities, trade, finance, and service.
[3] Including fuels.

TRANSPORTATION

Data on rail and water transportation are not available for 1959, since they are not published until the late fall of the year after the year reported. Therefore the data in tables 34 and 35 cover 1958.

TABLE 34.—Indexes of average freight rates on carload traffic, 1957–58, and average revenue per ton, originated or terminated, 1956–58, in the United States

Item	Indexes [1] (1950=100)		Average revenue per ton [2] (dollars)		
	1957	1958	1956	1957	1958
Products of mines	110	115	2.96	3.11	3.16
Iron ore	115	125	2.07	2.19	2.39
Clay and bentonite	119	129	6.58	7.34	7.79
Sand, industrial	113	121	3.05	3.28	3.53
Gravel and sand, n.o.s	110	116	1.29	1.40	1.35
Stone and rock, broken, ground and crushed	111	117	1.57	1.68	1.72
Fluxing stone and raw dolomite	117	129	1.58	1.73	1.89
Salt	109	112	6.37	6.76	6.96
Phosphate rock	108	111	2.32	2.47	2.34
Mineral manufactures and miscellaneous	112	119	10.68	11.52	11.85
Fertilizers, n.o.s	112	119	7.62	8.11	8.37
Iron, pig	117	125	4.49	5.34	5.30
Cement: Natural and portland	102	105	4.14	4.31	4.03
Lime, n.o.s	116	125	5.73	6.10	6.46
Scrap iron and scrap steel	113	122	3.97	4.13	4.39
Furnace slag	109	116	1.88	1.98	2.08
Nonmineral categories:					
Products of agriculture	112	117	8.48	8.71	8.66
Animals and products	116	123	22.34	23.73	24.21
Products of forests	117	124	7.58	8.04	8.35
Forwarder traffic	115	124	40.67	45.33	45.39
All commodities	112	118	6.32	[3] 6.63	6.96

[1] U.S. Interstate Commerce Commission, Bureau of Transport Economics and Statistics, Index of Average Freight Rates on Railroad Carload Traffic 1949–57: Statement R1-1, 1949-57, August 1959. Indexes are based on the Commission's 1-percent waybill sample. 1959 data are not available.

[2] U.S. Interstate Commerce Commission, Bureau of Transport Economics and Statistics, Freight Commodity Statistics, Class 1 Steam Railways in the United States: Statement 57100, 1956; 58100, 1957; 59100, 1958, table 5.

[3] Revised figure.

The Maritime Administration, U.S. Department of Commerce, published a comprehensive tabulation of data called "Domestic Oceanborne and Great Lakes Commerce of the United States 1955–58." This publication gives detailed data on shipping by port of origin and port of destination by commodity. The United States is divided into 10 coastal areas: North Atlantic, South Atlantic, Gulf, California, Pacific Northwest, Great Lakes, Puerto Rico, Hawaii, Alaska and Pacific Islands. For each area, data are given by dry cargo and tanker, commodity, and port.

TABLE 35.—Rail and water transportation of mineral products in the United States, by products

(Thousand short tons)

Product	Rail [1]			Water [2]		
	1957	1958	Change from 1957 (percent)	1957	1958	Change from 1957 (percent)
Metals and minerals, except fuels:						
Iron ore	122,596	77,132	−37	86,663	54,114	−38
Iron and steel scrap	25,281	16,623	−34	2,209	1,631	−26
Metals and alloys	12,993	9,599	−26	3,015	2,339	−22
Other ores and concentrates	21,821	17,831	−18			
Other scrap	2,509	1,852	−26			
Slag	6,661	5,636	−15	(3)	(3)	(3)
Sand and gravel	66,149	64,315	−3	59,928	55,512	−7
Stone, crushed except limestone	53,603	53,774	(4)			
Limestone, crushed	19,625	14,054	−28	31,269	24,134	−23
Cement	32,148	33,487	+4	5,225	5,141	−2
Phosphate rock	19,352	19,994	+3	2,776	3,122	+12
Clays	10,000	9,196	−8	2,198	2,174	−1
Sulfur	4,016	3,649	−9	4,349	3,927	−10
Other	29,600	24,539	−17	3,904	3,646	−7
Total	426,354	351,681	−18	201,536	155,740	−23
Mineral fuels and related products:						
Coal:						
Anthracite [5]	[6] 30,285	23,770	−22	1,261	865	−31
Bituminous [5]	372,194	307,492	−17	151,161	126,688	−16
Coke [5]	19,564	12,635	−35	480	279	−42
Crude petroleum	2,046	1,196	−42	74,090	67,888	−8
Gasoline	8,853	8,366	−6	90,640	92,226	+2
Distillate fuel oil	9,553	8,475	−11	69,125	72,541	+5
Residual fuel oil				43,940	42,432	−3
Kerosene	19,038	18,134	−5	8,918	9,346	+5
Other				13,105	14,237	+9
Total	461,533	380,068	−18	452,720	426,502	−6
Total mineral products	887,887	731,749	−18	654,256	582,242	−11
Grand total all products	1,370,196	1,181,457	−14	772,862	695,665	−10
Mineral products, percent of grand total:						
Metals and minerals, except fuels	31	30		26	22	
Mineral fuels and related products	34	32		59	61	
Total mineral products	65	62		85	84	

[1] Revenue freight originated excluding forwarder and less-than-carlot shipments, for which data are not available. Source: Interstate Commerce Commission, Freight Commodity Statistics, Class I Steam Railways in the United States, for years ended Dec. 31, 1957 and 1958: Statements 58100 and 59100.

[2] Domestic traffic—all commercial movements between any point in continental United States or its territories and possessions and any other such point. Traffic with Panama Canal Zone, Virgin Islands, and Defense Department vehicles carrying military cargoes excluded. Source: Department of the Army, Waterborne Commerce of the United States, calendar year 1957 and calendar year 1958, pt. 5, National Summaries.

[3] Not separately classified.

[4] Less than 0.5 percent.

[5] Figures for rail shipments include briquets. For water shipment, briquets not reported by type of material; included with "Other."

[6] Includes "Anthracite to breakers and washeries" (thousand short tons): 1957—11,852; 1958—10,587.

The Great Lakes had almost 85 percent of the dry cargo tonnage of domestic water commerce; coastwise traffic had 90 percent of the tanker tonnage. The following tabulation indicates the importance of minerals, including fuels, in Great Lake shipping (in millions of short tons):

Commodity:	*1955*	*1956*	*1957*	*1958*
Iron ore	88.7	76.1	85.6	52.7
Bituminous coal and lignite	36.4	38.5	38.2	32.2
Crushed limestone	28.6	28.1	28.3	20.4
Building cement	1.6	1.7	2.1	1.9
Sand and gravel	1.9	1.8	1.6	1.0
All other commodities	8.5	8.3	8.0	5.9
Total	165.7	154.5	163.8	114.1

The mineral groups listed supplied 95 percent of the traffic in each of the 4 years covered in the data.

FOREIGN TRADE

Value.—Value of imports of nonfuel minerals increased in 1959 but did not reach the levels attained in 1957. Exports also increased for first time since 1957. Iron ore and concentrates continued to show increased imports value and reached a record high. The increase in exports, $20 million, was the result of a large increase in iron and steel scrap, molybdenum, and aluminum exports.

TABLE 36.—Value of minerals and mineral products imported and exported by the United States, 1957–59 by commodity groups and commodities,[1] in thousand dollars

[U.S. Department of Commerce]

SITC No.	Group and commodity	Imports for consumption [2]			Exports of domestic merchandise [3]		
		1957	1958	1959	1957	1958	1959
	CRUDE METALLIC MINERALS [4]						
281–01	Iron ore and concentrates	285,062	231,563	312,415	49,227	34,426	33,824
282–01	Iron and steel scrap	10,168	10,095	11,639	217,938	97,447	167,239
	Ores of nonferrous base metals and concentrates:						
283–07	Manganese	99,828	76,364	74,810	724	700	819
283–11	Tungsten	34,525	11,960	4,235	227	17	5
283–06	Tin	118	11,244	23,282	--------	--------	--------
283–01	Copper	70,238	74,561	98,437	9,964	5,865	1,808
283–08	Chromium	55,661	28,206	31,853	53	49	3,084
283–05	Zinc	89,075	51,902	39,292	1	--------	1
283–03	Bauxite (aluminum ore) and concentrates	60,951	70,142	73,203	4,847	968	2,672
283–04	Lead	61,617	51,856	27,019	257	252	54
[5] 283–19	Columbium	3,038	2,346	2,652	44	37	13
283–02	Nickel	5,300	1,855	1,770	--------	1	--------
[5] 283–19	Titanium:						
	Ilmenite	10,317	6,766	7,991	278	172	290
	Rutile	11,843	4,513	2,943			
[5] 283–19	Cobalt	1,320	--------	--------	--------	--------	543
[5] 283–19	Molybdenum	55	5,530	--------	32,428	15,045	24,778
[5] 283–19	Other	11,516	7,472	9,302	683	9,223	1,900
	Nonferrous metal scrap:						
284–01	Aluminum	5,396	2,969	3,299	6,435	5,595	10,485
	Old and scrap copper	3,039	2,676	1,654	28,414	9,429	5,292
	Old brass and bronze and clippings	2,393	1,852	698	[6] 32,968	[6] 10,456	[6] 12,497
	Other, not elsewhere included	4,932	3,663	3,277	5,852	3,285	3,494
285–02	Platinum-group metals	11,240	8,735	9,618	--------	--------	--------
	Total crude metallic minerals	837,632	666,270	739,389	390,340	192,967	268,798

See footnotes at end of table.

TABLE 36.—Value of minerals and mineral products imported and exported by the United States, 1957–59 by commodity groups and commodities,[1] in thousand dollars—Continued

[U.S. Department of Commerce]

SITC No.	Group and commodity	Imports for consumption [2]			Exports of domestic merchandise [3]		
		1957	1958	1959	1957	1958	1959
	METALS (UNWROUGHT) [4] [7]						
681-01	Pig iron and sponge iron	14, 525	12, 750	36, 621	57, 158	6, 928	773
681-02	Ferroalloys:						
	Ferromanganese	60, 232	11, 046	14, 067	1, 869	464	388
	Ferrochromium	14, 460	7. 818	29, 750	2, 419	1, 012	2, 096
	Other	4, 512	1, 276	2, 390	3, 639	2, 730	4, 024
682-01	Copper	276, 554	133, 234	146, 805	212, 515	191, 932	93, 142
687-01	Tin	130, 739	90, 381	103, 298	1, 526	1. 336	1, 890
684-01	Aluminum	107, 339	117, 297	111, 259	14, 051	24, 220	53, 518
683-01	Nickel (including scrap)	156, 786	87, 565	111, 485	---------	---------	--------
686-01	Zinc	63, 947	35, 625	34, 002	2, 618	797	2, 841
685-01	Lead	89, 993	76, 217	71, 506	1, 345	661	943
689-01	Cobalt	32, 559	28, 664	35, 926	(8)	(8)	(8)
	Mercury	9, 333	3. 914	5, 992	484	95	92
	Other nonferrous base metals	32, 643	21, 795	62, 521	9, 479	8, 123	12, 787
671-02	Platinum-group metals, including unworked and partly worked	24, 492	16, 237	27, 295	2, 804	2, 812	2, 563
	Total metals	1, 018, 114	643, 819	792, 917	309, 907	241, 110	175, 057
	Total metals and metallic minerals	1, 855, 746	1, 310, 089	1, 532, 306	700, 247	434, 077	443, 855
	CRUDE NONMETALLIC MINERALS (EXCEPT FUELS)						
	Diamonds:						
[5] 672-01	Gems, rough or uncut	77, 142	72, 430	94, 299	424	478	607
[5] 272-07	Industrial	50, 870	23, 680	62, 530	544	537	844
	Total	128, 012	96, 110	156, 829	968	1, 015	1, 451
272-12	Asbestos, crude, washed, or ground	60, 140	58, 314	65, 007	340	407	763
271-02	Sodium nitrate	17, 107	13, 431	13, 322	182	---------	--------
272-13	Mica, unmanufactured (including scrap)	10, 910	13, 477	14, 089	46	91	126
[5] 272-14	Fluorspar	16, 031	9, 777	13, 368	81	191	69
272-11	Stone for industrial uses, except dimension	8, 882	7, 890	12, 927	763	921	641
272-06	Sulfur	12, 232	13, 551	13, 901	44, 966	41, 367	42, 000
271-03	Phosphates, natural, ground, or unground	3, 090	2, 944	3, 421	28, 189	25, 234	28, 602
272-04	Clay	2, 938	2, 900	3, 288	13, 528	12, 129	13, 474
(9)	Other nonmetallic minerals (except fuels)	30, 884	44, 248	35, 039	26, 590	26, 375	30, 686
	Total crude nonmetallic minerals (except fuels)	290, 226	262, 642	331, 191	115, 653	107, 730	117, 812
	Grand total, minerals and metals (except fuels)	2. 145, 972	1, 572, 731	1, 863, 497	815, 900	541, 807	561, 667

[1] Grouping of commodities is based upon Standard International Trade Classification (SITC) of the United Nations. Basic data were compiled by Office of the Chief Economist, Bureau of Mines, from copies of unpublished tabulations prepared by Bureau of the Census for the United Nations; tabulations represent a tentative conversion of U.S. import and export classification to SITC categories. Revisions in these data have been made by Office of the Chief Economist insofar as possible to (1) include for various classifications latest revisions compiled by Mae B. Price and Elsie D. Page of Bureau of Mines, from records of U.S. Department of Commerce; (2) incorporate in all years shown changes in assignments of classifications to SITC categories made by Bureau of the Census; and (3) in a few instances make other changes in such assignments that would make the data more comparable or more in line with SITC.

As could be expected, individual commodities and groupings shown or omitted will not in all instances be in accord with usual Bureau of Mines practice as followed in individual commodity chapters in this Minerals Yearbook. In a few cases, values will differ from those for the same commodity in corresponding chapter because of reclassifications, exclusions, or other reasons usually explained by footnotes in chapter.

[2] Includes items entered for immediate consumption, items withdrawn from bonded storage warehouse for consumption, and ores, etc., smelted and refined under bond—included at time smelted or refined product is withdrawn for consumption or for export.

[3] Includes both mineral products of domestic origin and foreign mineral products that have been smelted, refined, manufactured, or otherwise processed in United States.

[4] Excludes gold and silver.

[5] Part of SITC category indicated is covered; remainder of category is covered elsewhere in major grouping.

[6] Copper-base alloy scrap (new and old) including brass and bronze.

[7] Includes alloys.

[8] Exports, if any, are negligible and included with "Nonferrous metal scrap, other" (284-01; see "Crude metallic minerals").

[9] Includes all SITC numbers 271-04· 272-01, -02, -03, -05, -08, -15, -16, and -19; and those parts of numbers 672-01, 272-07 and -14 not shown separately above.

Tariffs.—The U.S. Tariff Commission issued a report March 2, 1959 on its investigation of iron ore, conducted under section 332 of the Tariff Act of 1930. This report described the domestic industry and discussed domestic and foreign production of iron ore, imports, exports, domestic consumption, channels of distribution, price of domestic and imported ore, and U.S. customs treatment since 1930. The Commission announced August 4, 1959, that it was undertaking on its own initiative a study under section 332 of the trend of imports of various lead and zinc products not subject to the quota imposed on unmanufactured lead and zinc since October 1, 1958. On September 1, 1959, the Commission announced a broader study of the domestic lead and zinc industry, pursuant to Senate Resolution 162 of the 86th Congress, adopted August 21, 1959. The report on these investigations was not issued by yearend. The Commission rejected an industry request for formal review of the lead-zinc quotas on December 15, 1959, citing the above investigation adequate and the request untimely. A section 332 investigation of fluorspar was also instituted September 1.

After application from a group of domestic producers, an investigation under the "escape clause" was instituted on zinc sheets. The report of this investigation was not issued by yearend.

During the year, the Director of the Office of Civil and Defense Mobilization rejected the pending applications of the fluorspar, tungsten, and cobalt industries under section 8 of the Trade Agreements Act, the so-called "national defense" clause.

WORLD REVIEW

World Production.—United Nations index of world mining production (including fuels) increased to 122 in 1959 as compared with 116 in 1958 (1953=100). The 5-percent increase was higher than the 3-percent rise for the United States.

TABLE 37.—Index of world metal-mining industrial production[1]

(1953=100)

Year	Free World	North America[2]	Latin America[3]	Asia: East and Southeast[4]	Europe[5]
1955	[6] 110	[6] 108	[6] 111	[6] 107	112
1956	[6] 117	[6] 113	[6] 117	[6] 115	120
1957	[6] 125	[6] 122	[6] 129	[6] 114	[6] 128
1958	[6] 116	[6] 108	[6] 117	[6] 102	[6] 123
1959	120	107	120	108	119
First quarter	116	108	106	99	118
Second quarter	132	136	128	108	123
Third quarter	116	94	122	109	114
Fourth quarter[7]	116	89	123	115	122

[1] U.N. Monthly Bulletin of Statistics: Vol. 14, May 1960, pp. 10–14.
[2] Canada and United States.
[3] Central, South America, and Caribbean Islands.
[4] Burma, Cambodia, Ceylon, Federation of Malaya, and Colony of Singapore, Hong Kong, India, Indonesia, Japan, South Korea, Laos, Pakistan, Philippines, China (Taiwan), Thailand, and South Viet-Nam.
[5] Excludes Albania, Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, Rumania, and U.S.S.R.
[6] Revised figure.
[7] Provisional.

TABLE 38.—Index numbers of production in mining and quarrying, and production in basic metal industries in selected OEEC countries[1]

(1953=100)

Year	All member countries	Austria	Belgium-Luxembourg[2]	France	Germany, West	Greece	Italy	Netherlands	Norway	Sweden	Turkey	United Kingdom
					MINING AND QUARRYING							
1952	99	93	101	104	97	58	88	100	[3] 89	99	83	100
1953	100	100	100	100	100	100	100	100	100	100	100	100
1954	101	109	96	103	104	123	110	100	101	91	88	101
1955	105	116	100	110	110	132	123	101	[3] 111	104	97	100
1956	108	120	100	113	115	150	139	102	123	115	107	100
1957	[3] 112	127	[3] 98	120	119	195	156	105	124	120	110	100
1958	110	124	92	[3] 128	119	205	159	110	[3] 123	112	(4)	95
1959	111	120	79	147	115	(4)	171	113	118	110	(4)	93
					BASIC METAL INDUSTRIES							
1952	104	91	111	112	105	90	101	81	[3] 98	102	------	[3] 102
1953	100	100	100	100	100	100	100	100	100	100	------	100
1954	113	119	108	114	116	103	119	117	[3] 103	110	------	108
1955	131	140	125	133	141	98	148	133	[3] 127	125	------	117
1956	139	151	135	140	150	102	162	131	[3] 154	137	------	119
1957	145	167	131	153	154	120	182	135	[3] 167	[3] 140	------	120
1958	139	165	126	158	146	132	[3] 171	134	[3] 170	[3] 138	------	109
1959	(4)	175	136	(4)	159	(4)	184	(4)	192	157	------	(4)

---

[1] Organization for European Economic Cooperation (OEEC), General Statistics, No. 2, March 1960, pp. 4, 8.
[2] Weighted average, computed by authors, using OEEC weights.
[3] Revised figure.
[4] Data not available.

World Prices.—Prices of metal ores were slightly lower than in 1958 but were stable for the year, increasing slightly in the last quarter. Price indexes for minerals and primary commodities both were somewhat softer and failed to show the last quarter increase.

Ocean Freight Rates.—Indexes of ocean freight rates began to move upward during the last half of 1959 but were still very low as compared with the 5 years preceding 1958.

TABLE 39.—World trade price and freight-rate indexes[1]

(1953=100)

Year	Price indexes			Trip charter freight rate indexes[2]		
	Primary commodities	Total minerals	Metal ores	General cargo	Ore	Fertilizers
1955	99	102	103	165	144	141
1956	100	109	110	203	174	159
1957	102	114	107	145	138	131
1958	[3] 96	108	100	87	90	83
1959	94	103	99	93	90	75
First quarter	93	105	99	88	91	68
Second quarter	94	102	99	87	87	90
Third quarter	95	102	99	91	85	(4)
Fourth quarter	95	102	100	106	94	(4)

---

[1] U.N. Monthly Bulletin of Statistics, March 1960, special tables A and C.
[2] United Kingdom indexes based upon weighted average of quotations by all nations on routes important to United Kingdom tramp fleet in 1951.
[3] Revised figure.
[4] Data not available.

U.S. GOVERNMENT PRINTING OFFICE: 1960

Review of Metallurgical Technology

By Rollien R. Wells [1], Earl T. Hayes [2]

THERE are two recognized methods of recording the state of the metallurgical art. One involves delineation of individual advances reported in the literature. This approach is used effectively in the excellent annual reviews published by some of the leading technical journals and in the technology sections of the individual commodity chapters in this volume. In an effort to more clearly indicate the current trend of metallurgical research and development, the authors of this chapter chose the method of discussing generally selected items of interest brought to their attention during 1959. Since technology cannot be confined by dates on a calendar, most of the items mentioned have been in the process of development for several years. No attempt was made to identify the sources of information used here. Material was drawn from many sources: Nonconfidential correspondence and conversations with authorities of the metallurgical fraternity, papers delivered at technical meetings, and articles noted in the technical press, including particularly Engineering and Mining Journal, Metal Progress, Journal of Metals, Mining Engineering, Industrial and Engineering Chemistry, Chemical Engineering, Chemical and Engineering News, Chemical Week, Materials in Design Engineering, Review of Metal Literature, the Canadian Mining and Metallurgical Bulletin, the Mining Journal (British), and the Journal of the Institute of Metals (British).

During the last decade, much metallurgical research was directed toward discovery and preparation of materials suitable for use in atomic reactors. Now we have entered an era in which metallurgical research is dominated by the urgent need to keep pace with the materials requirements of an accelerating space research and development program. Man has made striking progress in creating fantastically complicated missiles that surge from their launching pads and hurl themselves into space. Problems concerned with materials of construction are many: Materials must be found to withstand erosive, corrosive. high-temperature combustion products of liquid and solid fuels; materials for a missile framework must be light, yet must maintain high strength at elevated temperatures; skin material must be able to withstand extreme temperatures for short periods in an oxidizing atmosphere, must maintain usable strength at high temperatures, and must not go through a brittle range before reaching maximum surface temperature. As rocket motors and fuel technol-

---

[1] Assistant chief metallurgist.
[2] Chief metallurgist.

ogy improve, speed possibilities continue to increase, thus giving rise to more stringent requirements for construction metals. For example, it has been predicted that continuous aircraft speeds in atmosphere will reach 2,500 to 2,700 miles per hour during the next 10 years. Skin temperatures at this speed will reach 2,000° F. and reentry velocities will create short-duration temperatures as high as 10,000° F. All this has brought about a multimillion dollar research program to evaluate metals and alloys as to weight, corrosion, operational heating, aging characteristics, resistance to rough handling, and ease of fabrication.

The gross weight of a missile is vitally important, since each added pound results in a significant decrease in range. Hence, the relationship of strength to weight is one measure of the usability of a construction material. By this standard, some of the newer aluminum alloys are of interest because of strength-weight ratios far superior to steel; unfortunately, these higher strength aluminum materials cannot be welded satisfactorily. The heat-treated titanium alloy, 6Al-4V, is reported to have a strength-weight ratio at room temperature superior to all other materials. It is suitable, however, for only special applications such as fuel-storage tanks, because its strength drops drastically above 800° F. Promising recent developments include titanium alloys that maintain high strength up to 1,000° F., but the use of these materials is restricted by high price and the necessity for special fabrication techniques, such as inert-atmosphere welding to prevent embrittlement.

Beryllium, because of a high strength-density ratio and the ability to withstand temperatures up to 1,200° F., will find limited use in air frame construction—after formidable fabrication problems are solved. Many researchers currently are working to combat beryllium's extreme brittleness and toxicity. Beryllium also is favorably considered for use as missile nose cones of the heat-sink type, although some experts have predicted that, to keep space vehicles from burning when reentering the earth's atmosphere, the use of ablating (vaporizing) ceramics and plastics will soon outmode the heat-sink approach.

Some of the newer stainless steels exhibit ultimate tensile strengths as high as 250,000 p.s.i. at room temperature and retain strengths of up to 130,000 p.s.i. at 1,000° F. One of the newest developments is an yttrium-stainless steel alloy (1 percent Y in 446 stainless) that is reported to be resistant to oxidation at 2,500° F. and to have improved workability, weldability, and resistance to recrystallization at elevated temperatures. High strength characteristics, coupled with good corrosion resistance and ready response to standard fabrication techniques, have resulted in the increasing use of stainless steels in missile construction. The related family of superalloys (high in nickel, cobalt, and chromium) is more oxidation- and heat-resistant than stainless steel and displays considerably higher strength above 1,000° F. The old standby, Nichrome, is still one of the best oxidation-resistant materials made, but is deficient in temperatures above 2,300° F.

Molybdenum has been used extensively in space-vehicle construction because of several favorable properties. It has a high melting point (4,760° F.) high recrystallization temperature (about 2,065° F.), high modulus of elasticity, very low coefficient of expansion, and high thermal conductivity. Although its density is higher than is desired, it is relatively cheap compared with other highly refractory metals. Its chief drawback is that it oxidizes readily, and above 1,450° F. the molybdenum tri-oxide volatilizes and completely destroys the metal. Much research has been, and is being, conducted to develop metal, intermetallic compounds or ceramic protective coatings for molybdenum and molybdenum alloys. Nickel and chromium, plated in alternate layers, provide a good combination of diffusivity, melting point, and cost and show promise for service up to 2,000° F.

Use of vanadium and its alloys has been deterred by the fact that at 1,250° F. in air a liquid oxide forms, thus making processing under protective conditions necessary. Plated nickel coatings, however, inhibit the formation of oxides and allow some use of vanadium alloys up to 1,700° F. These alloys are ductile and easily fabricated and in addition have thermal conductivity double that of stainless steel—an important factor for some missile applications.

One of the most significant recent developments contributing to an increased interest in columbium as a construction metal has been the commercial production of high-purty columbium, using electron-beam furnaces, at the Wah Chang Corp. plant at Albany, Ore. Ingots up to 12 inches in diameter and weighing 3,100 pounds were produced. This metal is considered to be a promising base for highly refractory alloys for use above 2,000° F., although it is conceded generally that 2,500° F. will be their limit. Reappraisal of resources indicates that the world supply of columbium is ample, a reversal to the belief of only 5 years ago. Columbium has several properties indicating its usefulness in space research; high-temperature strength, ready fabricability, and resistance to liquid-metal corrosion. On the other hand, columbium is a getter for oxygen and becomes brittle with oxygen pickup; unless alloys can be developed that are resistant to oxygen passage, columbium, like molybdenum, will require protective coatings.

Tungsten, like molybdenum, is subject to catastrophic oxidation (but at a higher temperature), difficult to arc-melt in large quantities, and is extremely hard; the commercial grades are brittle at room temperature. Also, like molybdenum, it suffers from ductile-to-brittle transition behavior above room temperature, possibly due to the presence of oxygen. Regardless of these drawbacks, tungsten is finding use in the missile field because of high hardness, corrosion resistance, and the highest melting point (6,170° F.) and recrystallization temperature (about 2,850° F.) of all metals. Development of tungsten alloys is in the embryo stage, but research in this field has been accelerated rapidly during the last 2 years. Most of the effort has been directed toward development of new alloys and new fabricating techniques. Fansteel Metallurgical Corp. has developed hot-forging (3,000° F.), machining and spinning procedures; Stauffer-Temescal Corp. has produced ductile tungsten in an electron-beam furnace; Kennecott Copper Corp. among others has made ductile tungsten alloys by combination with 50 percent rhenium; Oregon Metallurgical Corp. has commercially arc-melted tungsten alloys.

Tantalum generally is not considered for extensive application because of the limited supply available in the earth's crust. Also, its price and density are higher than that of its sister metal, columbium. Currently, much interest is being generated by new tantalum-tungsten alloys. Fansteel National Research Corp., and Stauffer-Temescal have announced the development of Ta-W alloys. One such alloy, containing 90 percent tantalum and 10 percent tungsten, reportedly is as strong as tungsten metal up to 4,500° F., much more resistant to oxidation than tungsten, and, after electron-beam melting, is readily fabricated, using conventional steelworking techniques. The tantalum-tungsten alloy is envisioned for use as rocket nozzles in operational missiles.

The demands of space engineering not only have stimulated work in the development of metals and alloys for construction use but also have led to increased study of fabrication and structural methods. The trend in this field is reflected by the increased use of built-up or composite structures. Such structures include corrugated panels, trusscore panels, honeycomb, and clad units. For example, phenomenal strength-weight ratios have been achieved with honeycomb structures built from beryllium foil, using an ultrasonic welding technique for fabrication. The difficulty encountered in machining and finishing units composed of ceramics, carbides, and the hard materials and their alloys has resulted in the development of new finishing methods, including ultrasonic milling, chemical milling, mechanical erosion, and electroerosion. Casting-method research has led to advances in consumable arc welding and has allowed successful casting of molybdenum by the Bureau of Mines and of columbium by the Union Carbide Metals Corp.

Most solid propellant units designed for missiles and rockets have no cooling systems. The reactant gases of a missile are extremely hot and highly corrosive and erosive; thus severe conditions that occur in the nozzle entrance and throat sections require special materials. Excellent thermodiffusivity of graphite and its high deterioration temperature (6,000° F.) allow its use in the nozzle throat section, but its poor resistance to erosion have led to extensive programs to perfect suitable materials other than graphite for this unit. Ceramics have been tried, but they have low strength, are brittle, and have little resistance to thermal shock. Some fiber-reinforced phenolic-resin materials show promise. One answer to the problem may be the use of a tungsten metal liner in the graphite unit. Lack of oxidation resistance should not hamper tungsten in this application, since the discharge gases create a reducing atmosphere and operation times are short. Fabrication of a liner from tungsten sheet would be impractical, if not impossible, but refinement of low-temperature vapor deposition (developed by the Bureau of Mines) may prove to be useful for this purpose. By this method, high-priority tungsten of theoretical density can be deposited on irregular surfaces by reduction of tungsten hexafluoride with hydrogen gas at about 1,100° F.

It is only natural that the rapidly expanding missile-research program of the last few years, with its need for high-temperature materials and high mach-number wind tunnels, necessitated simultaneous development of equipment capable of producing high temperatures needed for simulated environment studies. Thus, the plasma jet—a laboratory curiosity for many years—won recognition almost overnight as a research and production tool. The plasma jet consists, basically, of a small tube in which a stream of gas is heated by an electric arc. The gas emerging from the device resembles an open flame, but since no combustion takes place, temperatures are not limited by internal heats of reaction and are much higher. By adding electric energy continuously, the plasma jet can develop gas temperatures as high as 30,000° F.; combustion of hydrocarbons with oxygen develops a maximum of 5,600° F. The tool has found ready use for furnishing high-temperature air in excess of 6,000° F. for wind-tunnel nozzles for simulated missile-reentry problems. Plasma jet torches have been found valuable for cutting materials like tungsten, Inconel–X, and graphite; 1-inch steel plate can be cut at twice the speed and half the cost of a commercial oxygen torch.

The plasma jet also has been the basis of the inexpensive solution to many industrial wear problems—flame-spraying metallic or metallic oxide coatings on units subject to excessive wear. Flame-spray equipment is now being sold commercially. Production jobs range from coatings on gas-turbine blades and large rolls for paper mills to valve seats and butcher-knife edges. Recent research in a relatively unknown field has shown some unusual properties of stratified coatings produced by flame-spray techniques. Resulting from such studies has been the production of nickel-aluminum oxide mixtures possessing good thermal shock properties.

Thermoelectricity is, in its simplest terms, the use of thermocouples for converting heat to electricity, and vice versa. A thermocouple is "a union of two conductors, as bars or wires, of dissimilar metals joined at their extermities". When such a junction is heated, a small electric current is generated, proportional to the temperature. This principle has been used for many years in controlling electric furnaces and other industrial equipment. Until fairly recently, it was almost forgotten that Jean Peltier, back in 1835, demonstrated to the French Academy of Sciences that if direct current were passed in one direction through such a thermocouple a drop of water could be made to boil, and that if the current were reversed the water would freeze to ice. Since the efficiency of conversion was extremely low, the effect was dismissed with a shrug for more than a century. In the last 5 to 8 years, however, scientists have been successful in raising the efficiency of conversion of heat to energy from about 5 to 18 percent; in some areas this is nearly competitive with steam generation, which is in the order of 30 percent. It seems that even today thermoelectric home-refrigeration units could compete with the older motor-driven-compressor, gas-expansion type. Air-conditioning units could be practical under certain conditions.

Although other combinations of conductors have been used experimentally, bismuth-tellurium couples seem to be the most efficient for thermoelectricity conversion. So tellurium and bismuth, cursed as nuisances by every smelter operator since man began separating metals, suddenly became the center of attention for many of the nonferrous extractive metallurgists of the world. Already this new-found use has consumed the accumulated stocks of tellurium; and no supplement has yet been found to the principal source of this metal—tankhouse sludge from electrolytic copper refineries.

A continued marked increase in the use of the new oxygen-converter process for steelmaking was noted in 1959. This process, unused by American steelmakers before 1954, now is employed to produce more than 4 million tons of steel annually—nearly 3 percent of the steel industry's total capacity of 148.6 million tons. It is reported that further substantial oxygen-converter installations are being built. Electric furnaces, once used only for fine alloys, now are employed widely for production of carbon steel. The annual capacity of electric furnaces was increased during the year by almost a million tons—to a total of 14.4 million tons. This capacity is double that of 19 years ago and constitutes almost 10 percent of the total steel capacity of the United States. Steelmaking by the Bessemer process continues to decrease. About 85 percent of the Nation's steel is made in open-hearth furnaces; it is worthy of note, however, that during the last year open-hearth capacity of the industry increased by only about 100,000 tons—less than one-tenth of the combined expansion in electric and oxygen furnaces.

Successful tests at Strategic-Udy's Ontario pilot plant led to the announcement that the Udy process will be employed to treat copper smelter slag at two new western integrated steel plants. Webb and Knapp Strategic Corp. plans to have the first plant on stream by late 1961 to treat material from the United Verde smelter slag dump at Clarkdale, Ariz. The 30-million-ton dump contains about 33 percent Fe, 0.5 percent Cu, and 2 percent Zn. The company plans to produce semisteel, finished steel, fabricated mill products, and byproduct copper and zinc. In addition, the final slag will be processed into lightweight aggregate and building materials. The initial capacity will be 500 tons of steel per day. Webb and Knapp also have arranged to purchase the 3,000-ton daily production of hot slag from the Anaconda copper smelter at Anaconda, Mont., and the 40-million-ton slag dump there. A similar Udy process plant is expected to be completed at Anaconda in 1963. The Quebec South Shore Steel Co. has announced that it will use a like process developed by Strategic-Udy to produce steel and recover titanium from titaniferous iron ores in a 150,000-ton-per-year plant at Montreal, Canada to be completed in 1961.

Allis Chalmers Manufacturing Co's. grate-kiln system has been hailed as the answer to many problems involved in the agglomeration, heat-treating, or processing of many raw materials such as iron ore and concentrates, magnesite, cement, phosphate rock, dolomite, and limestone. Basically, the treatment consists of hardening green balls or pellets (prepared in a conventional balling drum or pan) in a moving-grate drying furnace with heat supplied by kiln exhaust gases, followed by induration at about 2,400° F. in a rotary kiln. It is claimed that the grate-kiln system produces uniform, hard, durable pellets; that fuel efficiency is excellent; and that dust losses are low. The system apparently has found favor with lime and cement producers; several plants using this method reportedly are to be constructed. Meanwhile the iron-producing companies, which offer the largest potential market for the system, are continuing their investigation of this and other agglomerating systems.

Man's age-old dream of recovering gold from sea water was revived again with announcements about the processes of "foam separation" and "ion flotation." Both processes take advantage of the fact that in a liquid mixture surface-active components (solutes which lower surface tension) are preferentially adsorbed at gas-liquid interfaces, while surface inactive components concentrate in the bulk liquid. Passage of gas through the liquid creates foam, which is easily removed, thus concentrating the surface-active materials. Solutions of metal ions normally are not surface-active; for separation by foaming methods the metals must be associated with some surface-active material such as anionic surface actants, organic chelating and complexing agents, or negatively charged materials exhibiting surface activity. Radiation Applications, Inc., in the fall of 1958 announced results of work conducted by Dr. E. L. Gadden and associates at Columbia University. R.A.I. work primarily has been concerned with the removal of strontium and cesium from radioactive waste. The company reports that they have investigated a number of foaming and complexing agents including aromatic sulfonates, simple amino acids, fatty acids, polypeptides, and various amino acid derivatives. Ion flotation, which Armour Industrial Chemical Co. has publicized, was developed by Professor Felix Sebba of the University of Witwatersrand, Johannesburg, South Africa. Professor Sebba's description of his process would indicate that it is limited to the use of those surface actants that will form insoluable soaps with the ion to be removed.

The processes are not effective above 10^{-3} molar concentration but increase in effectiveness as the concentration becomes less. R.A.I. has reported successful removal of strontium to a molar concentration of 10^{-9}. Thus it seems that the methods are particularly effective in the concentration range where methods such as chemical precipitation, absorption, and ion exchange become impractical.

Foam separation and ion flotation have yet to progress beyond the laboratory stage, and for many applications seem to be economically impractical. Professor Sebba, however, predicts eventual economic recovery of copper, cobalt, aluminum, uranium, and gold from sea water. Applications such as the removal of trace impurities from high-purity metal salts and concentration of trace-metal impurities to allow application of standard analytical techniques are readily visualized.

Research by the Bureau of Mines resulted in reappraisal of the potential of another half-forgotten treatment method—the segregation process for recovery of copper from oxide and sulfide ores. A similar method was developed in 1923 by Minerals Separation, Ltd., of London, England, for treatment of the oxidized ores of the copper belt in northern Rhodesia and the Belgian Congo, but commercial installations never were made. Briefly, the process comprises heating crushed ore with salt and coke or other carbonaceous material at about 700° C. to produce fine particles of metallic copper, which subsequently are recovered by flotation methods. Small-scale batch and continuous tests by the Bureau of Mines showed that the process has merit for treating oxidized and mixed oxide-sulfide copper ores and demonstrated that ores having calcareous, siliceous or bentonitic gangue can be processed with good recovery of copper. Tests of two ores revealed that the process is technologically feasible on a continuous scale. Conventional sulfide-flotation procedures can be used to recover the copper from the heat-treated ore, but considerably larger quantities of reagents are required than for conventional copper sulfide flotation. The Bureau is continuing research in an effort to improve the process and to define the proper conditions for optimum segregation. The method meanwhile is being tried on pilot-mill scale by a Mexican mining firm. An Arizona company has announced that it will construct a 500-ton-per-day segregation plant to treat a copper silicate ore; initial production of 500 tons per day by spring of 1960 is planned, with an eventual increase to 1,000-ton capicity.

The successful commercial application of a new method for the beneficiation of rock salt was announced. The method, developed at Battelle Memorial Institute in 1957, consists of heating gangue particles of a salt-gangue mixture by radiant heat, followed by separation on a belt coated with a heat-sensitive resin. The heated particles adhere to the resin and are rejected; the unheated salt particles are collected as high-grade concentrate. The plant, installed in the Detroit mine of International Salt Co., treats hourly 35 tons of material in the size range of ¼ to ⅝ inch. The method was developed specifically for rock salt, but it is believed that the principles involved may be applicable to other separation problems.

The biggest news during 1959 in the uranium-processing field was the commercial application of a combined alkaline leach and resin-in-pulp method of uranium recovery. Solvent extraction and ion-exchange recovery methods were developed primarily for acid leach processes. Alkaline leaching uses less reagent than acid leaching, but autoclaving is required; normally uranium is recovered by chemical precipitation from filtered leach liquor. Economic analysis of the capital and operating costs of an alkaline filtration versus the alkaline resin-in-pulp ion-exchange process showed that ores containing high bentonitic slime can be treated more economically by the alkaline-R.I.P. method. As a result, Uranium Reduction Co. of Moab, Utah, announced the conversion of 880 tons per day of its plant to alkaline leach for the treatment of ores containing 10 to 15 percent lime; one section will be maintained for acid leaching of low-lime ores. The alkaline leach-R.I.P. process was pioneered at Grand Junction by National Lead Co. and used at the Government-owned Monticello mill until it closed in January 1960.

Of more than passing interest is development of the D.S.M. "sieve bend" screen, which may replace vibrating screens at many mineral-dressing plants. This unit, originally developed by the Dutch State Mines, is a stationary bar-type screen, which may be operated in closed circuit with a ball or rod mill. Pulp is fed tangentially onto a concave screen surface of stainless steel wedge wire, with the bars perpendicular to the direction of flow. A split at 35-mesh is effected with an opening of about 16-mesh, and screen blinding is thus minimized. Proponents claim that the additional advantages are that it requires very little floor space, has no moving parts, gives high screening efficiency, and has extremely high capacity per foot of screening surface. Successful tests in commercial plants on iron ores and nonmetallics have been reported.

Commercial operation of a zinc blast furnace was used for treatment of complex lead-zinc ores by the Imperial Smelting Corp. at Avonmouth, England. Success of the operation is due to maintenance of a high carbon dioxide-carbon monoxide ratio in the furnace and to development of a lead splash condenser, which allows condensation of zinc from the blast-furnace gas. The process depends on the solution of zinc vapor in liquid lead and subsequent removal of the zinc at a lower temperature because of the decrease of the solubility of zinc in lead. Early work, using a furnace atmosphere high in carbon monoxide gas, was unsuccessful because of low thermal efficiency and reduction of iron oxides.

Updraft sintering of lead concentrate—a treatment developed independently and simultaneously by the Broken Hill Associated Smelters in Port Pirie, Australia, and the Lurgi Gesellschaft fur Chemie und Huttenwesen, Frankfurt-am-Main, Germany—has resulted in many advantages compared with the downdraft process it replaced at both plants. Some of the advantages are listed as higher output, lower power consumption, less wear on equipment, higher sulfur dioxide content of the off-gases, and the possibility of producing a more homogeneous sinter of high lead content. At the Lurgi plant, sintering is conducted on concentrate mixes containing a minimum of 70 percent lead; the resulting sinter is smelted in a short rotary furnace.

A new construction material has been developed: Foamed aluminum, made by mixing zirconium hydride with molten aluminum, was first made on a commercial basis in late 1959. The material is reported to be lighter and have better insulating properties at lower cost than most common structural materials. The present market is for roofing and building panels, but the producers also hope to enter the extruded- and molded-parts field with products ranging from airplane floats to water skis.

Technetium, one of the rarest of the rare metals, is now being recovered from waste fission-product solutions by the United Kingdom Atomic Energy Authority. The extraction process includes separation by ion-exchange resin, removal with strong nitric acid, and concentration by evaporation. The solution is further purified and concentrated by extraction with methyl-ethyl ketone and another evaporation step. The method of reduction to metal has not been announced. So far, processing more than 100 tons of radioactive waste has yielded 20 grams of technetium

Any observer of beneficiation and hydrometallurgical practice cannot be unaware of the changes brought about by a new class of organic flocculating agents created only about 6 years ago. The reagents found strongest support in uranium-processing plants, where they proved to be far superior for separating uranium-bearing solutions from clay slime particles than the glue originally used as a flocculant. Their use now has spread to plants processing such materials as copper, gypsum, alum, cement, nickel, cobalt, rare earths, magnesia, clay, borax, potash, soda ash, lithium, petroleum wastes, and woodpulp. Improvements in flocculation activity of ten to several hundredfold have been noted. The results have shown themselves in increased capacity of existing plants, reduced capital costs of new plants, and more efficient use of valuable space. In some instances separations have been made that previously were economically impossible. Most widely publicized have been a group of synthetic polymers made by Dow Chemical Co., American Cyanamid Co., B. F. Goodrich Chemicals, and Monsanto Chemicals. Also of note are several natural guar products including Stein Hall's Jaguar and General Mill's Guartec. The organic reagents are characterized as water-soluble compounds of high molecular weight. Unlike inorganic flocculants such as alum or ferric chloride, the amount required is not affected significantly by the concentration of the solids to be removed. Unfortunately the mechanism of flocculation still is not clearly understood, so that the choice of a flocculant for a particular use must be made by empirical methods.

The Japanese reported one answer to the problem of what to do with unwanted slag. The standard process for the production of nickel from garnierite ore is producing a nickel matte and a slag by fusion of ore with limestone, silica, gypsum, and coke. In the modified process, phosphate rock is used instead of limestone. The result is coproduction of nickel matte and calcium magnesium phosphate. The phosphate material is a good fertilizer for acid soils and is welcome in Japan, where the need for fertilizer is great. Fusion temperature of the charge is higher in the new process, and thus furnace operation is more difficult. Too, the phosphate rock must be imported. In spite of these obvious drawbacks a number of Japanese companies are planning to employ this simultaneous production technique.

A currently popular guessing game is based on the question, "What will be the trend of technology in the 1960's?" Although few of us would care to forecast the exact nature of the next breakthrough, we need no highly polished crystal ball to predict that the rapid pace of scientific research and technological development will continue for at least another decade. In fact, judging from past records the rate probably will be increased materially. After all, it took man from 3000 B.C. until 1830 A.D. to break the "oat barrier" by invention of the train—the first mode of travel faster than horseback. By 1945 man could travel 470 m.p.h.; then in a mere 11 years, he reached the rate of 2,226 m.p.h. According to one prominent metallurgist, "scientists now know more about the fundamental structure of metals from having studied high-purity germanium and silicon for 10 years than they knew after 100 years of messing around with iron and copper." By today's standards, advances in the next 10 years may be fantastic.

Review of Mining Technology

By Paul T. Allsman[1] and James E. Hill[2]

◆

SCIENTIFIC inquiries concerning phenomena that may influence mining technology were widely publicized during the year. The deep-hole drilling project "Moho,"[3] the use of nuclear explosives underground, and the recovery of minerals from the depths of the sea became subjects of scientific and general discussion. The mining industry continued to watch these developments with keen interest, but its more immediate concern was the increasing tempo of competition between mineral commodities, the domestic producers of these commodities, and foreign sources of supply. The competitive situation has intensified the industry's efforts to develop more efficient new mining methods, as well as to improve the efficiency of present practices.

The attitude of the industry was well illustrated by rapidly expended use of low-cost ammonium nitrate explosives, the establishment of rigid schedules for equipment maintenance, and close attention to the detailed costs of production. The complexity of planning a new coal mine is aptly illustrated by the editors of Mechanization in the April 1959 issue, in which they outline the cost of developing a mine and the various problems, factors, and decisions involved.[4]

EXPLORATION AND SAMPLING

While largely unheralded, the unprecedented improvements in surveying techniques have made major contribution to exploration efforts. New instruments and methods have increased productivity, maintained accuracy, and decreased costs.[5] Aerial photography, an essential part of modern photogrammetry, continued to improve. The latest device was a super-wide-angle lens with a 122° angle of coverage. Rapid and accurate surveys were attained with the new high-resolution, low-distortion, wide-angle cameras, projectors for aerotriangulation and compilation, and plotters that may be linked to systems for electronic-computer analysis of the results. The Stereomat, an

---

[1] Chief mining engineer.

[2] Assistant chief mining engineer.

[3] Drilling Magazine, Probing the Mysteries of the Earth's Interior: Vol. 21, No. 1, November 1959, pp. 74–75, 98.

[4] McCurdy, Wayne A., and Fleming, R. M., So—You are Planning a New Mine: Mechanization, vol. 23, No. 4, April 1959, pp. 85–116.

[5] Moore, Roland H., What's New in Surveying Instruments: Civil Engineering, vol. 29, No. 8, August 1959, pp. 52–55.

electronically activated plotting instrument, does automatic profiling and semiautomatic contouring.

Accurate instruments have been developed in the past few years for economic measurement of distance for triangulation base lines and traverse courses. The Geodimeter uses the velocity of light to measure distances. A modulated beam of light is directed from the apparatus to a reflector at another station. The distance between the two stations is determined as a function of the phase difference between the emitted and reflected beam. Distances up to 30 miles have been measured with accuracy acceptable for a geodetic base line. The Tellurometer uses the known velocity of radio waves to measure distances. Utilizing a radio signal transmitter at one station and a receiver at the other station, the distance is measured from the phase difference of the signal and the known velocity of the wave. The Micro-Dist uses the basic principle of the Tellurometer, but the master and remote units are interchangeable and readings are taken from a direct-reading counter rather than a cathode-ray tube.

Revived interest in adapting the gyro principle to surveying has led to development of several gyrotheodolites.[6] Miniaturization of parts has decreased bulk and weight, objectionable features of earlier models. Some of the new gyrocompass designs approach a size that may be utilized for surveying small-diameter boreholes. A gyrotheodolite designed by C. Platt of Hamburg, Germany, is based on the floating pendulous north-seeking system with electrostatically centered spherical float. The bulk, weight, and cost of the instrument deter its general acceptance for mine surveying, but the marked improvements in this respect over the earlier German models should lead to eventual acceptance for special survey applications.

The new Federal mining-claim-assessment law recognizes geophysical exploration as valid assessment work. This should invite a more universal use of geophysical methods now and in the future. Exploration departments of most of the large mining companies employ geophysical methods, but their limited use in mining as compared with petroleum exploration results in a great divergence of opinion among mine management as to when, how, and where to use specific methods and equipment.[7] Hand magnetometer, surface electromagnetic, natural potential, and other electrical methods still prevail in most mining work. Recent improvements in geophysical technique and equipment tend to make geophysical methods attractive despite their cost, especially as costs for other types of explorations are rising.

Geophysical equipment costs range from about $25 for an inexpensive magnetic dip needle to more than $35,000 for a continuous-recording magnetometer or electromagnetometer. Aerial continuous traverse work costs approximately $6 per mile per method. Average mobile continuous traverse charges are $4.50 per mile. Large reconnaissance surveys can cost less than 10 cents per acre; a limited detailed survey may run more than $200 an acre. An average cost is about $20 per acre per method.

---

[6] Pfleider, E. P., Gyro-Compass Surveys Underground Workings and Boreholes: Min. Eng., vol. 11, No. 5, May 1959, pp. 521–526.

[7] Heindricks, Walter E., Jr., Trends in the Application of Geophysics: Min. Eng., vol. 11, No. 7, July 1959, pp. 688–690.

Preliminary results with an airborne gravity meter indicate that the techniques employed overcome some of the former difficulties caused by the large forces imposed on the meter by the motion of the plane.[8] One method uses a balanced system of two masses with a highly stable source of energy. A frequency-controlled timing unit periodically locks the two masses in a central position in their housing coincident with the natural frequency of the oscillating beam system. The distance between one of the masses and a fixed plate is measured by a capacity bridge.[9] Still in the stage of developing equipment, techniques, and interpretive data, the method has been used to outline a large iron ore deposit at Iron Mountain Lake, Quebec.

Induced polarization or overvoltage surveying used in conjunction with resistivity surveys has been successfully applied by Newmont Mining Corp. in exploration for disseminated sulfide deposits.[10] The earth-resistivity method was used more widely to explore for sand and gravel deposits, but the prevailing philosophy that it is a do-it-yourself cure-all for location of deposits often produces disappointing results.[11] The method is based on comparison, and correlation results are dependent on a reliable correlation table. With the use of good techniques and reliable interpretation, the method can be used to contour (1) types of soil by textural classifications, (2) relative quantities of each type of material, (3) location with respect to depth, and (4) lateral extent of each type. An interesting application of geophysical methods is the shock-wave technique used to determine the rippability of soil and rock layers.[12] A shock wave is generated by striking a steel plate laid on the rock surface with an 8-pound hammer. The wave is recorded on a geophone receiving instrument, and the time and distance data are related to applicable tables to indicate depth and rippability of the material.

At the Otanmaki mine in Finland magnetic borehole instruments and survey techniques were used to outline the magnetic-ilmenite ore bodies.[13] Ore lenses are essentially vertical. The ore zones are investigated by diamond drill holes 130 to 650 feet long, drilled from the haulage drifts. However, information from diamond drilling is not adequate for drawing up mine layouts and is supplemented from 200-foot holes drilled by long-hole methods. The magnetic instrument, which is essentially a permeameter, is inserted in these holes to provide information for classifying material as high- or low-grade ore, disseminated ore and waste rock. The equipment consists of two principal components, a probe and a receiver, connected by a cable. The probe is an electronic oscillator housed in a 1-inch-diameter plastic tube 15 inches long. The receiver is a preset amplifier indicating the frequency variation. The probe is attached to and inserted by a rigid rod assembly. The assembly is made up of 1-inch aluminum rods

---

[8] Engineering and Mining Journal, A Geophysical Breakthrough—The Airborne Gravity Meter: Vol. 160, No. 9, September 1959, p. 118.

[9] Lundberg, Hans T., and Ratcliffe, John H., Airborne Gravity Meter, Description and Preliminary Results: Min. Eng., vol. 11, No. 8, August 1959, pp. 817–820.

[10] Baldwin, Robert W., A Decade of Development in Overvoltage Surveying: Min. Eng., vol. 11, No. 3, March 1959, pp. 307–314.

[11] Barnes, Howard E., Earth Resistivity Interpretation for Sand and Gravel Prospecting: Pit and Quarry, vol. 51, No. 11, May 1959, pp. 92–96.

[12] Fahnstock, C. R., Shock-Wave Technique Reveals Subsurface Conditions: Excavating Engineer, vol. 53, No. 6, June 1959, pp. 27–30.

[13] Paarma, H. E., and Levanto, A. E., Underground Exploration at Otanmaki Mine: Mine and Quarry Eng., vol. 24, No. 12, December 1958, pp. 545–554.

with a milled groove down the side into which the cable connecting the probe and meter is pressed. The rods are joined by tongue and locking pin.

As mineral explorations probe deeper, the problems of deep drilling become more evident, together with the inadequacies of existing equipment and techniques to meet them. Recognition of the problem by both mining and petroleum exploration engineers is resulting in a more general evaluation of the techniques employed by the two groups. During the past several years the petroleum engineer has made increased use of "slim hole" drilling and has revived interest in methods similar in many respects to exploratory diamond drilling in mining. Air and gas as circulating medium for diamond drilling are used in drilling for oil and gas to increase speed of penetration and reduce cost.[14] On the other hand, the conventional oil field practice of using mud as a drilling fluid is being used in mineral exploration.[15] While drilling with mud requires some special equipment and controlled operating techniques, it improves core recovery, prevents caving, and reduces the need for casing. Successful techniques using mud drilling (40- to 45-second viscosity), bottom-discharge bits, and step-face bits have been applied to core the friable and blocky western Mesabi ores in Minnesota.[16] The ores are characterized by hard ore bands and a more or less cherty iron formation enclosed in a soft decomposed silica matrix. The coring problem is not only to sample the soft material without loss but to prevent blocking and grinding due to the hard seams.

The major advantages of air and gas drilling are increased bit life and speed of penetration. However, when small quantities of water are encountered the cuttings tend to ball and stick, thus reducing penetration rate. The removal of large quantities of water requires prohibitively large air pressures. The use of low-density drilling mud formed by foaming agents has been introduced, and in a sense the advantages both of air drilling and of mud as a circulating medium are obtained.[17]

At the instigation of South African mining groups, an equipment manufacture began designing for early production a diamond core drill capable of working to 15,000 feet.[18] Again the know-how of the oil industry in relation to deep drilling has been called upon in the design. The derrick, known as a jackknife type, is of tubular welded construction, designed to be assembled on the ground and hoisted to a vertical position. The hoist is a separate unit with a 3-foot-diameter drum, chain-driven and fitted with hydraulic braking for lowering the drill rods.

---

[14] Harris, W. I., and Jackson, Gordon, Recent Developments in Diamond Bit Design for Air and Gas Drilling: Proc. 16th Annual Meeting, Canadian Diamond Drilling Assoc., Toronto, Canada, June 1959, 8 pp. Smith, F. W., Equipment Requirements for Air and Gas Drilling: Drilling Mag., vol. 21, No. 2, December 1959, pp. 66–69.

[15] Hayes, John K., and Read, Vernon, Developments in Core-Drilling Techniques for Deep Minerals Exploration: Min. Eng., vol. 11, No. 1, January 1959, pp. 49–54.

[16] Randolph, E. Richard, Reid, Ian L., and Stephenson, Thomas E., Summary of Recent Experimental Rotary Core Drilling on the Mesabi Range: Pres. at 9th Annual Drilling Symposium, Pennsylvania State Univ., October 1959 (to be published in Proceedings of the Symposium).

[17] Goins, W. C., Jr., and Magner, H. J., Use of Foam-Producing Agents in Drilling: Pres. at 9th Annual Drilling Symposium, Pennsylvania State Univ., October 1959 (to be published in Proceedings of the Symposium).

[18] South African Mining and Engineering Journal, Reef-Designed Diamond Core Drill Nears Completion: Vol. 70, No. 3458, May 22, 1959, pp. 1194–1195.

The need for deeper exploration drilling and the increased costs of recent years have intensified interest in optimizing exploration techniques and refining sampling procedures. To obtain the most detailed and accurate information possible from exploration efforts at a minimum cost is a universal goal. Papers on the subject were presented at the Ninth Annual Drilling Symposium, Pennsylvania State University, and will be published in the Proceedings of the Symposium. The use of mathematical approaches, such as operations research and statistical analysis, was pursued as one means of reaching that goal. Dr. Robert J. Uffen suggested a number of relationships that may be applicable to optimizing a prospecting plan.[19] Three relationships stressed were (1) prospecting profit ratio, (2) completeness of search ratio, and (3) drilling coverage ratio. It is obvious that much work must be done to refine and give meaning to these ratios, but they do offer a rational guide to extensive and expensive prospecting ventures.

Another possible approach is the application of search theory, which was used extensively for military purposes.[20] Search theory considers the tactics of target-seeking and the strategy for allocation of effort, a very close analogy to mineral exploration. Development of electronic computers relieves an onerous aspect associated with the use of mathematical techniques. The combination was used with some success on a magnesite deposit at Gabbs, Nev., to correct the estimates of ore tonnages falling within desired ranges of quality.[21] The Federal Bureau of Mines continued its program of investigation on the theory of sampling with a major emphasis on the application of statistical methods.[22] Working in cooperation with several mining companies, the Bureau analyzed exploration and sampling dâta to investigate the validity and application of statistical methods. Studies were made of tests for random distribution of the mineral, changes in grade and their effects on randomness of sample data, and minimum number of samples for a range of volume required to sample to a specified degree of accuracy.

DEVELOPMENT

Sinking and equipping a shaft, an operation required in the early stages of developing most underground mines, is often difficult and expensive. As such, it is a subject of concern to many mining engineers, who have watched with interest the recent improvements in domestic and foreign shaft-sinking practices. A competitive aspect was added to this interest during the past year by claims and counterclaims from the Union of South Africa and the U.S.S.R. to the world's record for speed in shaft sinking. The Russian record in

---

[19] Uffen, Robert J., Determining an Optimum Prospecting Plan: Pres. at 9th Annual Drilling Symposium, Pennsylvania State Univ., October 1959 (to be published in Proceedings of the Symposium).

[20] Brown, Arthur A., Application of Search Theory to Problems of Drilling and Blasting: Pres. at 9th Annual Drilling Symposium, Pennsylvania State Univ., October 1959 (to be published in Proceedings of the Symposium).

[21] Shurtz, R. F., The Electronic Computer and Statistics for Predicting Ore Recovery: Min. Eng., vol. 11, No. 10, October 1959, pp. 1035–1044.

[22] Becker, Robert M., and Hazen, Scott W., Jr., Probability in the Estimation of Grade of Ore: Pres. at 9th Annual Drilling Symposium, Pennsylvania State Univ., October 1959 (to be published in Proceedings of the Symposium).

April of sinking the new Boutoff No. 3 shaft 868 feet in 30 days was shattered in October, when the Vaal Reefs gold mine shaft in the Union of South Africa was sunk 922 feet in 30 days.[23] By the end of the year a record of over 1,000 feet in 30 days was achieved in South Africa. The Vaal Reefs shaft was sunk at an average rate of 7.09 feet per shift, with an average shift time of 5 hours 15 minutes. Russian statistics show an average advance per shift of 7.5 feet, but the average shift time was 6 hours 28 minutes. The South African achievement was credited in large part to a careful study of time-consuming bottlenecks so that a fast operating cycle could be maintained. For the future any substantial increase in sinking speed is dependent on a breakthrough in the depth that can be broken per round. The record established at Vaal Reefs is even more impressive in that they excavated 55,000 tons compared with 25,000 at the New Boutoff mine.

Mechanical grabs were used by both Russians and South Africans to excavate broken rock. Vaal Reefs employed an electrically operated cantilever boom-type machine of 20-cubic-foot capacity.[24] The unit consists of a boom suspended from the center of the bottom deck of the sinking platform and arranged to be rotated in either direction. The grab hoist is on a traversing carriage which moves radially in the boom. The Russians used five pneumatic grabs, each of 5-cubic-foot capacity.[25] Winches are mounted on the lowest platform of a multiple-platform shaft-sinking cylinder.

An international shaft-sinking and tunneling symposium was held in London during July. The 25 papers presented at the meeting included reports on recent practices in Australia, Belgium, Canada, Czechoslovakia, France, Germany, Great Britain, the Netherlands, Hungary, Poland, South Africa, Sweden, the U.S.S.R., and the United States. The papers will be published by the Institute of Mining Engineers, 3 Grosvenor Crescent, London S.W.I., as a volume on proceedings at the symposium. A subject of general interest was the mechanical shaft mucker developed in the past few years. In Canada the Riddel Clam is widely used in shafts designed with the compartments in line, particularly in shafts with four or five compartments.[26] The Cryderman shaft machine is more commonly used in three-compartment shafts, shafts with compartments arranged in a square or rectangular pattern, and circular shafts, and occasionally in inclined shafts. Until about 15 years ago, shafts sunk in South Africa gold mines were generally rectangular sections lined with timber sets.[27]

---

[23] South African Mining and Engineering Journal. Vaal Reefs 27-Foot Diameter No. 2 Shaft: Vol. 70, No. 3478, Oct. 9, 1959, pp. 901–905.
Engineering and Mining Journal, South Africans Shatter Soviet Shaft Mark: Vol. 160, No. 11, November 1959, p. 128.

[24] Hewitson-Brown, F., Mechanical Lashing in Shaft Sinking: South African Min. Eng. Jour., vol. 70, No. 3475, Sept. 18, 1959, pp. 713, 715, 739.

[25] South African Mining and Engineering Journal, Shaft Sinking Methods in the U.S.S.R.: Vol. 70, No. 3457, May 15, 1959, pp. 1107–1109.

[26] Bennett, W. E., Harrison, Patrick, and Smith, G. E., Shaft Sinking in Canada: Symposium on Shaft Sinking and Tunnelling, The Institute of Mining Engineers, London, England, Paper 2, July 1959, 15 pp.

[27] MacConachie, H., Shaft Sinking Practice in South Africa: Symposium on Shaft Sinking and Tunnelling, The Institute of Mining Engineers, London, England, Paper 15, July 1959, 24 pp.

The advantages of concrete-lined circular shafts were not then sufficient to offset their low sinking speed, except under special conditions of difficult ground or when the time factor was unimportant. Since that time, however, the South Africans have become recognized masters in techniques that allow rapid and efficient sinking of circular concrete-lined shafts. An important advancement was the development of a multiplatform shaft staging designed for concurrent sinking and lining. Beginning with experiments in 1946, efficient mechanical mucking equipment using pneumatically operated cactus-type grabs has been developed. Various methods have been used to maneuver the grab. The oldest type still in use is a centrally pivoted boom traversing circumferentially along the perimeter of the shaft on a monorail fitted below the bottom deck of the stage. A later type featured a centrally pivoted electrically operated cantilever boom with rope and sheave arrangement in the boom for radial and vertical movement of the grab. The latest development eliminates use of ropes and sheaves by using hydraulic rams for all movements of the grab.

Driving raises is an important part of mining in Sweden, and considerable research was directed to improving raising practice.[28] Innovations included a steel ladder platform with the ladder advanced upward by air cylinder, a drilling platform hoisted through a borehole from above, raising with long-hole drilling, and more recently a drilling platform elevator consisting of a steel platform raised by a compressed-air motor which has a pinion climbing and a rack-equipped guide rail. The rack-equipped guide rail is fastened to the rock wall of the raise with expansion bolts. At the Kiruna mine the drilling platform has been adapted to a shaft loading apparatus by attaching a telescope feeder to operate a polygrab controlled by an operator on the platform.

A report by two members of the Academy of Mining, Ostrava, Czechoslovakia, described model tests and theoretical studies leading to design of a proposed shaft-sinking machine.[29] The machine would consist of a housing with a bell-shaped bottom designed to fit the cross section of the shaft. A liquid bath would be maintained in the lower part of the housing at the shaft face. Rock breaking would be accomplished by electrically powered hydraulic ramming with cavity effects. Broken rock would be removed by pumping the liquid out as new liquid is added.

A report on sinking the Lens Shaft No. 19 in France described a drilling platform that allowed drilling 8-foot holes without changing steel.[30] Drillers stand on four plank-type platforms about 4 feet high disposed radially in the shaft. The platforms are supported at the center of the shaft on a four-leg table arrangement and by the shaft-support channel along the circumference.

---

[28] Epstein, V. S., Shaft Raising and Sinking in Sweden: Symposium on Shaft Sinking and Tunnelling, The Institute of Mining Engineers, London, England, Paper 17, July 1959, 20 pp.

[29] Voropinov, J., and Kittrich, R., A new Machine for High Speed Shaft Sinking and Roadway Tunnelling: Symposium on Shaft Sinking and Tunnelling, The Institute of Mining Engineers, London, England, Paper 25, July 1959, 11 pp.

[30] Pot, F., The Sinking of Lens Shaft No. 19: Symposium on Shaft Sinking and Tunnelling, The Institute of Mining Engineers, London, England, Paper 4, July 1959, 18 pp.

Most of the remaining papers at the symposium were on practice in Europe and concerned rock-solidification methods for shaft sinking. Of the 55 shafts completed or started in Britain since 1947, all have used precementation or freezing to some extent.[31] Ordinarily, cementation is used where the bands of water-bearing strata are not thick enough to warrant freezing or where there are no impermeable strata in which to anchor the ice wall. Advances which have taken place in the freezing process since World War II have been due to improvements in refrigeration equipment, drilling techniques, and shaft-lining method used in conjunction with the process. Probably the most important advance was a change from conventional cast-iron liners to lining with bulk concrete backed by corrugated sheets. An interesting alternative to the freezing method of shaft sinking used at Statemine Emma and Beatrix in the Netherlands is shaft boring using drill mud, patterned on the principles of the Honigmann shaft-boring process.[32] The two Beatrix shafts are to be drilled 25 feet in diameter to a depth of 1,500 feet. A 6-foot pilot hole is successively reamed to full dimension using drilling mud in the hole to seal out water and prevent caving. A shaft lining consisting of two concentric steel shells filled with concrete is floated into place down the bored shaft.

Neither the high-speed shaft-sinking procedures developed and used in the Union of South Africa and the U.S.S.R., and recently in Britain, nor the complex shaft-lining systems used in Europe have a general counterpart in U.S. and Canadian mining practice. Mining conditions differ in many respects, including political and economic aspects, mining procedures, and operating requirements. A full-scale production shaft is seldom sunk in the initial period of mine development, and many shafts are sunk deeper in stages as the mine develops at depth. As it becomes economically feasible to mine the deeper large low-grade deposits, conditions will more nearly parallel those in foreign countries, and similar techniques will apply.

In the United States and Canada conventional shaft-sinking practices are the rule, with major improvements being in the mechanization of procedures. A typical example of current practice was the deepening of the Yates and Ross shafts at the Homestake mine in South Dakota.[33] Continuation of sinking and raising-and-stripping extended the mine workings from the 4,100 to the 6,200-foot level. Work was planned for the least possible interruption of production. Equipment included a six-drill shaft jumbo and mechanical mucker. At Shattuck Denn's Barden shaft in Utah[34] a jackleg drill jumbo suitable for use in the rectangular shaft section was devised. The conventional round sinking skip was replaced with a square, 70-cubic-foot skip of special design to reduce time in dumping. Another

---

[31] Marsh, F., Shaft Sinking in Great Britain Since 1947: Symposium on Shaft Sinking and Tunnelling, The Institute of Mining Engineers, London, England, Paper 8, July 1959, 21 pp.

[32] Weehuizen, J. M., New Shafts of the Dutch State Mines: Symposium on Shaft Sinking and Tunnelling, The Institute of Mining Engineers, London, England, Paper 13, July 1959, 36 pp.

Knox, G., The Honigmann Shaftboring Process for Sinking Through Soft Water Bearing Strata: Proc. South Wales Inst. Eng., vol. 48, No. 3, 1932, pp. 263–283.

[33] Campbell, Wm. C., Shaft Sinking at Homestake: Min. Cong. Jour., vol. 45, No. 9, September 1959, pp. 52–57.

[34] Mining Engineering, Faster Shaft Sinking with New Jumbo, Safety Skip: Vol. 11, No. 2, February 1959, pp. 186–187.

rather typical shaft-sinking operation is the Burgin shaft of the Bear Creek Mining Co. in Utah.[35] The three-compartment shaft was sunk to a depth of 1,100 feet as part of an exploration program. The major departure from older conventional methods was the use of a Cryderman shaft mucker. The shaft was completed in 142 days with a crew of 10 shaft men and 10 surface men. Direct cost of labor and materials per foot was $82.30.

Boring was used to an increasing extent to sink small-diameter shafts. The 66-inch calyx core drill, originally designed by J. B. Newsome and used at the Idaho Maryland mine in California in 1936, has been rehabilitated to core an air shaft at American Zinc's Young mine in Tennessee.[36] Rotary oil-drilling rigs were used to bore ventilation shafts.[37]

At Mercury, Nev., an oil-drilling contractor is boring a 44-inch-diameter hole through 965 feet of granite by a concurrent combination of drilling and reaming. The composite borer uses a conventional Hughes Tri-Cone bit in the center as a pilot. Fanning out from the pilot are two roller shaft cutters in the first 20-inch path, three cutters in the 30-inch path, three cutters in the 40-inch path, and four cutters in the 44-inch path. They cut a sloping face 20° from the horizontal with a certain amount of overlap cutting. The same contractor is drilling and reaming a 40-inch-diameter air shaft to a depth of 1,046 feet at the Rare Metals Corporation San Mateo mine in New Mexico.

A down-the-hole shaft-drilling machine has sunk twin shafts, each 76 inches in diameter, to a depth of 500 feet at the C. H. Mead Coal Co. in West Virginia.[38] The machine is an improved version of the original Zeni core drilling machine and is designed to drill out the entire hole. The cutting head is basically an oversized version of the oil-field-type rotary drill bit. Hydraulic jacks are used to anchor the drill housing to the wall of the hole and provide the downward thrust for drilling. Average drilling rate was 30 feet per 8-hour operating shift. Cuttings were discharged through predrilled holes to the mine working below. The Shell Oil Co., used a similar bit to sink a 52-inch shaft for construction of a large underground LPG-storage cavern in Illinois.[39]

Chemical solidification methods were used with varying degrees of success to sink through water-bearing strata. The newest combination, AM–9, made by American Cyanamid, was used by the Meremec Mining Co. in Missouri [40] and at the Cliffside shaft of Phillips Petroleum Co. in New Mexico. While use of the material is still in an experimental stage, it has a major advantage in being able to penetrate and seal materials impervious to cement grout. A 10-percent

---

[35] Everett, F. D., Sinking Methods and Costs at the Burgin Shaft, Bear Creek Mining Co., East Tintic Project, Utah County, Utah: Bureau of Mines Inf. Circ. 7879, 1959, 26 pp.

[36] Engineering and Mining Journal, How the Young Mine Cored an Air Shaft: Vol. 160, No. 11, November 1959, pp. 110–111.

[37] Farson, Bob, Super-Diameter Holes, New Contract Drilling Frontier: Drilling Magazine, vol. 20, No. 12, October 1959, pp. 1–5.

———, Mining: Big New Market for Contract Drilling? Drilling Magazine, vol. 21, No. 2, December 1959, p. 62.

[38] Mechanization, Shaft Sinking 30 feet Per Day: Vol. 23, No. 8, August 1959, pp. 76–78.

[39] Petroleum Week, Huge Bit Drills 52-Inch Hole: Vol. 9, No. 7, Aug. 14, 1959, p. 30.

[40] Bilheimer, Lee, Chemical Grouting Techniques Solves Meremec Shaft Sinking Problem: Eng. Min. Jour., vol. 160, No. 11, November 1959, pp. 107–108.

solution of AM-9 costs about $1 per gallon. Care must be exercised in mixing and handling as the ingredients are corrosive and toxic.[41]

DRILLING AND BLASTING

Theoretical consideration of the physical actions involved in drilling and blasting has been the subject of much research, but the numerous variables in practice make application of theory to operating problems extremely difficult. The Bureau of Mines has established a Mining Research Center at Minneapolis, Minn., and assigned to that center the study of rock penetration and fragmentation. This will concentrate at one center the major Bureau responsibility for theoretical and applied research on drilling and blasting for better correlation of theory and practice.

Hartman reviewed some of the major theoretical studies of drilling action and reported his more recent investigations[42] with the comment that rock drilling remains an art when it should become a science. He relates lack of progress in percussion-drilling techniques directly to ignorance of the nature of impact failure and fundamentals of rock penetration.

Mine operators sought improved efficiency in drilling and blasting practice through selection of efficient equipment, improved explosives, and design of the drill round. A specially designed drill pattern with two 5-inch-diameter burn holes was used at the Snowy Mountain project in Australia to advance a 12.5 by 12.5-foot tunnel a record 526 feet in 6 days.[43] A new method has been tried in Sweden, utilizing the more efficient slabbing action to advance a heading.[44] Holes are drilled parallel to the face from an adjacent parallel drilling gallery. A ring cut round is claimed to give promise of an efficient universal drift round.[45] The proposed round consists of six ring holes spaced radially around a center hole. All holes are parallel and drilled normal to the face. The ring holes are fired first, followed by the center hole at a 50-millisecond delay.

A novel method of drilling and blasting rock without removing overburden has been used successfully on canal construction in Sweden.[46] Special 52-foot-feed rigs were used for drilling. A special device substituted for the rotation mechanism gives increased torque and rotates both the drill pipe and the drill steel running inside the pipe. Hammer blows are also transmitted to both drill pipe and steel, which are sunk simultaneously through the overburden with powerful jetting. The pipe is collared in bedrock and then uncoupled from the drill, after which the rock is drilled in conventional manner. When a hole is completed, plastic pipe is inserted inside the drill pipe and

---

[41] Mark, Leonard E., The Use of AM-9 for Stabilization of Soils or Rock Caves: Pres. 9th Annual Drilling Symposium, Pennsylvania State Univ., October 1959 (to be published in Proceedings of the Symposium).

[42] Hartman, H. L., Basic Studies of Percussion Drilling: Min. Eng., vol. 11, No. 1, January 1959, pp. 68–75.

[43] Engineering and Mining Journal, Australians Use Burn-Cut for Record: Vol. 160 No. 2, December 1959, p. 100.

[44] Janelid, Ingvar, and Oleson, Gunnar, Janal Method, a New Mining Concept: Eng. Min. Jour., vol. 160, No. 7, July 1959, pp. 86–90.

[45] Haber, George B., Ring Cut Proves Promising Basis for Universal Drift Round: Eng. and Min. Jour., vol. 160, No. 7, July 1959, pp. 78–81.

[46] Brannfors, Sten, Blasting Without Removing the Overburden: Civil Eng., vol. 29, No. 11, November 1959, pp. 44–45.

the drill pipe is removed and reused. The first blast, consisting of 4,750 holes, broke 36,000 cubic yards of rock covered with 90,000 cubic yards of overburden. The overburden and broken rock were removed by a specially designed bucket dredge.

Recent tests of fertilizer-grade ammonium nitrate (AN) blasting agents by manufacturers, users, and research establishments were reported at the Fifth Annual Symposium on Mining Research at Rolla, Mo. Test results by the various researchers, agreed closely and can be generally summarized as (1) the higher the density of the prill the lower its sensitivity, (2) sensitivity increases with age of mixture, (3) detonation velocity ranges from 12,000 to 15,000 feet per second, increasing with increased density, and (4) effective fuel oil mixture ranges from 3 to 6 percent. John L. Ryon described the underground use of AN at the Detroit, Retsof, and Avery Island mines of International Salt Co.[47] The face is first undercut; then 2¼-inch holes are drilled to a depth of 8 feet. A mixer mounted on a forklift unit mixes enough AN and fuel oil to load one hole. The hole is bottom-primed with high-velocity dynamite and electric detonator. The AN-fuel mixture is then blown into the hole by a pneumatic loader. Possibly economy of the process is indicated by the respective costs of AN at 3½ cents a pound and dynamite at 18 cents a pound. Tests to determine generation of fumes and static electricity were made, and no serious hazard was indicated. However, the question of safety in the handling, mixing, and use of AN explosives, particularly underground, has not been resolved. The manufacturers, the users, and the Bureau of Mines are collaborating to establish satisfactory safety standards.[48]

Experiments in Sweden have led to a method of "smooth blasting" to minimize blasting cracks in the walls and roofs of underground openings.[49] The work was prompted by the need to construct a number of permanent underground structures. Essentially the method employs closely controlled hole spacing, charge size, explosive distribution in the hole, and ignition of the charges. Unloaded guide holes can be helpful in directing the line of break. Criteria for control were developed by model tests and practical experiments.

MECHANICAL FRAGMENTATION

Breaking rock for mining without the use of explosives has many advantages, which stimulate effort to achieve this purpose economically. Equipment has been developed and used successfully in softer rock formations, but no general-purpose tool has been devised. Interest in hydraulic methods was revived, particularly for mining coal.[50] Bureau of Mines experiments on hydraulic coal mining have advanced a working face by cutting with a hydraulic jet, but research

---

[47] Ryan, John L., Jr., Underground Use of Ammonium Nitrate for Blasting at the Detroit Mine of International Salt Co.: Pres. at 5th Annual Mining Research Symposium, Missouri School of Mines, Rolla, Mo., November 1959.

[48] Hyslop, James, Some Safety Considerations in the Use of Ammonium Nitrate Blasting Agents: Pres. at 5th Annual Mining Research Symposium, Missouri School of Mines, Rolla, Mo., November 1959 (to be published in Proceedings of the Symposium).

[49] Langefors, Ulf, Smooth Blasting: Water Power, May 1959.

[50] Boyd, W. T., Mining and Transporting Coal Underground by Hydraulic Methods: A Literature Survey: Bureau of Mines Inf. Circ. 7887, 1959, 33 pp.

remains to be done on design of nozzle, jet action, and various conditions affecting efficient application of the method. As a result of the performance obtained with the Robbins tunnel-boring machine in driving the 25-foot 9-inch tunnel at Oahe Dam, a larger model has been made to drive the new 29½-foot tunnel now under construction.[51] At Vandenberg Air Force Base in California, a Badger tunneling machine excavated personnel tunnels for an underground Titan Missile base.[52] Using a cutter head equipped with chisel-shaped hard-metal-tipped knives, the machine cuts a 10-foot-diameter tunnel in shale. Chalky limestone at the Arkansas Cement Corp. quarry is being broken by rippers.[53] The broken material is picked up by a 33-yard pan scraper and hauled directly to the quarry hopper.

MATERIALS HANDLING: LOADING, TRANSPORTATION, HOISTING

The Kolbe wheel excavator, one of the world's largest earth-moving machines, was demonstrated in June at the Cuba, Ill., mine of United Electric Coal Co.[54] With a theoretical digging capacity of 4,800 cubic yards an hour, they expect to obtain an output of 3,500 cubic yards per hour on a yearly basis. For underground loading, the Transloader, a more sophisticated model of the Gismo, has been developed and shows lower loading and hauling cost than earlier models of the machine.[55]

In comparing the three basic open-pit haulage systems—rail, truck, and combination—used on the Mesabi, the basic factors of selection are cost and safety.[56] Truck haulage permits a higher degree of flexibility in mining, but rail haulage provides lower transportation cost. A comparison shows that despite an average haulage distance of 4.3 miles and elevation of 271 feet for rail haulage against a distance of 0.78 miles and elevation of 144 feet for trucks, rail haulage costs are 8 percent below those for trucks. Experience with electric-truck haulage at the Crestmore underground limestone mine shows that these units can carry about 50 percent more rock in about half the time required with diesel trucks.[57] Cost is lower, and ventilation problems are reduced.

A belt conveyor system used in conjunction with a bucket-wheel excavator transports 3,000 tons per hour at the Nchanga copper mine.[58] The initial lift is 170 feet, and this will be increased in 86-foot increments to a total of 1,000 feet. The total length of the

---

[51] Karolevitz, R., World's Largest Mole Tunnels at Oahe Dam: Excavating Engineer, vol. 53, No. 6, June 1959, pp. 31–32.

[52] Construction Methods and Equipment, Unusual Tunnelling Machine Bores Tunnels for Missile Base: Vol. 41, No. 12, December 1959, p. 99.

[53] Pit and Quarry, New 1,400,000-Bbl. Plant of Arkansas Cement Corp.: Vol. 51, No. 10, April 1959, pp. 80–83.

[54] Mining Congress Journal, Kolbe Wheel Excavator: Vol. 45, No. 7, July 1959, pp. 67–68.

[55] Calhoun, Wm. M., Transloader Mining: Canadian Min. Jour., vol. 80, No. 1, January 1959, pp. 61–64.

[56] Matheson, W. N., Jr., Selecting an Open Pit Haulage System: Min. and Eng., vol. 11, No. 4, April 1959, pp. 409–413.

[57] Nalle, P. B., Electric Truck Haulage at Crestmore: Min. Eng., vol. 11, No. 4, April 1959, pp. 405–408.

[58] South African Mining and Engineering Journal, The Conveying System with the Greatest Carrying Capacity in South Africa: Vol. 70, No. 3465, July 10, 1959, pp. 90–95.

conveyor system from bench to stacker dump is 11,709 feet. The Ada, Okla., plant of Ideal Cement Co. has a 5½-mile conveyor system between the quarry and plant.[59] Reported to be the longest permanent belt conveyor system ever built, it consists of seven separate belt conveyors. The entire production process, including the conveyor system, is controlled from a central control room. The longest of the seven belt conveyors is 2½ miles long; the shortest is 550 feet long. The system transports 1,000 tons of crushed limestone per hour. Elaborate steps have been taken to insure adequate power for starting under all conditions of load and to control the inertia forces that would be released in case of power failure. Individual conveyors have a longer coasting time progressively from the quarry to the plant.

GROUND SUPPORT AND CONTROL

Numerous reports were published during the year, reviewing the effects of rock properties and stress conditions in relation to mining.[60] The Bureau of Mines has prepared for publication a bulletin on design of underground openings in competent rock which summarizes its research in this field. A symposium on rock mechanics at the Colorado School of Mines in April also reviewed the subject, while attemping to relate factors common to comminution, underground rock failure, and rock breakage by explosives.[61] The various attempts to review the subject of rock mechanics are spurred by the large volume of information published since the end of World War II. The information published to date has been largely theoretical from investigations to establish applicable principles. Greater application of these data to mining problems is becoming evident as the information becomes better disseminated and understood. One application has been reported at Cananea Consolidated Copper Co. mine, where drill-core data are used to aid ground-control planning.[62] Combining factors of core recovery and modulus of rupture of the rock, a graph was obtained to indicate the relative competence of the rock in the area of a proposed drift. Studies of photoeleastic models were helpful in shaft planning at the Champion Reef mine in the Kolar Gold fields.[63]

Increased application of rock mechanics is evident in underground civil engineering works. The Snowy Mountains Hydro-Electric

---

[59] Skillings' Mining Review, Cross-Country Belt Conveyor System Serves Cement Plant: Vol. 48, No. 39, Dec. 26, 1959, pp. 1–4.

[60] Denkhaus, H. G., Hill, F. G., and Roux, A. J. A., Review of Recent Research Into Rockbursts and Strata Movement in Deep-Level Mining in South Africa: Trans. of the Inst. of Mining and Metallurgy (South Africa), vol. 68, 1958–59 (Bull. 629, April 1959, pp. 285–310).

Corlett, A. V., and Emery, C. L., Design of Functional Structure In or On Rock: The Eng. Jour. (Canada), vol. 42, No. 4, April 1959, pp. 86–92.

Leeman, E. R., The Measurement of Changes in Rock Stress Due to Mining: Mine and Quarry Eng., vol. 25, No. 7, July 1959, pp. 300–304.

Morrison, R. G. K., Some Basic Elements in Ground Control: Canadian Min. Jour., vol. 80, No. 9, September 1959, pp. 107–113.

Stefanko, R., Rock Mechanics—Aid to Strata Control: Mineral Industries (Pennsylvania State Univ.), vol. 29, No. 2, November 1959, pp. 4–7.

Issacson, E. de St. Q., Rock Pressure in Mines: Mining Publications, Ltd., London, England, 1959, 210 pp.

[61] Quarterly of the Colorado School of Mines, Third Symposium on Rock Mechanics: Vol. 54, No. 3, July 1959, 366 pp.

[62] Ruff, A. W., and Parkinson, L. J., How Cananea Uses Drill-Core Data to Aid Ground Control Planning: Eng. Min. Jour., vol. 160, No. 9, September 1959, pp. 88–91.

[63] Cowlin, W. R., and Isaacson, E. de St. Q., Planning and Research Necessitated by Rockbursts in an Underground Shaft: Mine and Quarry Eng. vol. 25, No. 1, January 1959, pp. 32–37, February 1959, pp. 76–82.

Authority in Australia utilized rock-physical-property tests, rock-stress analysis, model studies, and instrumentation for rock-mechanics investigations of underground structures included in the project.[64] Extensive rock work in construction of the Niagara power project by the Hydro-Electric Power Commission of Ontario made it desirable to obtain data on the structural-stability characteristics of the rock formations.[65] Careful measurement of rock movements were made, and the data were interpreted in terms of rock stability and effect on installed structures.

The difficulty of translating theoretical stress analysis to variable in situ rock conditions is a major problem. Model studies offer one possible solution; another is in situ measurement of stress and fracture patterns. Several methods of measuring fractures by sonic-wave propagation are being investigated.[66]

Experimental mining of pillars by St. Joseph Lead Co. at Bonne Terre, Mo., was carefully instrumented to obtain quantitative measurements of rock action in the affected area.[67] It was determined that reasonable stope convergence and pillar loading can be detected and measured by means of extensometer, seismotron, and convergence warning lights. The Bureau of Mines continued experiments on cementation of roof strata in coal mines.[68] Epoxy- and polyester-type resins have been injected as bonding material. Tests indicate that a method of strengthening mine roofs by injecting bonding material can be developed as a system of roof support. The Silver Mountain project of Hecla Mining Co. in Idaho has used a combination of spiling and yieldable supports to drive through extremely heavy ground.[69] A similar combination was used at the Sunnyside coal mine No. 3 in Utah to reopen caved development slopes.[70]

DRAINAGE

Large quantities of water contained in the dolomites of the South African Far West Rand have been a major problem of mining in the area. Although extensive precementation has been carried out in connection with shaft sinking, heavy flows of water have been encountered. Ultimate pumping capacity at the Western Deep Level is scheduled to be 30 million gallons a day.[71] Individual pumps capable of delivering 168,000 g.p.h. will operate in parallel against a static head of 3,400 feet. Experiments also have been made on the de-

---

[64] Moye, D. G., Rock Mechanics in the Investigation and Construction of T. I. Underground Power Station: Snowy Mountains, Australia: Pres. at Annual Meeting, Geological Society of America, St. Louis, Mo., November 1958, 49 pp.

[65] Hogg, A. D., Some Engineering Studies of Rock Movement in the Niagara Area: Pres. at Annual Meeting, Geological Society of America, St. Louis, Mo., November 1958, 27 pp.

[66] Lutsch, A., The Experimental Determination of the Extent and Degree of Fracture of Rock Faces by Means of an Ultrasonic Pulse Reflection Method: Jour. of the South African Inst. of Min. and Met., vol. 59, No. 8, March 1959, pp. 412.

[67] Reed, John J., Case History in Pillar Removal: Min. Eng., vol. 11, No. 7, July 1959, pp. 701–705.

[68] Maize, Earl R., and Oitto, R. H., Jr., Cementation of Bituminous Coal-Mine Roof Strata: Bureau of Mines Rept. of Investigations 5939, 1959, 22 pp.

[69] Crandall, W. E., The Use of Yieldable Steel Ring Sets at Silver Mountain: Pres. at Am. Min. Cong., Denver, Colo., 1959.

[70] Quigley, James, Advancing Through Caved Ground with Yieldable Arches: Min. Eng., vol. 11, No. 7, July 1959, pp. 720–722.

[71] South African Mining Engineering Journal, Water Control at Western Deep Levels: Vol. 70, No. 3468, July 10, 1959, pp. 71–73.

sign of underground bulkheads to control water at high pressures.[72] Local and foreign practices were investigated, and specially designed bulkheads were tested for leakage and failure. It was determined that the required length of a concrete plug depends more on leakage than on the structural strength of the plug.

An aspect of water control that is gaining increased attention is the possible effect of water on the stability of mine openings. It has been found that the instability of slopes in open-pit mines is the result of excess hydrostatic pressure behind the face of the pit.[73] Effective stabilization can be accomplished in many cases by subsurface drainage to relieve hydrostatic stress. The effect of a saturated rock formation on the stability of an underground opening has not been determined, but obviously this condition will affect the transfer of pressure and stress within the rock.

VENTILATION

High temperatures encountered at depth in mines on the Rand in South Africa continue to pose serious ventilation problems. Excluding capital redemption, total ventilation cost at the East Rand Proprietary mines is about 38 cents per ton mined.[74] As mining progresses to 12,000-foot depths, this cost is expected to increase to about 63 cents. At a depth of 12,000 feet, rock temperature will be approximately 130° F., and at air velocities of 500 to 600 feet per minute maximum permissible wet-bulb temperature will be 92° F. Heat flow from the rock will be 200 B.t.u.'s per minute for each 5 square feet of rock face.

A high dust concentration in mine air at the Pronto mine in Canada was reduced by changes in the ventilation pattern, ore handling practices, and arrangement of ore pass, dumps and grizzly station.[75] Dust generation and air surges caused by dumping in the original ore-pass system were the major contributing sources of air contamination. Plans to deepen the shaft included dust-control measures to correct the faulty conditions introduced by the original ore-pass system.

An idea of the ventilation requirements of the deep gold mines in South Africa can be gained from recent contracts for ventilation plants.[76] A contract for Harmony Gold Mines specifies four units each of 400,000 c.f.m. at 30-inch water gage, each driven by a 2,600-h.p. motor. Western Deep Level has specified four units each of 550,000 c.f.m. at 24-inch water gage. Vaal Reefs has ordered two units each of 575,000 c.f.m at 23-inch water gage.

---

[72] Garrett, W. S., and Campbell Pitt, L. T., Tests on an Experimental Underground Bulkhead for high Pressures: Jour. of the South African Inst. of Min. and Met., vol. 59, No. 5, December 1958, p. 257.

[73] Wilson, S. D., Slope Stabilization in Open Pit Mining: Pres. at Min. Cong., Denver, Colo., September 1959.

[74] Mining Journal (London), Ventilation Costs in Ultra-Deep Mines: Vol. 252, No. 6456, May 15, 1959, pp. 525.

[75] Pudney, Harold, How Pronto Cut Dusting at Dumps and Passes: Eng. and Min. Jour., vol. 160, No. 11, November 1959, pp. 103–106.

[76] South African Mining and Engineering Journal, Big Fans for Big Mines: Vol. 70, No. 3483, Nov. 13, 1959, p. 1263.

HEALTH AND SAFETY

Papers were presented by authors from eight countries at the 10th International Conference of Directors of Safety in Mines Research held at Pittsburgh, Pa., during September. Primarily concerned with coal mine safety, the subjects covered included safety of explosives, testing of explosives, hazards of blasting, gas and dust explosions, ignition, ventilation and fire hazards.

In comparing fire protection facilities of coal mines and industrial plants, the plants place much greater emphasis on fire protection.[77] On a comparative basis of capital investment in fire protection versus total mine or plant investment, the least equipped plant spends as much as the best equipped mine.

MINING PRACTICE AND PERFORMANCE

Mechanization and mobility are being introduced wherever possible into mine operations. This has been particularly evident in open-pit and trackless room-and-pillar mining. One result has been a shift in supervisory responsibility to increased concern with machinery. Productivity may be directly related to machine operating time, as is evident in the extreme case of the giant excavators now used in strip mining. Equipment selection for an efficient balanced production schedule is of prime importance for a successful operation. Equipment maintenance and replacement is an integral part of production cost. Reported experience at the Bagdad open-pit mine in Arizona gives an idea of the complexity of balancing equipment capacity for maximum efficiency.[78] With various types of equipment, loading costs varied from 3 to 22 cents, and hauling costs from 3.6 to 10.6 cents, per ton. At the Anaconda Co. Berkeley pit at Butte, Mont., nearly 19 percent of total man-hours and 23 percent of total operating costs are charged to repair of capital equipment.[79]

The New York Trap Rock Corp. has adopted an approach to equipment replacement that evaluates the factors necessary for a sound decision.[80] Using the basic pattern developed by the Machinery and Allied Products Institute, Washington, D.C., an individual plan was evolved to evaluate a request for equipment replacement. To the basic formulae comparing estimated operating cost of present and new equipment is added the difference between cost of continuing ownership and of acquiring new equipment. For present equipment, consideration is given to such items as restorative repairs, salvage value, salvage-value loss, and interest or cost of money. For proposed equipment, consideration is given to actual depreciation, cost of money, and anticipated salvage value. After replacement a periodic appraisal of new equipment is made. F. G. Kuehl, of International

---

[77] Stahl, R. W., Firefighting Facilities at Coal Mines Compared With Those at Other Industrial Plants: Bureau of Mines Inf. Circ. 7931, 1959, 11 pp.

[78] Hardwick, W. R., and Jones, E. L., Open-Pit Copper Mining Methods and Costs at the Bagdad Mine, Bagdad Copper Corp., Yavapai County, Ariz.: Bureau of Mines Inf. Circ. 7929, 1959, 30 pp.

[79] McWilliams, John R., Mining Methods and Costs at The Anaconda Co., Berkeley Pit, Butte, Mont.: Bureau of Mines Inf. Circ. 7888, 1959, 46 pp.

[80] Schwellenback, H. J., Replacement of Capital Equipment: Min. Eng., vol. 11, No. 10, October 1959, pp. 1003–1005.

Talc Co., proposes a method of calculating "pay-out time" for machinery replacement.[81]

Two of the newer Canadian mines, one mining a steeply dipping and the other a flat lying ore body, have achieved high productivity. The Geco Mine in Ontario uses a system of sublevel blasthole stoping and has eliminated tramming by a combination of scram-drift slushing, transfer raises, ore pass to an underground crushing station, and conveyor system from the crusher to the hoisting shaft.[82] A production of 25 tons per underground manshift is obtained. At Gaspe Copper, experimental stoping operations established that with patterned rock bolting mining widths of 50 feet could be maintained.[83] The B ore body is mined fullface in stopes 45 feet wide and 20 to 36 feet high. In the C ore body, an upper heading 45 feet wide and 18 to 50 feet high is mined fullface, followed by benching the lower portion of the ore using horizontal drilling. Production of 32 tons per manshift is obtained.

---

[81] Kuehl, F. G., Economics of Equipment Replacement in the Mining Industry: Pres. at American Min. Cong., Denver, Colo., September 1959.

[82] Marshall, G. M. T., Blasthole Mining at Geco: Min. Eng., vol. 11, No. 8, August 1959, pp. 797–802.

[83] Brissenden, W. G., Mining at Gaspe Copper: Min. Eng., vol. 11, No. 9, September 1959, pp. 899–903.

Technologic Trends in the Mineral Industries

(Metals and Nonmetals Except Fuels)

By Donald R. Irving [1] and Arthur Berger [2]

◆

THIS CHAPTER is new to the Minerals Yearbook and will appear regularly hereafter. Its purpose is to present statistics that reflect technologic trends in the minerals and metals industries (except fuels).

Much useful information has been collected annually through the Bureau of Mines mineral commodity and employment and injuries canvasses. However, these data must be supplemented by further data to permit evaluation of the type, direction, and rate of technologic change, which are vitally important in long-term mineral planning. In addition to, and fully as important as, expanding the available data is the need to ascertain that the various items collected are obtained from identical reporting units, to enable direct comparisons to be made.

Expanded collection of data on technologic trends is a logical extension of the statistical program of the Bureau of Mines.[3] Next to the records of production and consumption, the most significant indexes of change in the mineral industries are the trends in mineral technology and labor, material, and energy productivity. Some of these changes have been reported in commodity chapters (vol. I) and State chapters (vol. III) of the Minerals Yearbook. In the 1930's the Yearbook contained chapters on Ore-Concentration Statistics (1930–35) and Progress in Mine Mechanization (1937). Also in the 1930's, the Works Project Administration enlisted the cooperation of the Bureau of Mines to study the technology, employment, and output per man in mineral industries, which resulted in a series of publications.[4]

---

[1] Assistant to the Chief, Division of Minerals.

[2] Assistant chief statistician.

[3] Yopes, Paul F., Measurement of Technologic Trends in the Mineral Industries: Paper presented at AIME Annual Meeting, February 1956, 10 pp.

[4] Tryon, F. G., Read, T. T., Heald, K. C., Rice, G. S., and Bowles, Oliver, Technology and the Mineral Industries: Works Project Administration Rept. E–1, April 1937, 63 pp.

Plein, L. N., Berquist, F. E., and Tryon, F. G., Mechanization Trends in the Metal and Nonmetal Mining as Indicated by Sales of Underground Loading Equipment: Works Project Administration Rept. E–3, June 1937, 19 pp.

Yaworski, Nicholas, Spencer, Vivian, Saeger, G. A., and Kiessling, O. E., Fuel Efficiency in Cement Manufacture, 1909–1935: Works Project Administration Rept. E–5, April 1938, 92 pp.

Corry, A. V., and Kiessling, O. E., Mineral Technology and Output Per Man Studies: Grade of Ore: Works Project Administration Rept. E–6, August 1938, 114 pp.

Haskell, A. P., Jr., and Kiessling, O. E., Technology, Employment, and Output Per

More recently, the Bureau of Labor Statistics, U.S. Department of Labor, published data on trends in output in mining from 1935 to 1949.[5] Productivity studies are continuously underway to determine and analyze the Nation's economic growth rate.[6] These various studies seek to determine the factors that influence productivity or efficiency and to measure the effect of individual factors. Invariably, analyses disclose that some of the causes of increased productivity are readily discernible, whereas others can only be conjectured. Rarely, if ever, can a cause be isolated and its results measured precisely. Even long-term changes based on gross data often prove to be gravely distorted reflections of actual trends. Frequently, trends that seem firmly established are broken, interrupted, or lose their earlier and more dependable characteristics. The reasons for the breaks may be too complex for evaluation. They may stem from the deep unplumbed nature of people, which causes changing fashions and customs, or be so obscure as to be unrecognized. Despite these handicaps, the analysis and measurement of past changes give useful knowledge for industrial and governmental planning, provided the user fully understands their limitations and guards against drawing unwarranted conclusions from poorly understood and sometimes poorly measured data.

Planning for this chapter began in 1956, and the mineral industries were canvassed for 1957, 1958, and 1959 data. This 3-year span is too short to establish technologic trends, but the information from the canvasses has proved useful in other ways. Some of the 1957 data were published in the 1958 Minerals Yearbook,[7] and 1958 data on the use of water in the mineral industries were given in a special report.[8]

All metals and minerals except the fossil fuels are within the planned scope of this chapter. Technologically, the studies will extend from exploration and development through all subsequent preparation stages until the materials lose their identity as mineral commodities or enter commerce, whichever comes later. This chapter is intended to supplement the commodity, employment and injuries, and review chapters of volume I of the Minerals Yearbook. In some instances it will contain similar or identical data rearranged to reveal trends or to allow comparisons of commodities. Examples of data available in various commodity chapters of volume I of the Minerals Yearbook are given in tables 1 through 8.

Man in Phosphate-Rock Mining, 1880–1937: Works Project Administration Rept. E–7, November 1938, 130 pp.

Leong, Y. S., Erdreich, Emil, Buritt, J. C., Kiessling, O. E., Nighman, C. E., and Heikes, G. C., Technology, Employment, and Output Per Man in Copper Mining: Works Project Administration Rept. E–12, February 1940, 260 pp.

Yaworski, N., Kiessling, O. E., Baxter, C. H., Eaton, Lucien, and Davis, E. W., Technology, Employment, and Output Per Man in Iron Mining: Works Project Administration, Rept. E–13, June 1940, 264 pp.

Spencer, V. E., Production, Employment, and Productivity in the Mineral Extractive Industries, 1880–1938: Works Project Administration Rept. S–2, June 1940, 168 pp.

[5] U.S. Department of Labor, Bureau of Labor Statistics, Trends in Output Per Man-Hour in Mining, 1935–49: August 1950, 40 pp.

[6] U.S. Department of Labor, Bureau of Labor Statistics, Productivity: A Bibliography: Bull. 1226, November 1957 (874 references cited), 182 pp.

[7] Allsman, P. T., and Hill, J. E., Review of Mining Technology: Ch. in Bureau of Mines Minerals Yearbook 1958, vol. I, 1959, pp. 66–67.

[8] MacMillan, R. T., Water Use in the Mineral Industry: Bureau of Mines Spec. Rept., January 1960. Vol. I, River Basins (Water Use Regions), 21 pp.; vol. II, Metropolitan Areas, 13 pp.

Copper.—The percentage of copper ore mined by open-pit methods reached a peak in 1952. However, the overall grade of copper ore continued to decline and reached a low of 0.78 percent copper in 1959.

TABLE 1.—Copper ores and copper produced in the United States, distributed by principal mining methods

Year	Production			Distribution by mining method					
	Ore			Open pit		Block caving		Other	
	Thousand short tons	Copper, thousand short tons	Copper (percent)	Ore (percent)	Copper (percent)	Ore (percent)	Copper (percent)	Ore (percent)	Copper (percent)
1939	55,239	714	1.29	59	42	20	15	21	43
1943	98,120	1,069	1.09	69	55	16	14	15	31
1946	62,232	595	.96	66	60	17	15	17	25
1947	87,864	832	.95	73	69	14	12	13	19
1948	84,729	818	.97	76	69	14	11	10	20
1949	76,033	731	.96	78	72	12	9	10	19
1950	94,586	886	.94	81	76	8	7	11	17
1951	95,494	901	.94	84	76	7	7	9	17
1952	99,947	901	.94	85	77	7	6	8	17
1953	101,065	906	.90	83	75	8	7	9	18
1954	93,654	816	.87	83	75	10	15	7	10
1955	112,550	979	.87	83	77	5	10	12	13
1956	131,776	1,082	.82	78	73	9	13	13	14
1957	129,716	1,061	.82	77	72	11	14	9	14
1958	114,824	959	.84	76	71	13	15	11	14
1959	103,716	807	.78	79	74	9	12	12	14

Gold.—In contrast to most other commodities, the gold content of placer gravels mined has increased. This trend reflects the rising costs of labor and materials and a constant price for gold.

Iron Ore.—The iron-ore mining industry attempts to maintain a stable labor force; therefore, the rate of production per man from year to year is more a function of the quantity of ore produced than of changes in productivity, unless the industry pattern is changed through other influences. The long-range increase in productivity reflects not only increased operating efficiency but the increasing proportion of open-pit production. The marked increase in the concentration ratio was principally the result of taconite and jaspillite deposits being brought into production; however, consumer insistence on higher grade ore, which resulted in beneficiation of some hematite ores, also was a significant factor.

Comparable data for 1923–35 appeared in the Iron Ore, Pig Iron, Ferro-Alloys, and Steel Chapter of Minerals Yearbook 1937, Review of 1936.

Phosphate Rock.—The differences in the types of phosphate-rock ores mined in Florida, Tennessee, and the Western States (Idaho, Montana, Utah, and Wyoming) and the changing technology of the phosphate-rock processing industry in the Western States are reflected in the data in tables 4, 5, and 6. The decrease in the phosphorous pentoxide (P_2O_5) content of marketable phosphate rock from the Western States, from 32 percent in 1944 to slightly less than 27 percent in 1959, results from expanded output of elemental phosphorous in electric furnaces beginning about 1948. The increasing

TABLE 2.—Gold production at placer mines in the United States by method of recovery

Year	Bucketline dredging			Dragline dredging		
	Mines producing	Material treated (thousand cubic yards)	Average value per cubic yard	Mines producing	Material treated (thousand cubic yards)	Average value per cubic yard
1943	20	23,857	$0.161	3	3,180	$0.157
1944	17	25,844	.141	2	1,213	.180
1945	35	41,184	.131	9	457	.203
1946	59	108,198	.152	65	7,506	.179
1947	60	120,362	.150	71	10,326	.188
1948	57	120,062	.139	42	5,224	.211
1949	52	110,897	.134	35	4,583	.174
1950	43	108,250	.159	23	4,623	.159
1951	36	93,215	.152	25	2,343	.132
1952	37	69,941	.179	16	1,937	.154
1953	21	65,314	.184	14	660	.130
1954	22	62,082	.201	15	554	.264
1955	25	53,352	.228	19	480	.214
1956	19	48,955	.210	16	774	.113
1957	18	45,489	.229	13	378	.145
1958	17	43,693	.230	11	132	.301
1959	16	36,998	.237	12	157	.464

Year	Suction dredging			Nonfloating washing plants		
	Mines producing	Material treated (thousand cubic yards)	Average value per cubic yard	Mines producing	Material treated (thousand cubic yards)	Average value per cubic yard
1943	----------	----------	----------	23	713	$0.173
1944	----------	----------	----------	17	289	.192
1945	----------	----------	----------	38	1,175	.291
1946	4	43	$0.244	93	3,480	.430
1947	12	80	.259	137	4,281	.469
1948	8	84	.197	153	5,985	.385
1949	12	279	.178	183	4,995	.497
1950	17	264	.189	185	8,510	.353
1951	13	180	.139	117	7,049	.346
1952	9	74	.144	103	4,795	.400
1953	7	88	.136	128	4,019	.508
1954	3	4	.488	128	2,974	.618
1955	5	2	.671	118	2,259	.826
1956	2	24	.040	110	1,355	1.235
1957	----------	----------	----------	94	2,188	.631
1958	3	3	.328	107	2,601	1.037
1959	4	7	.369	89	2,569	1.367

Year	Hydraulicking			Underground placer and small-scale hand methods			All placers		
	Mines producing	Material treated (thousand cubic yards)	Average value per cubic yard	Mines producing	Material treated (thousand cubic yards)	Average value per cubic yard	Mines producing	Material treated (thousand cubic yards)	Average value per cubic yard
1943	99	884	$0.436	217	147	$1.170	362	28,781	$0.193
1944	24	244	.147	310	132	.754	[1] 367	27,722	.156
1945	111	1,200	.413	189	132	1.086	382	44,148	.146
1946	157	2,724	.415	311	702	.309	689	122,653	.169
1947	167	2,839	.477	331	794	.520	778	138,682	.171
1948	137	1,709	.348	327	321	1.148	724	133,385	.158
1949	81	780	.319	318	255	.630	[1] 680	121,789	.153
1950	88	640	.238	291	277	.727	647	122,564	.175
1951	51	258	.470	171	105	1.215	413	103,150	.166
1952	33	130	.356	133	105	.914	331	76,982	.194
1953	48	440	.153	155	166	.591	373	70,687	.202
1954	48	258	.282	138	182	.699	354	66,054	.223
1955	44	200	.267	98	242	.560	309	56,535	.254
1956	36	50	1.014	83	103	.798	266	51,261	.238
1957	30	100	.752	73	64	1.270	228	48,219	.249
1958	49	348	.331	102	80	1.162	289	46,857	.277
1959	35	101	.855	75	41	2.683	231	39,873	.315

[1] A mine using more than 1 method of recovery is counted but once in arriving at total for all methods.

TABLE 3.—Production[1] of crude and usable iron ore in the United States

Year	Crude ore				Usable ore			
	Thousand gross tons	Gross tons per man-hour	Open pit, percent	Underground, percent	Thousand gross tons	Gross tons per man-hour	Iron, percent	Concentration ratio, crude to usable ore
1936	54,856	1.473	63.1	36.9	48,789	1.310	50.6	1.12
1937	80,906	1.574	67.5	32.5	72,094	1.402	50.5	1.12
1938	31,718	1.036	51.7	48.3	28,447	.929	49.6	1.11
1939	57,353	1.469	63.3	36.7	51,732	1.325	50.3	1.11
1940	83,404	1.711	67.3	32.7	73,696	1.512	50.6	1.13
1941	107,720	1.784	73.7	26.3	92,410	1.531	50.9	1.17
1942	126,527	1.682	73.4	26.6	104,883	1.394	51.0	1.21
1943	119,675	1.562	72.6	27.4	100,595	1.313	51.0	1.19
1944	112,255	1.710	74.2	25.8	94,654	1.442	50.7	1.19
1945	107,509	1.768	74.2	25.8	89,056	1.465	51.3	1.21
1946	85,152	1.698	75.8	24.2	71,294	1.422	50.4	1.15
1947	114,899	1.773	75.1	24.9	93,475	1.442	50.3	1.23
1948	127,375	1.833	78.4	21.6	101,617	1.462	49.3	1.25
1949	105,713	1.709	74.5	25.5	85,264	1.378	50.0	1.24
1950	126,678	1.920	77.0	23.0	98,409	1.492	49.3	1.29
1951	153,181	2.028	79.0	21.0	117,003	1.549	50.6	1.31
1952	129,261	2.042	78.1	21.9	98,157	1.551	50.4	1.32
1953	157,870	2.362	79.3	20.7	118,390	1.771	50.3	1.33
1954	109,861	2.234	77.7	22.3	77,752	1.581	50.7	1.41
1955	142,251	3.094	81.0	19.0	102,294	2.225	51.1	1.39
1956	147,088	2.920	81.9	18.1	97,313	1.932	51.2	1.51
1957	162,198	3.120	82.4	17.6	106,066	2.040	51.2	1.53
1958	110,642	3.130	83.6	16.4	67,372	1.910	53.0	1.64

---

[1] Includes manganese-bearing ore in the Lake Superior District.

need to upgrade western ores to meet specifications for both Acid- and Furnace-grade phosphate rock is shown by a drop in the proportion of marketable phosphate rock from approximately 98 percent in 1953 to 80 percent in 1959.

TABLE 4.—Marketable production of phosphate rock in the United States

Year	Florida		Tennessee		Western States		Total United States	
	Thousand long tons	P_2O_5 content (percent)	Thousand long tons	P_2O_5 content (percent)	Thousand long tons	P_2O_5 content (percent)	Thousand long tons	P_2O_5 content (percent)
1944	3,487	33.55	1,413	28.87	300	32.00	5,200	32.19
1945	3,815	33.50	1,261	28.23	324	31.79	5,400	32.17
1946	5,281	33.26	1,316	28.80	572	31.63	7,169	32.31
1947	6,381	33.24	1,490	28,46	1,240	31.69	9,111	32.25
1948	7,184	33.37	1,500	28.07	704	30.97	9,388	32.33
1949	6,695	33.53	1,403	27.51	779	30.30	8,877	32.30
1950	8,597	33.20	1,472	28.19	1,045	28.52	11,114	32.09
1951	8,212	33.44	1,424	27.30	1,139	28.36	10,775	32.09
1952	9,205	33.57	1,445	26.37	1,415	28.20	12,065	32.08
1953	9,331	33.58	1,519	26.27	1,654	27.51	12,504	31.88
1954	10,437	33.09	1,633	25.84	1,751	27.64	13,821	31.55
1955	8,747	33.54	1,466	26.53	2,052	27.49	12,265	31.69
1956	11,822	33.07	1,685	25.99	2,240	27.32	15,747	31.50
1957	10,191	32.89	1,812	25.88	1,973	27.12	13,976	31.17
1958	10,851	33.11	1,903	26.01	2,125	27.29	14,879	31.37
1959	11,564	32.81	1,755	26.10	2,550	26.94	15,869	31.12

TABLE 5.—Mine production of phosphate rock ore in the United States

Year	Florida		Tennessee		Western States		Total United States	
	Thousand long tons	P_2O_5 content (percent)	Thousand long tons	P_2O_5 content (percent)	Thousand long tons	P_2O_5 content (percent)	Thousand long tons	P_2O_5 content (percent)
1953	35, 972	11. 39	2, 465	21. 95	1, 702	27. 32	40, 139	12. 71
1954	41, 232	11. 47	2, 571	20. 50	1, 783	27. 43	45, 586	12. 60
1955	34, 491	11. 26	2, 980	17. 11	2, 200	26. 82	39, 671	12. 56
1956	47, 250	9. 59	2, 524	22. 82	2, 424	26. 65	52, 198	11. 02
1957	40, 584	10. 28	2, 752	21. 33	2, 124	26. 13	45, 460	11. 69
1958	41, 084	11. 09	3, 003	20. 81	2, 372	26. 31	46, 459	12. 49
1959	43, 365	10. 79	2, 709	20. 52	3, 175	25. 61	49, 249	12. 28

TABLE 6.—Production of marketable phosphate rock per ton of ore in the United States in percent

Year	Florida	Tennessee	Western States
1953	25. 9	61. 6	97. 2
1954	25. 3	63. 5	98. 2
1955	25. 4	49. 2	93. 3
1956	25. 0	66. 8	92. 4
1957	25. 1	65. 8	92. 9
1958	26. 4	63. 4	89. 6
1959	26. 7	64. 8	80. 3

Sand and Gravel.—Productivity in the commercial sand and gravel industry in the United States doubled from 1940 to 1959 as automation assumed an increasingly important role. A secondary factor was the increase in the percentage of plants with capacities of 100,000 to 1,000,000 short tons a year.

TABLE 7.—Productivity, size of plants, and degree of preparation in the commercial sand and gravel industry in the United States

Year	Percentage of commercial industry reporting	Production		Size of plant by size group			Prepared material, percent
		Thousand short tons	Tons per man-hour	Less than 100,000 tons annually, percent	100,000–1,000,000 tons annually, percent	Over 1,000,000 tons annually, percent	
1940	77	101, 143	3. 3	85. 5	14. 3	0. 2	88
1941	80	144, 595	3. 7	80. 2	19. 5	. 3	88
1942	79	183, 256	3. 6	76. 6	22. 7	. 7	86
1943	78	138, 114	3. 3	79. 7	19. 9	. 4	87
1944	80	120, 968	3. 3	82. 8	17. 0	. 2	85
1945	77	116, 632	3. 5	80. 8	19. 0	. 2	85
1946	83	159, 203	4. 1	75. 5	23. 9	. 6	91
1947	85	179, 665	4. 0	74. 4	24. 9	. 7	91
1948	86	200, 707	4. 4	73. 4	25. 9	. 7	91
1949	86	199, 656	4. 3	74. 4	25. 0	. 6	91
1950	92	236, 420	4. 7	72. 3	26. 8	. 9	90
1951	90	258, 336	5. 0	67. 4	31. 4	1. 2	89
1952	93	280, 507	5. 2	67. 5	31. 4	1. 1	90
1953	90	278, 745	5. 5	69. 9	29. 1	1. 0	89
1954	92	364, 647	5. 3	75. 5	23. 9	. 6	88
1955	86	362, 780	5. 7	75. 0	24. 2	. 8	88
1956	87	410, 774	6. 2	72. 3	26. 7	1. 0	87
1957	81	373, 430	6. 2	73. 2	25. 9	. 9	82
1958	79	384, 059	6. 9	69. 6	29. 5	. 9	84
1959	100	534, 924	6. 8	72. 1	26. 9	1. 0	87

Uranium.—The effects of an assured market and intensified exploration are illustrated in the more than 100-fold increase in production and almost 90-fold increase in reserves of uranium between 1948 and 1959.

TABLE 8.—Production, grade, and reserves of uranium ore in the United States

Year	Production		Reserves, million short tons	Year	Production		Reserves, million short tons
	Thousand short tons	Grade, percent U_3O_8			Thousand short tons	Grade, percent U_3O_8	
1948	54	0.31	1.0	1954	914	.32	10.0
1949	89	.27	1.0	1955	1,306	.30	27.0
1950	230	.31	2.0	1956	2,185	.28	63.0
1951	290	.32	2.0	1957	3,303	.28	78.0
1952	390	.32	3.0	1958	4,416	.27	82.5
1953	610	.31	5.0	1959	6,117	.26	88.9

New Information (1958 Canvass).—Before the 1958 canvass was completed it became evident that for greatest utility the data should be coded for machine tabulation. Reconciliation of the 1958 data on technology, employment, and production has been delayed mainly by mechanical problems resulting from the transfer of the data from canvass forms to punch cards. However, available data are presented for the following commodities: Barite, bauxite, chromite, copper, diatomite, fluorspar, iron ore, lead, manganese, perlite, pumice, tripoli, and zinc. The Bureau of Mines anticipates that 1958, 1959, and 1960 statistics will be available for the 1960 chapter on technologic trends, covering an expanded list of commodities and additional technologic data.

In preparing data for tables 9 through 25, which are new to the Minerals Yearbook and which cover only 1958, mines were classified on the basis of their economically dominant commodity. For example, if the major source of income came from copper, the mine was listed as a copper mine, even if the tonnage of another commodity (for example, zinc) was greater. For many commodities, especially nonmetals, classification is not a major problem, as the entire marketable product usually is one commodity. Lead was the only one of the 13 commodities for which data are presented that had more than 20 percent of its output produced in mines where lead was not the major source of income (table 9).

TABLE 9.—Selected mineral commodities produced in the United States showing percent of total production as a primary product, 1958

Commodity	Percent	Commodity	Percent
Barite	100	Lead	70
Bauxite	100	Manganese	80
Chromite	97	Perlite	100
Copper	97	Pumice	100
Diatomite	84	Tripoli	100
Fluorspar	100	Zinc	83
Iron ore	99		

Percent of Usable Product.—The percentage recovery of usable product is the reciprocal of tonnage of crude ore to usable product. Table 10 shows the 1958 figures.

TABLE 10.—Relation of crude ore mined to usable product in the United States, 1958, for selected commodities

Commodity	Usable product, percent	Ratio of crude ore to usable product, tons	Commodity	Uusable product, percent	Ratio of crude ore to usable product, tons
Copper	0.8	123	Barite	59	1.7
Lead	2.4	42	Iron ore	63	1.6
Zinc	4.0	25	Perlite	77	1.3
Manganese	33	3.0	Bauxite	83	1.2
Fluorspar	37	2.7	Pumice	83	1.2
Chromite	40	2.5	Tripoli	100	1.0
Diatomite	53	1.9			

Underground vs. Surface Mining.—As shown in table 11, the percentage of ore mined by underground methods ranges from 99 (lead) to zero (diatomite, perlite, and pumice). Table 12 gives the approximate grade of selected ores mined by underground and surface methods. The percentage of copper and iron ore produced at underground and surface mines, by major States, is given in tables 13 and 14.

TABLE 11.—Distribution of ore tonnage between underground and surface mining in the United States, 1958, for selected commodities

Commodity	Underground, percent	Surface, percent	Commodity	Underground, percent	Surface, percent
Barite	15	85	Iron ore	16	83
Bauxite	18	82	Lead	99	1
Chromite	74	26	Manganese	24	76
Copper	22	78	Perlite	----------	100
Diotomite	----------	100	Pumice	----------	100
Fluorspar	77	23	Zinc	98	2

TABLE 12.—Percent of usable product to crude ore mined for selected commodities by underground and surface methods in the United States, 1958

Commodity	Usable product, percent		Commodity	Usable product, percent	
	Underground	Surface		Underground	Surface
Barite	65	56	Fluorspar	33	50
Bauxite	83	89	Iron ore	84	56
Chromite	33	11	Manganese	21	39
Copper	1	.8			

TABLE 13.—Copper mined by underground and surface methods by major States, 1958

State	Underground, percent	Surface, percent	State	Underground, percent	Surface, percent
Arizona	26	74	Nevada	5	95
Michigan	85	15	New Mexico	(1)	99+
Montana	34	66	Utah	----------	100

[1] Less than 0.5 percent.

TABLE 14.—Iron ore mined by underground and surface methods by major States, 1958

State	Underground, percent	Surface, percent	State	Underground, percent	Surface, percent
Alabama	69	31	Minnesota	2	98
Michigan	86	14	Utah		100

Total Material and Crude Ore Handled vs. Usable Product.—For 12 of the 13 commodities quantitative data were obtained on crude material handled as well as crude ore mined (table 15). The difference between the two figures represents overburden and waste removed during mining, exploration, and development. In general, the figures represent material handled at producing mines and do not include material handled at prospects and mines in the initial development stage. The figures on total material handled emphasize the magnitude of the earth-moving job that must be performed each year to obtain the minerals needed for the economy of the United States and indicate a large potential market for explosives and mining machinery. Table 17 gives a breakdown of total material handled in underground and surface mines per ton of usable product.

TABLE 15.—Material handled for selected commodities in the United States, 1958

Commodity		Total material handled	Crude ore mined	Overburden and waste
Barite	thousand short tons	(1)	794	(1)
Bauxite	thousand long tons	1,823	1,540	283
Chromite	thousand short tons	441	354	87
Copper	do	208,767	114,587	94,180
Diatomite	do	5,154	696	4,458
Fluorspar	do	1,054	856	198
Iron ore	thousand long tons	214,472	108,105	106,367
Lead	thousand short tons	8,958	6,369	2,589
Manganese	do	2,161	1,933	228
Perlite	do	337	330	7
Pumice	do	2,117	2,012	105
Tripoli	do	26	26	(1)
Zinc	do	7,292	6,077	1,215

(1) Data not available.

Relation of Ore Mined to Usable Product.—*Bauxite.*—The ratio of bauxite ore mined to usable product for Arkansas, the major producing State, was 1.1 to 1, the same as the national average.

Chromite.—The ratio of chromite ore mined to usable product for Montana, the major producing State, was 2.1 to 1, compared with the national ratio of 2.5 to 1.

Copper.—The ratio of copper ore mined to copper recovered in the six major copper producing States ranged fom 106 to 1 in New Mexico to 170 to 1 in Michigan, compared with the national average of 123 to 1. The high ratio for Michigan results from inclusion of old tailings pumped from Lake Superior.

Fluorspar.—About half of the fluorspar produced in the United States came from Illinois in 1958. The ratio of fluorspar ore mined

TABLE 16.—Relation of total material handled and crude ore mined to usable product for selected commodities in the United States, 1958

Commodity	Usable product	Tons of material to usable product	Tons of crude ore to usable product	Tons of overburden and waste to usable product
Barite	Ore	(1)	1.7	(1)
Bauxite	do	1.4	1.2	0.2
Chromite	do	3.2	2.5	.7
Copper	Metal	224	123	101
Diatomite	Ore	14.1	1.9	12.2
Fluorspar	do	3.3	2.7	.6
Iron ore	do	3.3	1.6	1.7
Lead	Metal	48	42	6
Manganese	Concentrate	3.4	3.0	.4
Perlite	Ore	1.3	1.3	
Pumice	do	1.2	1.2	
Tripoli	do	1	1	
Zinc	Metal	30	25	5

[1] Data not available.

TABLE 17.—Relation of total material handled to usable product by underground and surface methods, for selected commodities in the United States, 1958

Commodity	Material handled per ton of usable product, tons		Underground, percent of surface
	Underground	Surface	
Bauxite	1.2	1.7	71
Chromite	31	9	344
Copper	107	265	40
Fluorspar	3.2	3.6	89
Iron ore	2.0	3.6	56
Manganese	7.2	2.7	267
Zinc	31		

to usable product in Illinois was 3.0 to 1, compared with the national average of 2.7 to 1.

Iron Ore.—The ratio of crude iron ore mined to usable ore in Minnesota, which accounted for almost two-thirds of the U.S. output, was 1.8 to 1, compared with the national average of 1.6 to 1 and ratios of 1.5 to 1 for Alabama and 1.1 to 1 for Michigan.

TABLE 18.—Relation of crude copper ore mined to recovered copper for major States, 1958

State	Recovery of copper, percent	Ratio of crude ore to copper, tons	State	Recovery of copper, percent	Ratio of crude ore to copper, tons
Arizona	0.9	117	Nevada	0.7	147
Michigan	.6	170	New Mexico	.9	106
Montana	.8	121	Utah	.8	129

TABLE 19.—Relation of crude iron ore mined to usable ore for major States, 1958

State	Usable ore, percent	Ratio of crude ore to usable ore, tons
Alabama	67	1.5
Michigan	91	1.1
Minnesota	56	1.8

Lead.—In Missouri, which produced 40 percent of the domestic lead in 1958, 42 tons of ore was mined to produce 1 ton of lead. The comparable national ratio was 42 to 1.

Manganese.—In the United States, 3.0 tons of manganese ore was mined to produce 1 ton of usable product. Comparable ratios for the five major producing States ranged from 2.2 to 1 for Minnesota and New Mexico to 7.0 to 1 for Montana. Data are not available for Michigan, a substantial producer of manganese, because the manganese output of most mines was secondary to iron ore in value and the mines were classified as iron-ore mines.

Zinc.—In Tennessee, the leading zinc-producing State, an average of 32 tons of ore had to be mined to obtain 1 ton of zinc—a ratio about three times those of the other important zinc-producing States and considerably higher than the national average of 25 to 1.

TABLE 20.—Relation of crude manganese ore to usable product for major States, 1958

State	Usable product, percent	Ratio of crude ore to usable product, tons	State	Usable product, percent	Ratio of crude ore to usable product, tons
Arizona	31	3.2	Nevada	28	3.6
Minnesota	45	2.2	New Mexico	45	2.2
Montana	14	7.0			

TABLE 21.—Relation of crude zinc ore mined to recoverable zinc for major States, 1958

State	Recovery of zinc, percent	Ratio of crude ore to zinc, tons	State	Recovery of zinc, percent	Ratio of crude ore to zinc, tons
Idaho	9	11	New York	10	10
Montana	8	13	Tennessee	3	32

Underground Mining Methods.—In 1958, 65 percent of the copper produced underground in the United States was mined by block caving. Four methods—room and pillar (25 percent), block caving (21 percent), sublevel caving (20 percent), and open stope (20 percent)—accounted for 86 percent of the iron ore mined underground. Seventy-seven percent of the manganese ore mined underground was recovered from timbered stopes.

TABLE 22.—Copper ore mined by underground methods, by States, 1958

(Thousand short tons)

State	Block caving	Cut and fill	Open stope	Room and pillar	Shrinkage stope	Square set	Timbered stope	Top slice	Unspecified	Total
Arizona	13,357	291	21		34	712		5	37	14,457
Idaho					4					4
Michigan			1,597	4,230	123					5,950
Montana	3,035	318	1		2	2	192		24	3,572
Nevada	68		19		15	426				515
New Mexico			1							16
North Carolina									154	154
Oregon					1					1
Tennessee			770							770
Total	16,460	609	2,409	4,230	179	1,140	192	5	215	25,439
Percent	65	2	9	17	1	4	1	(1)	1	100

[1] Less than 0.5 percent.

TABLE 23.—Iron ore mined by underground methods, by States, 1958

(Thousand long tons)

State	Block caving	Cut and fill	Open stope	Room and pillar	Shrinkage stope	Sublevel caving	Top slice	Unspecified	Total
Alabama				3,726				12	3,738
Michigan	1,889		3,215	336	331	1,766		299	7,882
Minnesota		164				1,185	329	90	1,768
Missouri				433					433
New Jersey			138	15	597			405	1,155
New York			378	94				118	590
Pennsylvania	1,471		14		4				1,489
Texas								8	8
Wisconsin						878		275	1,153
Wyoming	499								499
Total	3,859	164	3,745	4,604	932	3,829	329	1,207	18,692
Percent	21	1	20	25	5	20	2	6	100

[1] Less than 0.5 percent.

TABLE 24.—Manganese ore mined by underground methods, by States, 1958

(Thousand short tons)

State	Cut and fill	Open stope	Room and pillar	Square set	Sublevel caving	Timbered stope	Unspecified	Total
Arizona		4	22		8			34
Arkansas		1					1	2
California		5	14					19
Montana		15		3		374	28	420
Nevada	1	1						2
New Mexico	1	1	7					9
Total	2	27	43	3	8	374	29	486
Percent	(1)	5	9	1	2	77	6	100

[1] Less than 0.5 percent.

Productivity.—The tonnages of crude ore mined and of total material handled per man-hour in the United States in 1958 were essentially the same for copper- and iron-ore mining.

TABLE 25.—Copper mining productivity by States, 1958

(Underground and open pit)

State	Crude ore per man-hour (short tons)	Total material handled per man-hour (short tons)
Arizona	4.5	9.7
Michigan	2.3	2.4
Montana	4.0	8.9
Nevada	6.1	15.6
Average	4.4	8.1

Statistical Summary of Mineral Production

By Kathleen J. D'Amico[1]

◆

THIS SUMMARY is shown in volumes I and III of this series on mineral production in the United States (including Alaska and Hawaii), its island possessions, the Canal Zone, and the Commonwealth of Puerto Rico, and on the principal minerals imported into and exported from the United States. For further details on production, see the several commodity and area chapters. A summary table comparing world and U.S. mineral production also is included.

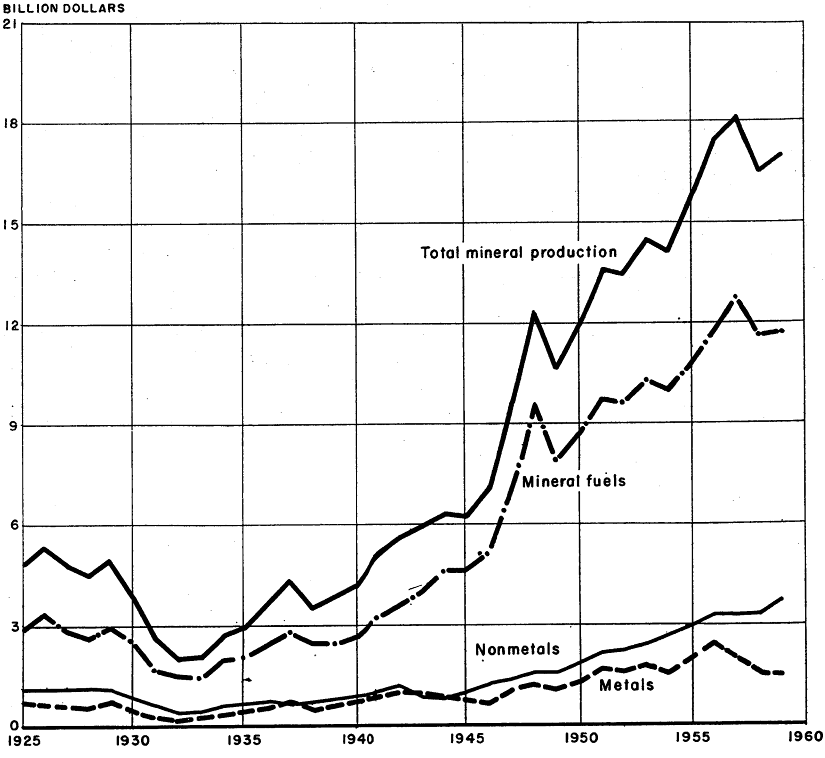

FIGURE 1.—Value of mineral production in the United States, 1925–59.

---

[1] Publications editor.

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.

Data for clays and stone, 1954–59, include output used in making cement and lime. Mineral-production totals have been adjusted to eliminate duplicating these values.

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

TABLE 1.—Value of mineral production in the United States,[1] 1925–59, by mineral groups [2]

(Millions)

Year	Mineral fuels	Nonmetals (except fuels)	Metals	Total	Year	Mineral fuels	Nonmetals (except fuels)	Metals	Total
1925	$2,910	$1,187	$715	$4,812	1943	$4,028	$916	$987	$5,931
1926	3,371	1,219	721	5,311	1944	4,574	836	900	6,310
1927	2,875	1,201	622	4,698	1945	4,569	888	774	6,231
1928	2,666	1,163	655	4,484	1946	5,090	1,243	729	7,062
1929	2,940	1,166	802	4,908	1947	7,188	1,338	1,084	9,610
1930	2,500	973	507	3,980	1948	9,502	1,552	1,219	12,273
1931	1,620	671	287	2,578	1949	7,920	1,559	1,101	10,580
1932	1,460	412	128	2,000	1950	8,689	1,822	1,351	11,862
1933	1,413	432	205	2,050	1951	9,779	2,079	1,671	13,529
1934	1,947	520	277	2,744	1952	9,616	2,163	1,617	13,396
1935	2,013	564	365	2,942	1953	10,257	2,350	1,811	14,418
1936	2,405	685	516	3,606	1954	9,919	[3] 2,630	1,518	14,067
1937	2,798	711	756	4,265	1955	10,780	[3 4] 2,957	2,055	15,792
1938	2,436	622	460	3,518	1956	11,741	[3 4] 3,266	2,358	17,365
1939	2,423	754	631	3,808	1957	[4] 12,709	[3 4] 3,267	2,137	18,113
1940	2,662	784	752	4,198	1958	[4] 11,589	[3 4] 3,346	[4] 1,593	[4] 16,528
1941	3,228	989	890	5,107	1959	11,794	[3] 3,720	1,570	17,084
1942	3,568	1,056	999	5,623					

[1] Excludes Alaska and Hawaii, 1925–53.

[2] Data for 1925–46 are not strictly comparable with those for subsequent years, since for the earlier years the value of heavy clay products has not been replaced by the value of raw clays used for such products.

[3] Total adjusted to eliminate duplicating value of clays and stone.

[4] Revised figure.

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

Mineral	1956		1957		1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
MINERAL FUELS								
Asphalt and related bitumens (native):								
Bituminous limestone and sandstone	1, 458, 533	$4, 114	1, 168, 507	$3, 221	1, 326, 493	$3, 343	1, 518, 765	$3, 868
Gilsonite	89, 003	3, 822	207, 704	4, 259	317, 280	4, 864	379, 362	9, 385
Carbon dioxide, natural (estimated) thousand cubic feet	713, 030	235	704, 276	139	722, 615	102	484, 074	71
Coal:								
Bituminous and lignite[2] thousand short tons	500, 874	2, 412, 004	492, 704	2, 504, 406	410, 446	1, 996, 281	412, 028	1, 965, 607
Pennsylvania anthracite do	28, 900	236, 785	25, 338	227, 754	21, 171	187, 898	20, 649	172, 320
Helium thousand cubic feet	266, 937	4, 413	310, 365	5, 112	352, 134	5, 741	375, 408	6, 144
Natural gas million cubic feet	10, 081, 923	1, 083, 812	10, 680, 258	1, 201, 759	11, 030, 298	1, 317, 492	[3] 11, 619, 951	[3] 1, 396, 834
Natural-gas liquids:								
Natural gasoline and cycle products thousand gallons	5, 807, 100	431, 958	5, 734, 307	415, 791	5, 596, 458	393, 139	5, 597, 102	408, 694
LP-gases do	6, 487, 413	265, 185	6, 655, 282	263, 665	6, 783, 000	296, 571	7, 874, 706	349, 802
Peat	272, 972	2, 320	316, 217	3, 458	327, 813	3, 446	419, 460	4, 372
Petroleum (crude) thousand 42-gallon barrels	2, 617, 283	7, 296, 760	2, 616, 901	8, 079, 259	2, 449, 016	7, 380, 065	[3] 2, 574, 590	[3] 7, 476, 369
Total mineral fuels		11, 741, 000		12, 709, 000		11, 589, 000		11, 794, 000
NONMETALS (EXCEPT FUELS)								
Abrasive stone[4]	(4)	$363	(4)	$331	(4)	[5] $182	(4)	$315
Asbestos	41, 312	4, 742	43, 653	4, 917	43, 979	5, 127	45, 325	4, 379
Barite	1, 299, 888	13, 498	1, 145, 791	12, 897	605, 402	7, 510	901, 815	10, 301
Boron minerals	546, 815	32, 848	541, 124	38, 041	528, 209	38, 310	619, 946	46, 150
Bromine thousand pounds	196, 730	47, 434	191, 971	48, 038	176, 397	46, 689	195, 483	51, 508
Cement thousand 376-pound barrels	321, 395	989, 233	229, 189	961, 499	317, 263	1, 038, 672	346, 675	1, 144, 867
Clays thousand short tons	50, 775	163, 048	45, 620	155, 805	43, 750	143, 487	49, 383	159, 659
Emery	12, 153	174	11, 893	184	7, 687	126	8, 555	150
Feldspar long tons	560, 074	5, 829	498, 057	4, 935	469, 738	4, 278	548, 390	5, 213
Fluorspar	329, 719	14, 257	328, 872	15, 777	319, 513	15, 071	185, 091	8, 680
Garnet (abrasive)	9, 812	1, 073	9, 776	1, 080	[6] 12, 303	[6] 869	14, 568	1, 211
Gem stones (estimated)	(7)	925	(7)	882	(7)	1, 006	(7)	1, 184
Gypsum thousand short tons	10, 316	34, 099	9, 195	29, 871	9, 600	32, 495	10, 900	[10] 39, 231
Lime do	10, 567	135, 532	10, 266	135, 143	9, 203	[6] 120, 921	12, 498	163, 890
Magnesite	686, 569	2, 502	678, 489	3, 258	492, 982	2, 409	594, 307	2, 401
Magnesium compounds from sea water and brines (except for metals) MgO equivalent	169, 019	13, 668	184, 236	15, 997	207, 053	16, 419	276, 309	21, 636
Marl, calcareous (except for cement)	285, 653	215	(8)	(8)	(8)	(8)	(8)	(8)

See footnotes at end of table.

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

Mineral	1956		1957		1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
NONMETALS (EXCEPT FUELS)—continued								
Mica:								
Scrap	86,309	$1,850	92,438	$2,109	93,347	$2,065	99,941	$2,645
Sheet ... pounds	887,871	2,757	690,052	2,492	[6] 661,344	[6] 2,845	706,395	3,419
Perlite	310,800	2,550	301,605	2,562	291,994	2,463	324,669	2,737
Phosphate rock ... thousand long tons	15,747	97,922	13,976	87,689	14,879	93,693	15,869	98,758
Potassium salts ... thousand short tons, K_2O equivalent	2,172	82,107	2,266	84,612	2,147	75,000	2,383	80,393
Pumice ... thousand short tons	1,482	4,749	1,827	4,628	1,973	5,287	2,276	5,863
Pyrites ... thousand long tons	1,070	9,743	1,067	9,087	974	7,987	(9)	(9)
Salt (common) ... thousand short tons	24,206	136,139	23,844	148,887	21,911	141,486	25,160	155,839
Sand and gravel ... do	631,495	602,412	632,255	599,750	[6] 684,498	[6] 652,789	[10] 730,205	[10] 728,712
Slate	645	11,666	632	11,029	(11)	(11)	(11)	(11)
Sodium carbonate (natural)	652,891	17,400	652,717	17,792	628,619	17,032	735,261	19,078
Sodium sulfate (natural)	332,990	6,437	331,382	6,542	347,445	6,716	402,743	7,689
Stone [12] ... thousand short tons	504,031	763,313	532,791	814,373	[6] 535,923	[6] 826,685	584,163	911,982
Strontium minerals (crude)	4,040	77	(9)	(9)	(9)	(9)	(9)	(9)
Sulfur:								
Frasch-process mines ... thousand long tons	5,676	150,356	5,035	122,915	4,644	109,272	5,222	121,777
Other mines ... long tons	185,532	(9)	(9)	(9)	153,574	1,505	151,932	1,418
Talc, pyrophyllite, and soapstone	739,039	4,859	684,453	4,796	[6] 718,165	[6] 4,718	795,008	5,651
Tripoli	45,009	203	50,717	195	47,044	183	52,968	219
Vermiculite	192,628	2,543	183,987	2,603	[6] 190,564	[6] 2,728	206,579	3,082
Value of items that cannot be disclosed: Aplite, brucite, calcium-magnesium chloride, diatomite, epsom salts from epsomite (1956–57), graphite, iodine, kyanite, lithium minerals, greensand marl, nitrogen compounds (1957–59), olivine, staurolite (1957–58), sharpening stones (1956–58), wollastonite, and values indicated by footnote 9		35,033		37,086		[6] 39,765		50,470
Total nonmetals [13]		3,266,000		3,267,000		[6] 3,346,000		3,720,000
METALS								
Antimony ore and concentrate ... antimony content	590	(14)	710	(14)	716	(14)	688	(14)
Bauxite ... long tons, dried equivalent	1,743,344	$13,973	1,416,172	$12,868	1,310,685	$11,898	1,700,235	$17,725
Beryllium concentrate ... gross weight	445	231	521	276	463	238	328	171
Chromite ... do	[15] 207,662	[15] 8,715	166,157	7,816	143,795	6,187	[16] 105,000	[16] 3,765
Cobalt (content of concentrate) ... thousand pounds	3,657	(14)	4,123	(14)	4,832	(14)	2,944	(14)
Columbium-tantalum concentrate [17] ... pounds	216,606	(14)	370,483	(14)	428,347	981	189,263	(14)
Copper (recoverable content of ores, etc.)	1,104,156	938,532	1,086,859	654,289	979,329	515,127	824,846	506,455
Gold (recoverable content of ores, etc.) ... troy ounces	1,827,159	63,950	1,793,597	62,776	1,739,249	60,874	1,603,802	56,133

Iron ore, usable (excluding byproduct iron sinter) thousand long tons, gross weight	96,944	750,354	104,157	865,703	[6] 66,288	[6] 569,154	59,164	514,067
Lead (recoverable content of ores, etc.)	352,826	110,787	338,216	96,730	267,377	62,566	255,586	58,786
Manganese ore (35 percent or more Mn) gross weight	344,735	26,990	366,334	29,363	[6] 327,309	[6] 23,637	229,174	17,903
Manganiferous ore (5 to 35 percent Mn) do	680,651	3,984	865,127	(14)	520,601	3,532	470,271	3,146
Manganiferous residuum do	130,129	(14)	(14)	(14)	(14)	(14)	(14)	(14)
Mercury 76-pound flasks	24,177	6,284	34,625	8,552	38,067	8,720	31,256	7,110
Molybdenum (content of concentrate) thousand pounds	57,126	63,901	57,143	67,605	42,328	50,371	51,603	64,655
Nickel (content of ore and concentrate)	7,392	(14)	12,901	(14)	13,489	(14)	[10] 13,374	(14)
Rare-earth and thorium concentrates	(14)	(14)	3,079	653	2,021	286	1,143	206
Silver (recoverable content of ores, etc.) thousand troy ounces	38,722	35,044	38,165	34,541	34,111	30,872	31,194	28,233
Tin (content of ore and concentrate) long tons	------	------	------	------	------	------	50	60
Titanium concentrate:								
Ilmenite gross weight	735,388	14,199	782,975	21,802	565,164	11,152	637,263	12,106
Rutile do	12,065	1,749	10,644	1,544	1,863	210	8,648	877
Tungsten ore and concentrate 60-percent WO$_3$ basis	14,737	51,201	5,520	8,186	3,788	3,991	3,649	4,502
Uranium ore	3,003,590	70,601	3,682,543	81,181	5,178,315	116,397	6,934,927	[10] 141,349
Vanadium (recoverable in ore and concentrate) thousand pounds	7,735	(14)	7,383	(14)	6,061	10,817	7,438	13,278
Zinc (recoverable content of ores, etc.)	542,340	148,503	531,735	123,235	412,005	84,113	425,303	97,787
Value of items that cannot be disclosed: Magnesium chloride for magnesium metal, platinum-group metals (crude), zirconium concentrate, and values indicated by footnote 14	------	48,704	------	59,558	------	22,264	------	21,763
Total metals	------	2,358,000	------	2,137,000	------	[6] 1,593,000	------	1,570,000
Grand total mineral production	------	17,365,000	------	18,113,000	------	[6] 16,528,000	------	17,084,000

---

[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] Preliminary figure.

[4] Grindstones, pulpstones, millstones, grinding pebbles, and tubemill liners, weight not recorded; excludes value of sharpening stones (1956–58), value for which is included with "Nonmetal items that cannot be disclosed".

[5] Excludes tubemill liners, value for which is included with "Nonmetal items that cannot be disclosed".

[6] Revised figure.

[7] Weight not recorded.

[8] Beginning with 1947 calcareous marl included with stone.

[9] Figure withheld to avoid disclosing individual company confidential data; value included with "Nonmetal items that cannot be disclosed".

[10] Final figure. Supersedes preliminary figure given in commodity chapter.

[11] Beginning with 1958 slate included with stone.

[12] Excludes abrasive stone, bituminous limestone, bituminous sandstone, and ground soapstone, all included elsewhere in table.

[13] Total adjusted to eliminate duplicating value of clays and stone.

[14] Figure withheld to avoid disclosing individual company confidential data; value included with "Metal items that cannot be disclosed".

[15] Includes 45,710 short tons of concentrate produced in 1955 and 1956 from low grade ore and concentrate stockpiled near Coquille, Oreg., during World War II.

[16] Excludes quantity consumed by American Chrome Co.

[17] Total weight of columbite-tantalite plus $(\text{Cb–Ta})_2\text{O}_5$ content of euxenite.

TABLE 3.—Minerals produced in the United States and principal producing States in 1959

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

TABLE 3.—Minerals produced in the United States and principal producing States in 1959—Continued

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

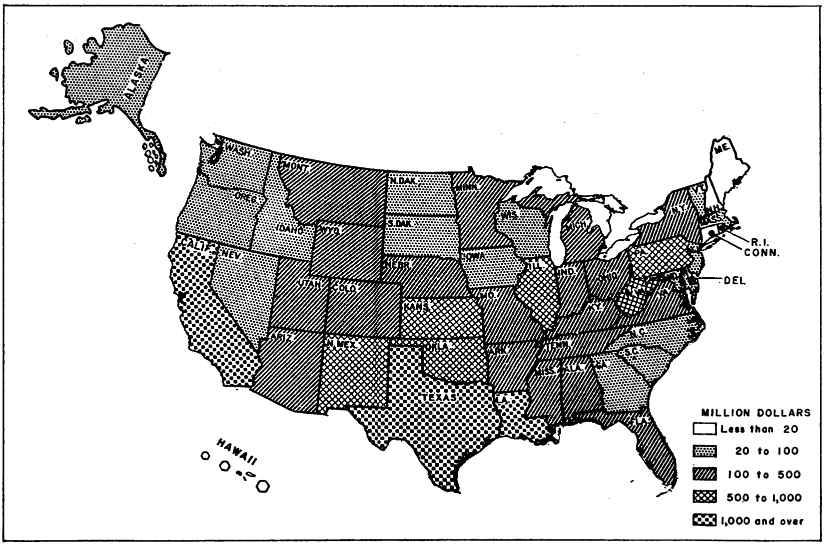

FIGURE 2.—Value of mineral production in the United States, 1959, by States.

TABLE 4.—Value of mineral production in the United States, in thousand dollars, and principal minerals produced in 1959

State	1956	1957	1958	1959			
				Value	Rank	Percent of U.S. total	Principal minerals in order of value
Alabama	$189, 186	$209, 549	$188, 938	$199, 319	21	1. 17	Coal, cement, stone, iron ore.
Alaska	23, 408	28, 792	21, 450	20, 495	44	. 12	Gold, coal, sand and gravel, mercury.
Arizona	484, 959	372, 641	314, 520	326, 888	16	1. 91	Copper, sand and gravel, zinc, cement.
Arkansas	134, 049	142, 685	131, 603	140, 555	27	. 82	Petroleum, bauxite, sand and gravel, stone.
California	1, 543, 978	1, 650, 035	1, 500, 367	1, 424, 039	3	8. 34	Petroleum, cement, natural gas, sand and gravel.
Colorado	321, 908	338, 504	306, 561	313, 438	17	1. 83	Petroleum, molybdenum, uranium ore, coal.
Connecticut	11, 737	16, 055	13, 128	12, 930	46	. 08	Stone, sand and gravel, lime, clays.
Delaware	1, 232	1, 042	1, 142	1, 284	50	. 01	Sand and gravel, stone, clays.
District of Columbia	----------	72	72	75	51	(1)	
Florida	140, 490	140, 467	142, 114	163, 447	24	. 96	Phosphate rock, stone, cement, titanium.
Georgia	67, 912	69, 799	75, 106	86, 262	30	. 50	Clays, stone, cement, sand and gravel.
Hawaii	6, 972	5, 930	6, 298	7, 630	47	. 05	Stone, sand and gravel, pumice, lime.
Idaho	75, 150	73, 502	64, 648	70, 209	32	. 41	Silver, lead, zinc, sand and gravel.
Illinois	572, 247	576, 324	576, 862	577, 372	8	3. 38	Petroleum, coal, stone, sand and gravel.
Indiana	196, 439	198, 034	197, 677	207, 701	20	1. 22	Coal, stone, petroleum, sand and gravel.
Iowa	66, 529	68, 986	85, 356	88, 557	29	. 52	Cement, stone, sand and gravel, gypsum.
Kansas	493, 770	511, 513	503, 788	500, 464	9	2. 93	Petroleum, natural gas, cement, stone.
Kentucky	443, 168	449, 390	402, 121	416, 391	10	2. 44	Coal, petroleum, stone, natural gas.
Louisiana	1, 288, 116	1, 517, 522	1, 523, 370	1, 654, 493	2	9. 68	Petroleum, natural gas, natural-gas liquids, sulfur.
Maine	12, 728	12, 711	12, 574	13, 278	45	. 08	Cement, sand and gravel, stone, mica.
Maryland	40, 534	39, 625	45, 735	53, 508	37	. 31	Cement, stone, sand and gravel, coal.
Massachusetts	25, 085	24, 789	23, 887	25, 916	42	. 15	Stone, sand and gravel, lime, clays.
Michigan	394, 556	404, 673	343, 487	379, 244	13	2. 22	Cement, iron ore, sand and gravel, salt.
Minnesota	501, 027	584, 038	395, 880	347, 178	15	2. 03	Iron ore, sand and gravel, stone, cement.
Mississippi	133, 098	144, 950	151, 411	181, 086	22	1. 06	Petroleum, natural gas, sand and gravel, cement.
Missouri	163, 693	152, 913	144, 120	157, 009	25	. 92	Cement, stone, lead, lime.
Montana	213, 704	191, 750	176, 728	167, 890	23	. 98	Petroleum, copper, sand and gravel, zinc.
Nebraska	71, 311	82, 928	90, 047	100, 213	28	. 59	Petroleum, cement, sand and gravel, stone.
Nevada	126, 681	86, 023	68, 293	70, 159	33	. 41	Copper, sand and gravel, gold, manganese ore.
New Hampshire	3, 436	3, 331	3, 919	4, 722	48	. 03	Sand and gravel, mica, stone, feldspar.
New Jersey	63, 988	64, 642	50, 380	59, 479	36	. 35	Stone, sand and gravel, iron ore, magnesium compounds.
New Mexico	514, 903	551, 155	559, 777	600, 269	7	3. 51	Petroleum, natural gas, potassium salts, uranium ore.
New York	237, 016	244, 114	205, 338	235, 119	18	1. 38	Cement, stone, sand and gravel, salt.
North Carolina	40, 873	37, 570	39, 891	40, 789	40	. 24	Stone, sand and gravel, mica, feldspar.
North Dakota	53, 509	56, 702	59, 445	67, 649	34	. 40	Petroleum, sand and gravel, coal, natural-gas liquids.
Ohio	375, 488	383, 000	344, 856	395, 901	11	2. 32	Coal, cement, stone, sand and gravel.
Oklahoma	757, 080	809, 004	761. 936	751, 907	5	4. 40	Petroleum, natural gas, natural-gas liquids, cement.
Oregon	34, 021	42, 820	45, 190	49, 831	38	. 29	Stone, sand and gravel, cement, nickel.
Pennsylvania	1, 088, 481	1, 077, 157	882, 040	863, 818	4	5. 06	Coal, cement, stone, natural gas.

Rhode Island	1, 627	1, 369	2, 249	2, 333	49	.01	Sand and gravel, stone, graphite.
South Carolina	21, 342	22, 168	22, 412	30, 598	41	.18	Cement, stone, clays, sand and gravel.
South Dakota	42, 281	39, 997	41, 534	48, 485	39	.28	Gold, sand and gravel, stone, cement.
Tennessee	137, 846	128, 739	124, 934	140, 739	26	.82	Stone, cement, coal, phosphate rock.
Texas	4, 241, 258	4, 484, 538	4, 033, 311	4, 201, 203	1	24. 59	Petroleum, natural gas, natural-gas liquids, cement.
Utah	399, 759	359, 335	367, 232	373, 017	14	2. 18	Petroleum, copper, uranium ore, coal.
Vermont	23, 131	21, 893	21, 443	23, 359	43	.14	Stone, asbestos, sand and gravel, talc.
Virginia	208, 806	227, 108	203, 277	222, 304	19	1. 30	Coal, stone, cement, sand and gravel.
Washington	61, 723	60, 471	60, 896	63, 894	35	.37	Sand and gravel, cement, stone, gold.
West Virginia	934, 999	981, 654	749, 747	737, 886	6	4. 32	Coal, natural gas, natural-gas liquids, sand and gravel.
Wisconsin	65, 860	68, 644	71, 334	71, 959	31	.42	Sand and gravel, stone, cement, iron ore.
Wyoming	314, 380	352, 532	369, 938	391, 621	12	2. 29	Petroleum, uranium, sodium carbonate, natural gas.
Total	17, 365, 000	18, 113, 000	16, 528, 000	17, 084, 000		100. 00	Petroleum, coal, natural gas, cement.

---

[1] Less than 1 percent.

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

ALABAMA

Mineral	1956		1957		1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
Cement[2] thousand 376-pound barrels	14,065	$41,840	13,000	$40,279	13,588	$42,930	14,819	$46,639
Clays[4] thousand short tons	1,594	2,147	1,316	1,504	1,548	1,787	1,786	2,089
Coal do	12,663	79,322	13,260	86,114	11,182	72,360	11,947	78,212
Iron ore (usable) thousand long tons, gross weight	5,633	34,824	6,223	40,518	3,659	23,393	4,165	23,922
Lime thousand short tons	466	5,089	554	6,271	520	[5] 5,851	579	6,847
Mica (sheet) pounds	1,122	7	(6)	(6)	(6)	(6)	818	7
Natural gas million cubic feet	42	3	190	12	323	30	[7] 320	[7] 30
Petroleum (crude) thousand 42-gallon barrels	3,069	7,335	5,406	(6)	5,887	(6)	[7] 5,019	(6)
Sand and gravel thousand short tons	4,999	4,621	5,065	4,883	4,128	4,210	4,352	4,594
Stone[8] do	12,343	14,702	9,519	11,972	11,080	17,068	11,886	18,728
Talc	2,200	5	1,600	3	(6)	(6)	(6)	(6)
Value of items that cannot be disclosed: Native asphalt, bauxite, slag cement, clays (kaolin), scrap mica, salt, stone (dimension limestone and marble 1957–59, shell, 1957, 1959, crushed sandstone 1959), and values indicated by footnote 6		4,083		23,344		26,508		23,860
Total Alabama[9]		189,186		209,549		[5] 188,938		199,319

ALASKA

Mineral	1956		1957		1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
Antimony ore and concentrate antimony content	28	(6)	17	(6)				
Chromite gross weight	7,193	$711	4,207	$431				
Clays thousand short tons							(10)	$1
Coal do	727	6,374	842	7,296	759	$6,931	660	5,869
Copper (recoverable content of ores, etc.)	(11)	(12)	(11)	(12)	5	3	36	22
Gem stones	(13)	(6)	(13)	(6)	(13)	(6)	(13)	18
Gold (recoverable content of ores, etc.) troy ounces	209,296	7,325	215,467	7,541	186,435	6,525	178,918	6,262
Lead (recoverable content of ores, etc.)	1	(12)	9	3	2	(12)		
Mercury 76-pound flasks	3,280	853	5,461	1,349	3,380	774	3,743	852
Natural gas million cubic feet					50	6	[7] 133	[7] 16
Petroleum (crude) thousand 42-gallon barrels					(6)	(6)	[7] 187	[7] 295
Sand and gravel thousand short tons	5,955	5,880	6,096	8,799	4,255	3,871	5,859	5,265
Silver (recoverable content of ores, etc.) thousand troy ounces	28	26	29	26	24	22	21	19
Stone thousand short tons	195	595	528	1,953	615	2,065	89	377
Value of items that cannot be disclosed: Platinum-group metals, uranium ore (1957–59), and values indicated by footnote 6		1,644		1,394		1,253		1,499
Total Alaska		23,408		28,792		21,450		20,495

ARIZONA

Mineral	1956		1957		1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
Beryllium concentrate……gross weight	6	$3	5	$2	18	$10	----------	----------
Clays[4]……thousand short tons	112	168	118	177	119	179	120	$179
Columbium-tantalum concentrate……pounds	----------	----------	2,435	7	----------	----------	----------	----------
Coal……thousand short tons	10	66	9	62	8	54	7	63
Copper (recoverable content of ores, etc.)	505,908	430,022	515,854	310,544	485,839	255,551	430,297	264,202
Gem stones	(13)	104	(13)	75	(13)	86	(13)	88
Gold (recoverable content of ores, etc.)……troy ounces	146,110	5,114	152,449	5,336	142,979	5,004	124,627	4,362
Gypsum……thousand short tons	96	366	(6)	(6)	(6)	(6)	(6)	(6)
Lead (recoverable content of ores, etc.)	11,999	3,768	12,441	3,558	11,890	2,782	9,999	2,300
Lime……thousand short tons	127	1,756	138	2,127	126	1,817	123	1,666
Manganese ore (35 percent or more Mn)……gross weight	42,088	3,468	79,505	6,626	62,279	5,220	68,183	5,727
Manganiferous ore (5 to 35 percent Mn)……do	----------	----------	----------	----------	1,455	32	10,693	234
Mercury……76-pound flasks	(6)	(6)	28	7	53	12	(6)	(6)
Mica (scrap)	----------	----------	1,650	17	1,717	25	3,069	55
Molybdenum (content of concentrate)……thousand pounds	2,392	2,670	2,385	3,071	2,320	2,827	3,181	4,019
Natural gas……million cubic feet	21	3	22	3	----------	----------	----------	----------
Perlite	15,928	108	15,646	114	(6)	(6)	(6)	(6)
Petroleum (crude)……thousand 42-gallon barrels	----------	----------	----------	----------	12	(6)	[7] 34	(6)
Pumice……thousand short tons	115	366	397	640	401	1,025	487	1,153
Sand and gravel……do	7,932	6,167	10,287	9,222	12,208	9,526	13,458	11,966
Silver (recoverable content of ores, etc.)……thousand troy ounces	5,179	4,687	5,279	4,778	4,685	4,240	3,898	3,528
Stone……thousand short tons	1,623	2,474	2,101	2,982	1,528	2,731	2,468	3,998
Tungsten concentrate……60-percent WO_3 basis	186	637	5	9	----------	----------	(11)	(6)
Uranium ore	274,505	5,408	286,037	6,277	257,756	7,049	253,390	6,309
Zinc (recoverable content of ores, etc.)	25,580	7,009	33,905	7,866	28,532	5,821	37,325	8,585
Value of items that cannot be disclosed: Asbestos, cement, clays (bentonite 1956, 1958–59), feldspar, fluorspar (1956–58), nitrogen compounds (1957–58), pyrites (1957–59), vanadium, and values indicated by footnote 6	----------	11,701	----------	10,441	----------	11,734	----------	9,837
Total Arizona[9]	----------	484,959	----------	372,641	----------	314,520	----------	326,888

See footnotes at end of table.

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

ARKANSAS

Mineral	1956		1957		1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
Abrasive stones (whetstones)	35	$11						
Barite	486,254	4,256	477,327	$4,537	182,779	$1,668	338,539	$3,097
Bauxite ... long tons, dried equivalent	1,668,432	13,307	1,356,898	12,314	1,257,916	11,394	1,631,643	17,048
Clays ... thousand short tons	719	1,636	617	1,586	578	1,578	782	2,406
Coal ... do	590	4,601	508	3,976	364	2,744	441	3,482
Gem stones	(13)	25	(13)	(6)	(13)	23	(13)	18
Iron ore (usable) ... thousand long tons, gross weight	(6)	(6)	7	35	(6)	(6)	----	----
Lead (recoverable content of ores, etc.)	----	----	----	----	----	----	38	9
Manganese ore (35 percent or more Mn) ... gross weight	29,485	2,066	23,261	1,726	22,221	1,737	17,742	1,398
Natural gas ... million cubic feet	30,162	1,810	31,327	2,256	32,890	2,664	[7] 42,500	[7] 3,500
Natural-gas liquids:								
Natural gasoline and cycle products ... thousand gallons	41,529	2,541	39,869	2,313	37,197	2,574	40,730	2,523
LP-gases ... do	56,146	2,293	54,034	2,097	53,518	2,743	55,731	3,048
Petroleum (crude) ... thousand 42-gallon barrels	29,355	78,965	31,047	90,657	28,700	80,934	[7] 26,329	[7] 72,931
Sand and gravel ... thousand short tons	10,200	8,730	8,599	6,949	8,644	7,039	11,696	11,857
Stone ... do	6,325	8,113	7,278	8,378	8,461	10,178	8,824	10,424
Zinc (recoverable content of ores, etc.)	----	----	----	----	----	----	49	11
Value of items that cannot be disclosed: Abrasive stones, bromine (1957–59), cement, gypsum, lime, slate (1956–57), soapstone, and values indicated by footnote 6	----	8,182	----	6,933	----	7,241	----	10,042
Total Arkansas[9]	----	134,049	----	142,685	----	131,603	----	140,555

CALIFORNIA

Barite	(6)	(6)	(6)	(6)	24,812	$272	28,143	$326
Boron minerals	546,815	$32,848	541,124	$38,041	528,209	38,310	619,946	46,150
Cement thousand 376-pound barrels	39,290	120,511	[2] 37,731	[2] 117,852	[2] 39,583	[2] 124,367	[2] 43,635	[2] 138,506
Chromite gross weight	27,082	2,192	34,901	2,789	20,588	1,646	(6)	(12)
Clays thousand short tons	2,982	6,137	[4] 2,729	[4] 5,740	2,394	5,012	2,726	5,646
Coal (lignite) do	12	120	(6)	(6)	(6)	(6)	(6)	(6)
Copper (recoverable content of ores, etc.)	859	730	945	569	749	394	663	407
Feldspar long tons	107,958	1,080	67,869	581	71,193	624	76,489	666
Gem stones	(13)	90	(13)	100	(13)	150	(13)	150
Gold (recoverable content of ores, etc.) troy ounces	193,816	6,784	170,885	5,981	185,385	6,489	146,141	5,115
Gypsum thousand short tons	1,399	3,402	1,268	2,995	1,423	3,184	1,686	3,788
Iron ore (usable) thousand long tons, gross weight	2,414	(6)	(6)	(6)	(6)	(6)	(6)	(6)
Lead (recoverable content of ores, etc.)	9,296	2,919	3,458	989	140	33	227	52
Lime thousand short tons	302	5,078	325	5,408	262	4,470	358	5,817
Magnesium compounds from sea water and bitterns (partly estimated) MgO equivalent	66,007	4,532	74,295	5,077	74,132	4,854	87,968	6,336
Manganese ore (35 percent or more Mn) gross weight	6,595	595	9,009	802	17,644	1,516	19,354	1,663
Mercury 76-pound flasks	9,017	2,344	16,511	4,078	22,365	5,123	17,100	3,890
Natural gas million cubic feet	504,458	113,503	492,338	116,684	465,582	108,481	[7] 488,664	[7] 114,152
Natural-gas liquids:								
Natural gasoline and cycle products thousand gallons	876,902	84,615	843,378	81,355	853,045	68,485	834,258	68,023
LP-gases do	410,232	21,332	390,743	20,421	342,992	18,678	396,331	21,260
Peat	18,918	215	35,916	424	28,617	374	34,604	449
Perlite	15,119	135	15,109	113	14,883	114	(6)	(6)
Petroleum (crude) thousand 42-gallon barrels	350,754	918,975	339,646	1,035,920	313,672	909,649	[7] 307,327	[7] 783,684
Pumice thousand short tons	634	2,334	459	1,510	377	1,670	574	2,162
Salt (common) do	1,444	7,606	1,330	8,721	1,297	(6)	1,388	(6)
Sand and gravel do	86,447	96,526	78,983	87,030	84,137	95,340	87,945	108,909
Silver (recoverable content of ores, etc.) thousand troy ounces	938	849	522	473	188	170	173	156
Stone thousand short tons	32,583	46,109	41,351	53,591	32,423	48,345	32,134	49,090
Talc, pyrophyllite and soapstone	153,710	1,419	133,915	1,526	[5] 129,638	[5] 1,339	148,266	1,500
Tungsten concentrate 60-percent WO$_3$ basis	3,719	13,449	1,750	2,735	(6)	(6)	(6)	(6)
Wollastonite	----------	----------	----------	----------	1,652	17	(6)	(6)
Zinc (recoverable content of ores, etc.)	8,049	2,205	2,969	689	51	10	78	18
Value of items that cannot be disclosed: Asbestos, bromine, calcium-magnesium chloride, carbon dioxide (1956-57, 1959), masonry cement, clay (kaolin 1957), diatomite, fluorspar (1957-58), abrasive garnet (1956), iodine, lithium minerals (1958-59), magnesite (1956, 1958-59), mica (1956-58), molybdenum, platinum-group metals (crude), potassium salts, pyrites, rare-earth metals concentrates, slate (1956-57), sodium carbonate and sulfate, strontium minerals (1956-57, 1959), sulfur ore, uranium ore, and values indicated by footnote 6	----------	63,654	----------	65,352	----------	[5] 68,564	----------	73,374
Total California [9]	----------	1,543,978	----------	1,650,035	----------	[5] 1,500,367	----------	1,424,039

See footnotes at end of table.

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

COLORADO

Mineral	1956 Short tons (unless otherwise stated)	1956 Value (thousands)	1957 Short tons (unless otherwise stated)	1957 Value (thousands)	1958 Short tons (unless otherwise stated)	1958 Value (thousands)	1959 Short tons (unless otherwise stated)	1959 Value (thousands)
Beryllium concentrate……gross weight	163	$88	182	$91	134	$58	124	$58
Carbon dioxide, natural……thousand cubic feet	(6)	(6)	(6)	(6)	(6)	(6)	175,223	(6)
Clays……thousand short tons	523	1,215	403	978	449	1,111	417	1,160
Coal……do	3,502	19,832	3,594	21,831	2,974	19,305	3,294	21,034
Columbium-tantalum concentrate [14]……pounds	52	(12)	103	(12)	2,280	7	------	------
Copper (recoverable content of ores, etc.)	4,228	3,594	5,115	3,079	4,193	2,206	2,940	1,805
Feldspar……long tons	47,014	327	43,818	307	34,648	237	(6)	(6)
Gem stones	(13)	30	(13)	35	(13)	38	(13)	43
Gold (recoverable content of ores, etc.)……troy ounces	97,668	3,418	87,928	3,078	79,539	2,784	61,097	2,138
Gypsum……thousand short tons	88	353	(6)	(6)	103	341	106	385
Iron ore (usable)……thousand long tons, gross weight	(6)	(6)	(6)	(6)	(6)	(6)	11	78
Lead (recoverable content of ores, etc.)	19,856	6,235	21,003	6,007	14,112	3,302	12,907	2,969
Lime……thousand short tons	------	------	2	45	(6)	(6)	(6)	(6)
Manganese ore (35 percent or more Mn)……gross weight	------	------	175	14	210	17	1,218	102
Mica:								
Scrap	517	7	312	6	387	6	68	1
Sheet……pounds	8	(12)	14	(12)	------	------	------	------
Natural gas……million cubic feet	54,205	5,312	95,259	9,526	82,464	8,659	[7] 98,600	[7] 10,600
Natural-gas liquids:								
Natural gasoline……thousand gallons	(6)	(6)	(6)	(6)	49,505	3,410	47,424	2,811
LP-gases……do	(6)	(6)	(6)	(6)	68,027	3,343	77,637	3,671
Peat	------	------	3,559	(6)	7,143	41	6,674	35
Petroleum (crude)……thousand 42-gallon barrels	58,516	162,674	54,982	166,046	48,736	145,721	[7] 46,150	[7] 133,835
Pumice……thousand short tons	50	109	25	53	34	65	40	66
Pyrites……thousand long tons	(6)	(6)	62	(6)	67	359	(6)	(6)
Rare-earth and thorium concentrates	16	23	749	24	650	35	9	1
Salt (common)……thousand short tons	4	18	(6)	(6)	(6)	(6)	(6)	(6)
Sand and gravel……do	15,152	11,082	16,400	13,994	20,626	17,842	20,897	18,817
Silver (recoverable content of ores, etc.)……thousand troy ounces	2,285	2,068	2,788	2,523	2,056	1,860	1,341	1,213
Stone……thousand short tons	2,250	5,217	2,438	4,168	2,930	4,943	2,824	5,537
Tin (content of ore and concentrate)……long tons	------	------	------	------	------	------	50	60
Tungsten concentrate……60-percent WO_3 basis	873	3,010	45	55	(6)	(6)	(6)	(6)
Uranium ore	496,517	12,410	740,055	15,605	939,706	22,486	1,044,089	[8] 22,546
Vanadium……thousand pounds	5,582	(6)	6,264	(6)	4,791	(6)	5,897	(6)
Zinc (recoverable content of ores, etc.)	40,246	11,027	47,000	10,904	37,132	7,575	35,388	8,139
Value of items that cannot be disclosed: Carbon dioxide, cement, fluorspar, molybdenum, perlite, and values indicated by footnote 6	------	75,632	------	81,907	------	62,855	------	79,229
Total Colorado [9]	------	321,908	------	338,504	------	[5] 306,561	------	313,438

CONNECTICUT

Beryllium concentrate……gross weight	(6)	(6)	(6)	(6)	(6)	(6)	13	$8
Clays……thousand short tons	338	$390	308	$409	199	$299	280	368
Gem stones	----	----	(13)	(6)	(13)	3	(13)	5
Lime……thousand short tons	40	609	30	503	29	464	(6)	(6)
Mica, sheet……pounds	310	2	(6)	(6)	(6)	(12)	----	----
Peat	3,190	13	2,004	11	1,764	11	2,090	13
Sand and gravel……thousand short tons	4,369	4,101	4,777	5,042	5,019	5,479	4,749	4,912
Stone……do	[8] 4,428	[8] 6,590	6,199	10,040	4,223	6,863	4,462	7,088
Value of items that cannot be disclosed: Feldspar, stone (dimension limestone 1956), and values indicated by footnote 6. Excludes limestone used in manufacturing lime (1959)	----	124	----	119	----	89	----	536
Total Connecticut	----	[9] 11,737	----	[9] 16,055	----	[9] 13,128	----	12,930

DELAWARE

Sand and gravel……thousand short tons	1,160	$967	974	$860	1,090	$962	1,241	$1,071
Stone……do	83	232	(6)	(6)	(6)	(6)	(6)	(6)
Value of items that cannot be disclosed: Nonmetals and values indicated by footnote 6	----	33	----	182	----	180	----	213
Total Delaware	----	1,232	----	1,042	----	1,142	----	1,284

FLORIDA

Clays……thousand short tons	432	$5,826	422	$6,067	450	$5,808	[4] 245	[4] $6,171
Gem stones	(13)	(6)	----	----	----	----	(13)	3
Lime……thousand short tons	40	490	(6)	(6)	(6)	(6)	111	1,238
Natural gas……million cubic feet	35	3	34	4	35	5	[7] 34	[7] 6
Peat	58,496	203	37,844	195	36,438	165	34,446	158
Petroleum (crude)……thousand 42-gallon barrels	479	(6)	461	(6)	449	(6)	[7] 424	(6)
Phosphate rock……thousand long tons	11,822	74,290	10,191	64,789	10,851	68,951	11,564	71,208
Sand and gravel……thousand short tons	5,815	5,034	6,753	6,148	5,490	4,389	6,674	5,177
Stone……do	18,779	25,183	21,786	30,467	[8] 23,549	[8] 30,983	[8] 26,917	[8] 35,940
Titanium concentrates……thousand short tons, gross weight	(6)	(6)	263	10,643	190	5,495	262	7,196
Zirconium concentrate	43,794	2,160	56,802	1,976	30,302	1,018	(6)	(6)
Value of items that cannot be disclosed: Cement, clays (kaolin and miscellaneous clay 1959), abrasive garnet (1956), magnesium compounds (1959), rare-earth metals concentrates, staurolite (1957–59), stone (dimension limestone 1958–59), and values indicated by footnote 6	----	28,452	----	[5] 22,514	----	[5] 28,510	----	40,034
Total Florida [9]	----	140,490	----	140,467	----	[5] 142,114	----	163,447

See footnotes at end of table.

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

GEORGIA

Mineral	1956		1957		1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
Clays……thousand short tons	3,047	$29,501	2,707	$30,120	2,942	$31,253	3,352	$36,232
Coal……do	8	42	13	63	9	44	7	34
Iron ore (usable)……thousand long tons, gross weight	357	1,609	443	2,109	209	1,008	186	945
Manganese ore (35 percent or more Mn)……gross weight	(6)	(6)	(6)	(6)	(6)	(6)	1,547	(6)
Manganiferous ore (5 to 35 percent Mn)……do	(6)	(6)	2,203	(6)	(6)	(6)	(6)	(6)
Mica (sheet)……pounds	20,149	150	16,933	158	15,102	82	18,461	119
Peat	6,225	48	4,690	45	4,491	(6)	4,288	(6)
Sand and gravel……thousand short tons	2,426	2,183	2,127	2,096	2,631	2,693	2,909	2,982
Stone……do	[8] 9,196	[8] 20,714	[8] 9,065	[8] 15,833	12,129	31,108	13,771	35,973
Talc and soapstone	57,916	122	49,372	106	(6)	(6)	53,692	107
Value of items that cannot be disclosed: Barite, bauxite, beryllium concentrate (1956-57), cement, feldspar, gem stones, iron ore (pigment material), scrap mica, slate (1956-57), stone (crushed marble and crushed sandstone 1956, dimension and crushed marble and crushed sandstone 1957), and minerals indicated by footnote 6	----	14,558	----	20,081	----	10,145	----	10,979
Total Georgia[9]	----	67,912	----	69,799	----	75,106	----	86,262

HAWAII

Mineral	1956		1957		1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
Clays……thousand short tons	2	$2	2	$3	(6)	(6)	(6)	(6)
Lime……do	10	306	8	271	8	$260	(6)	(6)
Pumice……do	59	92	266	493	260	481	276	$548
Salt……do	(10)	18	(10)	15	(10)	(6)	----	----
Sand and gravel……do	193	503	286	538	438	1,112	463	1,253
Stone……do	3,494	6,076	2,585	4,632	2,377	4,446	3,034	5,480
Value of items that cannot be disclosed: Other nonmetals and values indicated by footnote 6	----	----	----	----	----	13	----	363
Total Hawaii[15]	----	6,972	----	5,930	----	6,298	----	7,630

IDAHO

Antimony ore and concentrate .... antimony content..	549	(6)	664	(6)	677	(6)	678	(6)
Beryllium concentrate .... gross weight..	----------	----------	1	(12)	----------	----------	----------	----------
Clays [4] .... thousand short tons..	23	$13	23	$16	27	$20	39	$33
Cobalt (content of concentrate) .... thousand pounds..	2,385	(6)	2,618	(6)	3,078	(6)	1,141	(6)
Columbium-tantalum concentrate .... pounds..	215,900	(6)	364,768	(6)	422,612	(6)	189,263	(6)
Copper (recoverable content of ores, etc.)	6,656	5,658	7,912	4,763	9,846	5,179	8,713	5,350
Gem stones	(13)	(6)	(13)	(6)	(13)	(6)	(13)	5
Gold (recoverable content of ores, etc.) .... troy ounces..	9,210	322	12,301	431	15,896	556	10,479	367
Iron ore (usable) .... thousand long tons..	1	(6)	(6)	(6)	1	14	6	56
Lead (recoverable content of ores, etc.)	64,321	20,197	71,637	20,488	53,603	12,543	62,395	14,351
Mercury .... 76-pound flasks..	3,394	882	2,260	558	2,625	601	1,961	446
Mica:								
Scrap	----------	----------	----------	----------	1	(12)	----------	----------
Sheet .... pounds..	----------	----------	1,240	9	1,968	14	(6)	(6)
Nickel (content of ore and concentrate)	49	(6)	37	55	29	(6)	(6)	(6)
Phosphate rock .... thousand long tons..	1,438	6,539	1,307	5,684	1,291	5,652	1,610	7,412
Pumice .... thousand short tons..	102	206	100	168	108	172	93	137
Rare-earth metals concentrates	303	(6)	366	(6)	692	(6)	522	80
Sand and gravel .... thousand short tons..	7,874	5,661	6,665	5,274	[5] 6,879	[5] 6,404	9,184	8,080
Silver (recoverable content of ores, etc.) .... thousand troy ounces..	13,472	12,193	15,067	13,637	15,953	14,438	16,637	15,057
Stone .... thousand short tons..	1,791	2,752	1,542	2,759	[5] 1,391	[5] 1,794	1,079	1,931
Titanium concentrate .... gross weight..	48,619	261	28,397	(6)	2,223	(6)	(6)	(6)
Tungsten concentrate .... 60-percent WO_3 basis..	582	(6)	35	(6)	(6)	(6)	----------	----------
Uranium ore	----------	----------	(6)	(6)	(6)	(6)	3,374	30
Zinc (recoverable content of ores, etc.)	49,561	13,580	57,831	13,417	49,725	10,144	55,699	12,811
Value of items that cannot be disclosed: Barite, cement, clays (fire clay, bentonite 1958), abrasive garnet, gypsum (1958–59), peat (1957–59), zirconium concentrate (1958), and values indicated by footnote 6. Excludes limestone used in manufacturing cement	----------	6,885	----------	6,243	----------	[5] 7,117	----------	4,063
Total Idaho	----------	75,150	----------	73,502	----------	[5] 64,648	----------	70,209

See footnotes at end of table.

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

ILLINOIS

Mineral	1956		1957		1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
Cement thousand 376-pound barrels	9,301	$27,264	8,575	$26,356	9,618	$30,858	9,925	$31,794
Clays thousand short tons	2,258	4,005	1,917	5,155	2,335	5,910	2,229	4,950
Coal do	48,102	184,678	46,993	187,908	43,912	176,614	45,466	184,412
Fluorspar	178,254	8,470	169,939	8,827	152,087	7,931	112,469	5,908
Gem stones			(13)	2	(13)	1	(13)	1
Lead (recoverable content of ores, etc.)	3,832	1,203	2,970	849	1,610	377	2,570	591
Natural gas million cubic feet	6,177	933	9,647	1,495	12,983	1,921	[7] 12,500	[7] 1,900
Natural-gas liquids:								
Natural gasoline and cycle products thousand gallons	(6)	(6)	(6)	(6)	22,380	1,645	(6)	(6)
LP-gases do	(6)	(6)	(6)	(6)	353,129	20,866	(6)	(6)
Peat	14,451	158	11,480	106	11,588	72	9,117	72
Petroleum (crude) thousand 42-gallon barrels	82,346	241,274	77,083	240,499	80,275	240,825	78,435	[7] 234,521
Sand and gravel thousand short tons	31,239	33,254	30,151	32,572	29,866	33,453	30,241	33,717
Silver (recoverable content of ores, etc.) thousand troy ounces	2	1						
Stone thousand short tons	31,855	40,859	31,861	41,835	35,016	44,245	35,294	45,081
Zinc (recoverable content of ores, etc.)	24,039	6,587	22,185	5,147	24,940	5,088	26,815	6,167
Value of items that cannot be disclosed: Lime, tripoli, and values indicated by footnote 6		26,048		27,898		9,573		30,897
Total Illinois [9]		572,247		576,324		[5] 576,862		577,372

INDIANA

Mineral	1956		1957		1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
Abrasive stones	3	$5	4	$8	10	$10	5	$13
Cement thousand 376-pound barrels	(6)	(6)	[2] 12,598	[2] 40,742	[2] 14,730	[2] 48,858	(6)	(6)
Clays thousand short tons	2,051	3,457	1,475	2,569	1,370	2,477	1,692	2,915
Coal do	17,089	64,061	15,841	62,055	15,022	58,506	14,804	59,954
Lime do	(10)	1						
Marl, calcareous (except for cement)	99,561	66	(16)	(16)	(16)	(16)	(16)	(16)
Natural gas million cubic feet	791	96	671	88	378	59	[7] 600	[7] 100
Peat	11,383	79	13,805	130	12,106	145	15,393	202
Petroleum (crude) thousand 42-gallon barrels	11,513	33,733	12,662	39,632	11,864	35,711	[7] 12,003	[7] 35,649
Sand and gravel thousand short tons	18,302	15,432	16,750	14,206	16,862	15,045	20,357	17,924
Stone do	14,700	31,575	14,460	33,094	15,394	31,974	18,544	37,682
Value of items that cannot be disclosed: Cement (masonry and natural cement 1957–58), gypsum, and values indicated by footnote 6		50,284		[5] 7,675		[5] 7,539		56,048
Total Indiana [9]		196,439		198,034		197,677		207,701

IOWA

Cement thousand 376-pound barrels	10,760	$32,823	10,823	$34,881	12,675	$41,741	13,170	$44,048
Clays thousand short tons	[4] 852	[4] 1,078	[4] 752	[4] 944	[4] 837	[4] 1,054	912	1,168
Coal do	1,358	4,732	1,312	4,543	1,179	4,147	1,180	4,214
Gypsum do	1,177	3,919	1,123	3,773	1,230	4,491	1,318	5,587
Peat	27,375	(6)	(6)	(6)	(6)	(6)	----------	----------
Sand and gravel thousand short tons	12,895	9,525	12,042	8,927	12,411	10,965	13,484	11,658
Stone do	14,035	17,256	15,214	18,768	21,045	26,138	20,501	25,759
Value of items that cannot be disclosed: Fire clay (1956–58), lime, and values indicated by footnote 6	----------	467	----------	614	----------	633	----------	520
Total Iowa [9]	----------	66,529	----------	68,986	----------	85,356	----------	88,557

KANSAS

Cement [3] thousand 376-pound barrels	10,598	$30,696	8,178	$24,814	9,600	$30,047	10,405	$32,282
Clays thousand short tons	977	1,169	909	1,240	875	1,145	1,021	1,271
Coal do	884	3,856	749	3,331	823	3,711	772	3,607
Gem stones	----------	----------	----------	----------	----------	----------	(13)	1
Helium thousand cubic feet	45,035	698	36,743	570	27,888	432	21,643	343
Lead (recoverable content of ores, etc.)	7,635	2,398	4,257	1,217	1,299	304	481	111
Natural gas million cubic feet	526,091	59,448	586,690	66,883	561,816	64,047	[7] 565,000	[7] 65,000
Natural-gas liquids:								
Natural gasoline thousand gallons	105,482	5,928	119,247	6,569	110,293	6,229	107,814	5,576
LP-gases do	90,287	3,843	103,494	4,042	115,175	5,193	124,874	6,658
Petroleum (crude) thousand 42-gallon barrels	124,204	346,529	123,614	372,078	119,942	359,826	[7] 119,514	[7] 347,786
Salt (common) thousand short tons	1,004	9,167	1,018	10,353	1,073	11,348	1,123	13,670
Sand and gravel do	12,515	8,022	9,345	6,175	10,317	6,769	11,334	7,937
Stone do	13,434	15,703	[8] 10,412	[8] 11,926	[8] 12,424	[8] 15,036	[8] 13,999	[8] 17,108
Zinc (recoverable content of ores, etc.)	28,665	7,854	15,859	3,679	4,421	902	1,017	234
Value of items that cannot be disclosed: Natural cement, gypsum, pumice, stone (dimension and crushed sandstone, 1957–59), and values indicated by footnote 6	----------	1,465	----------	1,191	----------	1,627	----------	2,012
Total Kansas [9]	----------	493,770	----------	511,513	----------	[5] 503,788	----------	500,464

See footnotes at end of table.

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

Mineral	1956		1957		1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
KENTUCKY								
Barite	----------	----------	----------	----------	----------	----------	26,598	$335
Clays .... thousand short tons	905	$4,079	894	$3,915	737	$2,957	984	3,595
Coal .... do	74,555	331,358	74,667	338,109	66,312	289,385	62,810	270,139
Fluorspar	14,865	608	20,626	979	25,861	1,201	18,579	887
Lead (recoverable content of ores, etc.)	228	72	411	118	516	121	409	94
Natural gas .... million cubic feet	73,687	17,022	70,024	16,666	72,248	17,412	[7] 72,400	[7] 17,600
Natural-gas liquids:								
Natural gasoline .... thousand gallons	35,275	2,414	34,956	1,935	37,926	2,165	35,868	2,133
LP-gases .... do	248,992	8,709	176,033	7,403	150,655	8,491	213,171	12,267
Petroleum (crude) .... thousand 42-gallon barrels	17,628	51,297	17,029	53,301	17,509	51,652	[7] 26,343	[7] 74,024
Sand and gravel .... thousand short tons	5,684	5,974	4,482	4,556	4,685	4,835	5,081	5,568
Stone .... do	11,553	15,324	12,718	16,714	12,597	17,360	[8] 16,063	[8] 22,215
Zinc (recoverable content of ores, etc.)	417	114	837	194	1,258	257	673	155
Value of items that cannot be disclosed: Native asphalt (1956–57), cement, iron ore (1956), stone (crushed sandstone 1959), and silver	----------	7,079	----------	6,211	----------	7,059	----------	8,202
Total Kentucky [9]	----------	443,168	----------	449,390	----------	402,121	----------	416,391
LOUISIANA								
Clays [4] .... thousand short tons	785	$785	642	$642	755	$755	904	$904
Gypsum .... do	276	598	(6)	(6)	(6)	(6)	(6)	(6)
Natural gas .... million cubic feet	1,886,302	215,038	2,078,901	232,837	2,451,587	316,255	[7] 2,480,400	[7] 324,900
Natural-gas liquids:								
Natural gasoline and cycle products .... thousand gallons	773,949	62,394	775,009	63,956	783,099	50,371	846,110	60,295
LP-gases .... do	305,222	14,727	335,142	14,888	410,869	21,435	540,046	25,877
Petroleum (crude) .... thousand 42-gallon barrels	299,421	877,951	329,896	1,094,402	313,891	1,023,517	[7] 354,611	[7] 1,120,115
Salt (common) .... thousand short tons	3,704	17,695	3,461	18,944	3,442	18,960	4,807	20,918
Sand and gravel .... do	15,074	18,640	12,579	14,730	15,061	17,119	16,052	20,111
Stone .... do	4,405	6,674	4,383	7,152	5,453	9,532	5,670	10,874
Sulfur (Frasch-process) .... thousand long tons	2,239	59,330	2,156	52,690	2,028	47,651	2,252	52,779
Value of items that cannot be disclosed: Cement, clay (bentonite), lime, and values indicated by footnote 6	----------	16,348	----------	18,966	----------	20,475	----------	20,286
Total Louisiana [15]	----------	1,288,116	----------	1,517,522	----------	[5] 1,523,370	----------	1,654,493

MAINE

Beryllium concentrate...gross weight..	12	$7	4	$2	(11)	(12)	3	$2
Clays...thousand short tons..	26	23	30	28	23	$26	25	26
Feldspar...long tons..	22,219	144	14,330	92	13,034	83	(6)	(6)
Gem stones...	(13)	1	(13)	1	(13)	5	(13)	10
Lime...thousand short tons..	12	179	(6)	(6)	(6)	(6)	...	...
Mica:								
Scrap...	114	3	6	(12)	104	3	157	4
Sheet...pounds..	19,913	146	25,453	202	20,097	278	22,360	237
Peat...	(6)	(6)	3,770	175	(6)	(6)	(6)	(6)
Sand and gravel...thousand short tons..	7,196	3,085	8,037	3,099	8,941	3,746	9,452	3,644
Stone...do....	947	2,787	889	3,076	880	2,760	819	2,766
Value of items that cannot be disclosed: Cement, columbium-tantalum concentrate (1956), slate (1956-57), and values indicated by footnote 6....	...	6,912	...	6,617	...	6,363	...	7,050
Total Maine [15]...	...	12,728	...	12,711	...	12,574	...	13,278

MARYLAND

Clays [4]...thousand short tons..	636	$1,046	631	$963	605	$815	661	$944
Coal...do....	669	2,685	748	3,082	838	3,161	842	3,188
Gem stones...	(13)	(6)	(13)	(6)	(13)	2	(13)	2
Lime...thousand short tons..	53	581	(6)	(6)	(6)	(6)	(6)	(6)
Natural gas...million cubic feet..	4,619	1,169	4,649	1,218	4,266	1,148	[7] 5,400	[7] 1,500
Sand and gravel...thousand short tons..	10,147	12,395	8,679	11,594	[5] 8,513	[5] 11,368	10,034	12,983
Stone...do....	6,229	13,305	6,140	13,392	6,721	14,387	7,445	15,476
Value of items that cannot be disclosed: Beryllium concentrate (1956-57), cement, ball clay, greensand marl, mica (1957), potassium salts, talc and soapstone, and values indicated by footnote 6...	...	10,729	...	10,664	...	16,224	...	21,416
Total Maryland [9]...	...	40,534	...	39,625	...	[5] 45,735	...	53,508

MASSACHUSETTS

Clays...thousand short tons..	128	$213	78	$98	85	$111	101	$229
Lime...do....	134	2,093	137	2,233	139	2,121	144	2,289
Peat...	300	(6)	600	(6)	1,014	(6)	773	(6)
Sand and gravel...thousand short tons..	10,189	9,520	9,900	9,691	10,620	10,035	13,210	11,786
Stone...do....	5,442	13,753	4,877	13,165	4,649	12,354	5,102	12,375
Value of items that cannot be disclosed: Nonmetals and values indicated by footnote 6...	...	3	...	6	...	9	...	7
Total Massachusetts [15]...	...	25,085	...	24,789	...	23,887	...	25,916

See footnotes at end of table.

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

MICHIGAN

Mineral	1956		1957		1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
Cement.......thousand 376-pound barrels..	21,880	$67,798	22,045	$71,606	20,912	$70,432	23,026	77,324
Clays.......thousand short tons..	2,110	2,401	1,842	1,982	1,663	1,813	1,771	1,937
Copper (recoverable content of ores, etc.).......	61,526	52,297	58,400	35,157	58,005	30,511	55,300	33,954
Gypsum.......thousand short tons..	1,716	5,861	1,386	4,823	1,331	4,824	1,721	6,595
Iron ore (usable).......thousand long tons, gross weight..	12,536	98,111	13,123	111,484	8,111	69,845	7,247	62,921
Lime.......thousand short tons..	(6)	(6)	(6)	(6)	(6)	(6)	862	11,748
Manganiferous ore (5 to 35 percent Mn).......gross weight..	----------	----------	123,547	(6)	112,536	(6)	----------	----------
Marl, calcareous (except for cement).......	157,246	95	(16)	(16)	(16)	(16)	(16)	(16)
Natural gas.......million cubic feet..	10,911	1,451	9,122	1,715	14,243	2,649	[7] 12,300	[7] 2,300
Peat.......	31,111	475	80,271	1,406	107,342	1,684	191,661	2,357
Petroleum (crude).......thousand 42-gallon barrels..	10,740	30,824	10,169	31,117	9,308	27,366	[7] 10,438	[7] 30,688
Salt (common).......thousand short tons..	5,548	35,644	5,225	41,073	4,267	33,018	4,485	35,725
Sand and gravel.......do....	42,150	35,146	41,838	35,144	39,871	34,616	48,052	41,193
Silver (recoverable content of ores, etc.).......thousand troy ounces..	380	344	430	389	----------	----------	----------	----------
Stone.......thousand short tons..	33,999	31,010	34,495	34,176	27,188	26,846	30,095	30,379
Value of items that cannot be disclosed: Bromine, calcium-magnesium chloride, gem stones, magnesium compounds, natural-gas liquids, potassium salts, and values indicated by footnote 6.......	----------	38,737	----------	40,324	----------	[5] 45,558	----------	49,371
Total Michigan[9].......	----------	394,556	----------	404,673	----------	[5] 343,487	----------	379,244

MINNESOTA

Mineral	1956		1957		1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
Clays.......thousand short tons..	[4] 80	[4] $91	[4] 97	[4] $113	92	$150	153	$267
Iron ore (usable).......thousand long tons, gross weight..	62,637	461,904	67,656	541,474	42,503	354,528	36,109	306,920
Manganiferous ore (5 to 35 percent Mn).......gross weight..	633,919	(6)	692,295	(6)	370,603	(6)	429,102	(6)
Marl, calcareous (except for cement).......	875	(6)	(16)	(16)	(16)	(16)	(16)	(16)
Peat.......	(6)	(6)	1,300	(6)	(6)	(6)	----------	----------
Sand and gravel.......thousand short tons..	28,197	18,254	28,493	19,385	29,634	21,680	28,486	20,726
Stone.......do....	[8] 3,084	[8] 7,552	[8] 2,968	[8] 8,175	3,519	9,560	3,639	9,461
Value of items that cannot be disclosed: Abrasive stones, cement, fire clay (1956–57), gem stones, lime, manganese ore (1956–57), stone (crushed sandstone, 1956–57, calcareous marl 1957), and values indicated by footnote 6..	----------	13,443	----------	15,107	----------	10,154	----------	9,993
Total Minnesota[15].......	----------	501,027	----------	584,038	----------	395,880	----------	347,178

MISSISSIPPI

Clays ..... thousand short tons..	613	$3,590	616	$3,635	576	$3,338	747	$4,064
Iron ore ..... thousand long tons..	(17)	(12)	(17)	1	(17)	(12)	----------	----------
Natural gas ..... million cubic feet..	185,137	18,143	169,967	17,507	160,143	22,260	[7] 178,000	[7] 24,900
Natural-gas liquids:								
Natural gasoline and cycle products ..... thousand gallons..	24,829	1,751	25,152	1,469	25,738	1,658	23,207	1,495
LP-gases ..... do....	10,698	580	10,044	472	9,208	503	8,141	465
Petroleum (crude) ..... thousand 42-gallon barrels..	40,824	100,019	38,922	113,263	39,512	113,004	[7] 47,928	[7] 136,116
Sand and gravel ..... thousand short tons..	5,315	4,701	5,172	4,344	6,545	6,240	7,520	7,743
Stone ..... do....	656	656	[8] 60	[8] 54	[8] 102	[8] 92	[8] 126	[8] 114
Value of items that cannot be disclosed: Certain metals and nonmetals....	----------	4,174	----------	4,694	----------	4,820	----------	6,751
Total Mississippi [15]	----------	133,098	----------	144,950	----------	[5] 151,411	----------	181,086

MISSOURI

Barite	381,642	$4,462	317,350	$3,938	199,268	$2,666	296,093	$3,924
Cement [2] ..... thousand 376-pound barrels..	12,012	36,888	10,794	34,307	12,116	40,657	13,947	46,974
Clays ..... thousand short tons..	2,658	8,016	2,648	7,648	2,060	5,986	2,635	6,898
Coal ..... do....	3,283	13,223	2,976	12,691	2,592	11,111	2,748	11,937
Copper (recoverable content of ores, etc.)	1,890	1,606	1,604	966	1,429	752	1,065	654
Iron ore (usable) ..... thousand long tons, gross weight..	365	(6)	530	4,625	387	3,820	349	3,278
Lead (recoverable content of ores, etc.)	123,783	38,868	126,345	36,135	113,123	26,471	105,165	24,188
Lime ..... thousand short tons..	1,482	15,814	1,393	16,475	1,173	14,136	1,324	15,714
Natural gas ..... million cubic feet..	12	2	12	2	----------	----------	----------	----------
Nickel (content of ore and concentrate)	(6)	(6)	(6)	(6)	763	(6)	(6)	(6)
Petroleum (crude) ..... thousand 42-gallon barrels..	65	176	65	(6)	84	(6)	----------	----------
Sand and gravel ..... thousand short tons..	9,585	10,117	8,480	8,942	8,972	9,728	10,279	11,406
Silver (recoverable content of ores, etc.) ..... thousand troy ounces..	295	267	184	166	251	227	340	308
Stone ..... thousand short tons..	24,578	33,577	22,098	29,836	24,276	32,878	26,939	36,435
Zinc (recoverable content of ores, etc.)	4,380	1,200	2,951	685	362	74	92	21
Values of items that cannot be disclosed: Native asphalt, masonry cement (1956–57), cobalt, gem stones (1957–59), iron oxide pigment materials (1956), manganese ore (1957–58), and values indicated by footnote 6.....	----------	5,897	----------	2,793	----------	[5] 2,037	----------	2,108
Total Missouri [9]	----------	163,693	----------	152,913	----------	[5] 144,120	----------	157,009

See footnotes at end of table.

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

MONTANA

Mineral	1956		1957		1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
Chromite ..... gross weight	118,780	$3,807	119,149	$3,921	119,057	(6)	[25] 105,000	[25] $3,765
Clays [4] ..... thousand short tons	33	31	32	24	23	$19	46	48
Coal: Bituminous and lignite ..... do	846	3,468	413	2,161	305	1,475	345	1,478
Copper (recoverable content of ores, etc.)	95,426	81,962	91,512	55,090	90,683	47,699	65,911	40,469
Fluorspar	59,775	(6)	64,339	(6)	53,654	(6)	18,542	(6)
Gem stones	(13)	35	(13)	(6)	(13)	(6)	(13)	(6)
Gold (recoverable content of ores, etc.) ..... troy ounces	38,121	1,334	32,766	1,147	26,003	910	28,551	999
Iron ore (usable) ..... thousand long tons, gross weight	12	(6)	36	(6)	14	(6)	50	254
Lead (recoverable content of ores, etc.)	18,642	5,853	13,300	3,804	8,434	1,974	7,672	1,765
Manganese ore (35 percent or more Mn) ..... gross weight	80,552	(6)	68,298	(6)	53,123	4,036	21,604	1,520
Manganiferous ore (5 to 35 percent Mn) ..... do	4,752	(6)	4,547	(6)	(6)	(6)	2,415	34
Mica, sheet ..... pounds	56	1	13	(12)	(6)	(6)	(6)	(12)
Natural gas ..... million cubic feet	25,847	1,758	28,638	2,062	27,989	1,903	[7] 33,000	[7] 2,300
Petroleum (crude) ..... thousand 42-gallon barrels	21,760	56,141	27,172	73,364	27,957	74,086	[7] 30,079	[7] 77,002
Phosphate rock ..... thousand long tons	558	3,957	534	3,825	(6)	(6)	(6)	(6)
Sand and gravel ..... thousand short tons	10,024	7,174	11,403	8,732	13,432	12,593	10,930	12,587
Silver (recoverable content of ores, etc.) ..... thousand troy ounces	7,386	6,685	5,558	5,030	3,630	3,286	3,420	3,096
Stone ..... thousand short tons	1,247	1,816	2,567	3,654	[5] 1,786	[5] 2,468	1,186	1,691
Talc	22,197	210	(6)	(6)	(6)	(6)	(6)	(6)
Tungsten ore and concentrate ..... 60-percent WO_3 basis	1,230	(6)	661	(6)	--------	--------	--------	--------
Uranium ore	(6)	(6)	(6)	(6)	689	20	2,890	(6)
Zinc (recoverable content of ores, etc.)	70,520	19,322	50,520	11,721	33,238	6,781	27,848	6,405
Value of items that cannot be disclosed: Barite, cement, clay (bentonite, 1956; bentonite and fire clay, 1957–59), gypsum, lime, natural-gas liquids, pumice (1956), pyrites, rare-earth metal concentrates (1958–59), vanadium (1957), vermiculite, and values indicated by footnote 6	--------	21,056	--------	17,951	--------	[5] 20,318	--------	15,248
Total Montana [15]	--------	213,704	--------	191,750	--------	[5] 176,728	--------	167,890

NEBRASKA

Clays .... thousand short tons..	153	$154	134	$135	108	$110	131	$133
Gem stones	(13)	3	(13)	2	(13)	2	(13)	3
Natural gas .... million cubic feet..	13,541	2,844	14,249	2,280	11,405	1,711	[7] 19,100	[7] 2,900
Natural-gas liquids:								
Natural gasoline .... thousand gallons..	(6)	(6)	(6)	(6)	10,870	727	(6)	(6)
LP-gases .... do....	(6)	(6)	(6)	(6)	31,178	1,565	(6)	(6)
Petroleum (crude) .... thousand 42-gallon barrels..	16,204	45,209	19,586	58,366	20,373	59,897	[7] 23,669	[7] 68,167
Sand and gravel .... thousand short tons..	10,350	7,404	7,944	5,889	10,441	7,945	11,202	8,301
Stone .... do....	3,063	4,142	3,065	3,749	3,555	4,747	3,236	5,235
Value of items that cannot be disclosed: Cement, pumice, and values indicated by footnote 6	....	12,771	....	13,670	....	14,603	....	17,679
Total Nebraska [9]	....	71,311	....	82,928	....	[5] 90,047	....	100,213

NEVADA

Antimony ore and concentrate .... antimony content..	13	(6)	29	$9	39	$8	10	$2
Barite	178,440	$1,067	109,663	721	59,407	405	91,298	623
Clays .... thousand short tons..	14	32	12	20	(6)	(6)	(6)	(6)
Copper (recoverable content of ores, etc.)	80,824	68,700	77,750	46,806	66,137	34,788	57,375	35,228
Fluorspar	(6)	(6)	(6)	(6)	12,338	340	16,743	407
Gem stones	(13)	50	(13)	100	(13)	100	(13)	100
Gold (recoverable content of ores, etc.) .... troy ounces..	68,040	2,381	76,752	2,686	105,087	3,678	113,443	3,971
Gypsum .... thousand short tons..	790	2,701	674	(6)	686	2,306	818	2,738
Iron ore (usable) .... thousand long tons, gross weight..	917	5,021	904	5,341	594	3,149	698	3,712
Lead (recoverable content of ores, etc.)	6,384	2,004	5,979	1,710	4,150	971	1,357	312
Manganese ore (35 percent or more Mn) .... gross weight..	121,482	(6)	129,046	(6)	127,322	7,566	56,586	3,917
Mercury .... 76-pound flasks..	5,859	1,523	6,313	1,559	7,336	1,681	7,156	1,628
Petroleum .... thousand 42-gallon barrels..	64	111	44	76	40	69	[7] 32	(6)
Pumice .... thousand short tons..	12	34	(6)	(6)	(6)	(6)	(6)	(6)
Sand and gravel .... do....	4,687	4,569	5,233	5,190	5,503	5,311	6,436	7,522
Silver (recoverable content of ores, etc.) .... thousand troy ounces..	994	899	959	868	933	844	611	553
Stone .... thousand short tons..	1,401	2,281	925	1,585	813	1,335	840	1,587
Talc and soapstone	10,540	98	7,467	57	5,391	41	5,824	50
Tungsten concentrate .... 60-percent WO_3 basis..	5,400	19,263	1,196	1,676	(6)	(6)	(6)	(6)
Zinc (recoverable content of ores, etc.)	7,488	2,052	5,292	1,228	91	19	217	50
Value of items that cannot be disclosed: Brucite, diatomite, lime, magnesite, calcareous marl (1956), molybdenum, perlite, salt, sulfur ore, uranium ore, and values indicated by footnote 6	....	14,446	....	16,756	....	6,020	....	8,454
Total Nevada [15]	....	126,681	....	86,023	....	68,293	....	70,159

See footnotes at end of table.

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

NEW HAMPSHIRE

Mineral	1956		1957		1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
Beryllium concentrate, gross weight	(6)	(6)	4	$2	14	$8	20	$12
Clays, thousand short tons	36	$47	37	51	26	26	26	26
Gem stones	(13)	1	(13)	(12)	(13)	5	(13)	10
Mica:								
Sheet, pounds	50,873	178	53,554	460	[5] 81,472	[5] 646	119,163	1,133
Scrap	305	10	522	17	314	12	(6)	(6)
Peat	320	(6)	85	(6)	100	(6)	25	(6)
Sand and gravel, thousand short tons	3,862	1,822	4,505	1,970	4,940	2,620	5,124	2,887
Stone, do	(6)	(6)	(6)	(6)	(6)	(6)	82	488
Value of items that cannot be disclosed: Abrasive stones (1956-57), feldspar, and values indicated by footnote 6		1,378		831		602		166
Total New Hampshire		3,436		3,331		[5] 3,919		4,722

NEW JERSEY

Mineral	1956		1957		1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
Clays, thousand short tons	[4] 651	[4] $2,214	[4] 593	[4] $1,872	684	$2,181	700	$1,895
Gem stones	(13)	(6)	(13)	(12)	(13)	4	(13)	6
Iron ore (usable), thousand long tons, gross weight	912	16,842	877	16,668	(6)	(6)	(6)	(6)
Manganiferous residuum, gross weight	130,129	(6)	(6)	(6)	(6)	(6)	(6)	(6)
Peat	(6)	(6)	(6)	(6)	18,397	185	28,300	278
Sand and gravel, thousand short tons	11,194	18,239	10,323	17,619	9,877	16,145	11,033	18,620
Stone, do	9,012	20,825	8,792	21,222	8,229	19,193	10,079	22,133
Zinc (recoverable content of ores, etc.)[18]	4,667	1,260	12,530	2,857	607	125		
Value of items that cannot be disclosed: Ball clay (1956-57), lime, magnesium compounds, greensand marl, and values indicated by footnote 6. Excludes limestone used in manufacturing lime		4,608		4,404		12,547		16,547
Total New Jersey		63,988		64,642		50,380		59,479

NEW MEXICO

Barite	4,059	$81	4,441	$98	(6)	(6)	320	$6
Beryllium concentrate ..... gross weight	31	(6)	29	15	27	$16	11	6
Clays ..... thousand short tons	40	95	33	83	[4] 40	[4] 73	[4] 45	[4] 77
Coal ..... do	158	923	137	829	117	719	149	837
Columbium-tantalum concentrate ..... pounds	95	(12)	866	1	--------	--------	--------	--------
Copper (recoverable content of ores, etc.)	74,345	63,193	67,472	40,618	55,540	29,214	39,688	24,369
Fluorspar	--------	--------	--------	--------	--------	--------	200	7
Gem stones	(13)	30	(13)	30	(13)	28	(13)	39
Gold (recoverable content of ores, etc.) ..... troy ounces	3,275	115	3,212	112	3,378	118	3,155	110
Helium ..... thousand cubic feet	76,072	1,350	69,336	1,189	29,793	502	16,903	264
Iron ore (usable) ..... thousand long tons, gross weight	(6)	(6)	(17)	1	(17)	(6)	(17)	(6)
Lead (recoverable content of ores, etc.)	6,042	1,897	5,294	1,514	1,117	261	829	191
Lime ..... thousand short tons	31	373	24	290	21	260	16	209
Manganese ore (35 percent or more Mn) ..... gross weight	22,011	1,834	25,459	2,114	[5] 28,866	[5] 2,333	27,528	2,248
Manganiferous ore (5 to 35 percent Mn) ..... do	38,782	(6)	42,535	152	(6)	(6)	(6)	(6)
Mica:								
Scrap	767	22	1,347	47	787	24	210	7
Sheet ..... pounds	6,247	53	2,134	16	1,791	18	247	2
Natural gas ..... million cubic feet	626,340	55,118	723,004	67,962	761,446	79,190	[7] 777,800	[7] 81,700
Natural-gas liquids:								
Natural gasoline and cycle products ..... thousand gallons	306,595	16,560	309,010	19,941	258,312	15,131	264,133	16,859
LP-gases ..... do	308,218	11,065	375,930	13,046	458,178	17,331	552,257	22,320
Perlite	167,705	1,271	187,259	1,568	202,046	1,790	240,642	2,121
Petroleum (crude) ..... thousand 42-gallon barrels	87,893	241,706	94,759	283,128	98,515	293,974	[7] 105,692	[7] 301,394
Potassium salts ..... thousand short tons, K_2O equivalent	1,997	75,122	2,080	77,197	1,978	69,106	2,189	74,117
Pumice ..... thousand short tons	292	667	321	756	507	959	493	1,023
Salt (common) ..... do	58	501	53	429	31	275	36	322
Sand and gravel ..... do	6,054	5,776	7,991	7,803	13,205	11,413	12,460	13,332
Silver (recoverable content of ores, etc.) ..... thousand troy ounces	393	356	309	280	159	144	159	144
Stone ..... thousand short tons	1,268	1,272	1,348	1,618	1,730	1,507	461	542
Tungsten ore and concentrate ..... 60-percent WO_3 basis	(11)	2	--------	--------	--------	--------	--------	--------
Uranium ore	1,105,183	24,086	1,175,742	20,538	1,888,499	32,264	3,269,826	53,463
Zinc (recoverable content of ores, etc.)	35,010	9,593	32,680	7,582	9,034	1,843	4,636	1,066
Value of items that cannot be disclosed: Carbon dioxide, cement (1959), fire clay (1957–59), molybdenum, magnesium compounds, rare-earth metals concentrates (1956), vanadium, and values indicated by footnote 6	--------	1,933	--------	2,276	--------	1,345	--------	3,771
Total New Mexico [15]	--------	514,903	--------	551,155	--------	[5] 559,777	--------	600,269

See footnotes at end of table.

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

NEW YORK

Mineral	1956		1957		1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
Clays……thousand short tons	1,235	$1,508	1,002	$1,270	1,085	$1,419	1,309	$1,714
Emery	12,153	174	11,893	184	7,687	126	8,555	150
Gem stones	(13)	2	(13)	5	(13)	8	(13)	8
Gypsum……thousand short tons	1,140	4,817	864	3,749	834	3,869	919	4,663
Iron ore (usable)……thousand long tons, gross weight	3,188	41,094	3,329	44,567	1,944	25,683	2,044	28,050
Lead (recoverable content of ores, etc.)	1,608	505	1,667	477	579	135	481	111
Lime……thousand short tons	87	1,030	(6)	(6)	(6)	(6)	(6)	(6)
Natural gas……million cubic feet	4,098	1,160	2,869	815	2,808	859	[7] 4,000	[7] 1,320
Peat	2,900	23	(6)	(6)	13,606	117	12,875	138
Petroleum (crude)……thousand 42-gallon barrels	2,748	12,091	2,677	12,662	1,763	7,457	[7] 1,981	[7] 8,399
Salt (common)……thousand short tons	3,873	27,545	3,691	28,002	3,896	30,609	4,011	30,958
Sand and gravel……do	27,815	28,722	25,640	26,480	24,730	27,541	27,943	31,415
Silver (recoverable content of ores, etc.)……thousand troy ounces	84	76	64	58	67	60	52	47
Slate……thousand short tons	64	944	59	961	(19)	(19)	(19)	(19)
Stone……do	22,805	36,135	24,265	43,276	22,598	38,219	28,640	46,556
Zinc (recoverable content of ores, etc.)	59,111	16,196	64,659	15,001	53,014	10,815	43,464	9,997
Value of items that cannot be disclosed: Cement, abrasive garnet, iron oxide pigments (1956–58), talc, titanium concentrate, wollastonite, and values indicated by footnote 6	---	68,969	---	70,699	---	61,859	---	76,904
Total New York [9]	---	237,016	---	244,114	---	[5] 205,338	---	235,119

NORTH CAROLINA

Mineral	1956		1957		1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
Abrasive stones	[20] 454	$16	(13)	[21] $5	(13)	[21] $2	[22] 191	[22] $5
Beryllium concentrate……gross weight	3	2	1	1	(11)	(12)	---	---
Clays……thousand short tons	2,663	2,027	[4] 2,392	[4] 1,407	[4] 2,046	[4] 1,187	[4] 2,524	[4] 1,522
Feldspar……long tons	255,637	3,192	233,439	2,728	(6)	(6)	(6)	(6)
Gem stones	(13)	1	(13)	(12)	(13)	1	(13)	9
Gold (recoverable content of ores, etc.)……troy ounces	882	31	1,373	48	876	31	965	34
Lead (recoverable content of ores, etc.)	10	3	9	3	---	---	---	---
Mica:								
Scrap	47,125	1,065	53,452	1,173	50,897	1,041	47,736	1,212
Sheet……pounds	770,903	2,135	577,607	1,575	521,701	1,722	505,623	1,755
Sand and gravel……thousand short tons	7,581	6,264	6,829	5,724	7,044	5,880	8,580	7,426
Silver (recoverable content of ores, etc.)……thousand troy ounces	1	1	12	11	15	14	16	15
Stone……thousand short tons	[8] 8,352	[8] 11,472	[8] 9,455	[8] 12,839	12,385	19,132	12,859	20,302

Talc and pyrophyllite	125,487	529	120,905	558	126,158	614	127,296	647
Tungsten concentrate, 60-percent WO_3 basis	2,732	(6)	1,828	(6)	(6)	(6)	(6)	(6)
Zinc (recoverable content of ores, etc.)	------	------	2	(12)	------	------	------	------
Value of items that cannot be disclosed: Abrasive stone (grinding pebbles and tube-mill liners, 1957–58, millstones 1959), asbestos (1957–59), clay (bentonite 1957, kaolin 1958–59), copper, iron ore (1959), lithium minerals, olivine, slate (1957), stone (crushed and dimension granite, crushed limestone, crushed miscellaneous, and dimension sandstone, 1956; dimension granite, crushed basalt, dimension and crushed marble, crushed limestone, and crushed sandstone 1957), and values indicated by footnote 6	------	14,135	------	11,498	------	10,267	------	7,862
Total North Carolina	------	40,873	------	37,570	------	39,891	------	40,789
NORTH DAKOTA								
Clays [4], thousand short tons	52	$71	54	$67	54	$66	61	$79
Coal (lignite), do	2,815	6,578	2,561	5,947	2,314	5,409	2,413	5,426
Gem stones	------	------	(13)	(12)	(13)	1	(13)	1
Natural gas, million cubic feet	11,725	950	15,450	1,468	17,325	1,672	[7] 16,500	[7] 1,700
Petroleum (crude), thousand 42-gallon barrels	13,495	39,136	13,259	41,501	14,259	42,634	[7] 17,960	[7] 50,288
Pumice, thousand short tons	5	5	2	2	11	11	------	------
Sand and gravel, do	5,946	4,259	7,048	4,967	11,464	6,605	9,883	6,516
Stone, do	83	87	29	52	23	35	48	84
Value of items that cannot be disclosed: Clays (bentonite), natural gas liquids, and values indicated by footnote 6	------	2,423	------	2,698	------	3,012	------	3,555
Total North Dakota	------	53,509	------	56,702	------	[5] 59,445	------	67,649
OHIO								
Abrasive stones, grindstones and pulpstones	(6)	(6)	1,505	$132	852	$83	1,081	$101
Cement, thousand 376-pound barrels	16,065	$49,794	16,238	52,184	15,700	53,043	18,994	63,935
Clays, thousand short tons	6,703	17,675	6,136	16,073	5,220	13,082	5,478	15,346
Coal, do	38,934	148,650	36,862	146,134	32,028	126,241	35,112	135,729
Lime, do	2,995	40,805	2,763	38,383	2,411	32,471	3,190	45,121
Natural gas, million cubic feet	25,368	6,088	30,384	7,201	31,786	6,802	[7] 31,900	[7] 7,800
Peat	15,509	174	5,478	102	5,660	104	5,813	73
Petroleum (crude), thousand 42-gallon barrels	4,785	15,025	5,478	17,694	6,260	18,091	[7] 5,566	[7] 15,974
Salt (common), thousand short tons	2,972	15,923	2,825	16,936	2,443	17,443	2,858	20,486
Sand and gravel, do	30,200	36,146	30,596	37,503	29,624	36,619	38,604	45,139
Stone, do	[8] 33,418	[8] 50,947	[8] 37,451	[8] 61,847	29,122	49,782	[8] 36,155	[8] 59,326
Value of items that cannot be disclosed: Calcium-magnesium chloride (1956), gem stones (1958–59), gypsum, natural gasoline (1956–58), stone (crushed sandstone 1956, dimension limestone 1957, and calcareous marl, 1957, 1959), and values indicated by footnote 6	------	5,394	------	2,453	------	1,905	------	2,029
Total Ohio [9]	------	375,488	------	383,000	------	344,856	------	395,901

See footnotes at end of table.

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

OKLAHOMA

Mineral	1956		1957		1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
Clays[4] ... thousand short tons	705	$701	641	$642	576	$579	966	$970
Coal ... do	2,007	12,341	2,195	14,165	1,629	10,858	1,525	10,272
Helium ... thousand cubic feet	------	------	------	------	------	------	98,749	1,619
Lead (recoverable content of ores, etc.)	12,350	3,878	7,183	2,054	3,692	864	601	138
Natural gas ... million cubic feet	678,603	54,288	719,794	59,743	696,504	70,347	[7] 701,500	[7] 72,300
Natural-gas liquids:								
Natural gasoline and cycle products ... thousand gallons	489,963	26,543	460,644	25,329	440,798	26,029	448,353	29,443
LP-gases ... do	579,101	23,427	587,140	21,824	657,114	25,822	675,869	27,070
Petroleum (crude) ... thousand 42-gallon barrels	215,862	600,096	214,661	650,423	200,699	594,069	[7] 196,487	[7] 573,742
Pumice ... thousand short tons	(10)	3	(6)	(6)	(6)	(6)	(6)	(6)
Salt (common) ... do	10	90	7	63	4	41	(6)	(6)
Sand and gravel ... do	5,947	4,842	4,960	4,507	7,232	5,859	6,002	5,927
Stone ... do	10,547	12,417	12,016	14,064	10,794	12,232	12,683	14,980
Tripoli	(6)	(6)	22,236	67	(6)	(6)	(6)	(6)
Zinc (recoverable content of ores, etc.)	27,515	7,539	14,951	3,469	5,267	1,074	1,049	241
Value of items that cannot be disclosed: Native asphalt, clay (bentonite), cement, gem stones (1959), gypsum, lime, manganese ore (1957), uranium ore (1956), and values indicated by footnote 6	------	12,929	------	14,573	------	16,022	------	18,156
Total Oklahoma[9]	------	757,080	------	809,004	------	[5] 761,936	------	751,907

OREGON

Mineral	1956		1957		1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
Chromite ... gross weight	[23] 54,577	[23] $2,001	7,900	$675	4,133	(6)	------	------
Clays ... thousand short tons	257	278	240	266	252	$293	294	$308
Copper (recoverable content of ores, etc.)	7	6	23	14	10	5	------	------
Gem stones	(13)	250	(13)	200	(13)	(6)	(13)	(6)
Gold (recoverable content of ores, etc.) ... troy ounces	2,738	96	3,381	118	1,423	50	686	24
Iron ore (usable) ... thousand long tons	1	(6)	(17)	(6)	------	------	------	------
Lead (recoverable content of ores, etc.)	5	2	5	1	1	(12)	------	------
Mercury ... 76-pound flasks	1,893	492	3,993	986	2,276	521	1,224	278
Nickel (content of ore and concentrate)	6,866	(6)	12,276	(6)	12,697	(6)	12,374	(6)
Pumice ... thousand short tons	(6)	(6)	123	294	138	331	(6)	(6)
Sand and gravel ... do	11,637	11,647	12,843	13,481	10,464	10,265	18,087	15,506
Silver (recoverable content of ores, etc.) ... thousand troy ounces	14	12	16	14	3	2	(24)	(12)

Stone ......thousand short tons..	6, 098	7, 890	10, 583	11, 745	[5] 15, 077	[5] 15, 621	13, 341	16, 126
Value of items that cannot be disclosed: Carbon dioxide, cement, diatomite, iron ore (pigment material, 1956-57, 1959), lime (1957-58), sodium carbonate (1956), tungsten concentrate (1956-57), uranium ore (1956-57), and values indicated by footnote 6......	------------	12, 689	------------	15, 954	------------	19, 311	------------	18, 597
Total Oregon [9]......	------------	34, 021	------------	42, 820	------------	[5] 45, 190	------------	49, 831
PENNSYLVANIA								
Cement ......thousand 376-pound barrels..	51, 964	$162, 387	44, 680	$148, 130	42, 115	$142, 399	43, 356	$150, 918
Clays ......thousand short tons..	[4] 4, 413	[4] 23, 782	4, 074	22, 012	[4] 3, 318	[4] 17, 051	3, 466	17, 196
Coal:								
Anthracite ......do....	28, 900	236, 785	25, 338	227, 754	21, 171	187, 898	20, 649	172, 320
Bituminous ......do....	90, 287	479, 437	85, 365	492, 539	67, 771	373, 812	65, 347	345, 332
Cobalt (content of concentrate) ......thousand pounds..	533	(6)	599	(6)	564	(6)	280	(6)
Gem stones......	(13)	(6)	(13)	(6)	(13)	2	(13)	3
Lime ......thousand short tons..	1, 443	18, 282	1, 298	18, 406	1, 003	[5] 14, 161	1, 263	18, 261
Natural gas ......million cubic feet..	104, 508	33, 652	101, 801	31, 660	95, 869	27, 131	[7] 108, 000	[7] 30, 700
Natural-gas liquids:								
Natural-gasoline ......thousand gallons..	4, 081	251	3, 106	192	1, 608	107	2, 884	184
LP-gases ......do....	1, 127	99	1, 211	106	1, 363	123	1, 484	36
Peat......	20, 498	213	26, 086	236	23, 623	203	26, 948	262
Petroleum (crude) ......thousand 42-gallon barrels..	8, 230	35, 718	8, 179	38, 687	6, 472	26, 535	[7] 6, 156	[7] 25, 855
Sand and gravel ......thousand short tons..	14, 047	21, 321	12, 406	19, 570	11, 825	19, 180	14, 257	23, 233
Slate ......do....	154	4, 194	139	4, 005	(19)	(19)	(19)	(19)
Stone ......do....	[8] 44, 913	[8] 73, 831	43, 258	73, 090	40, 049	69, 694	43, 682	77, 421
Tripoli......	1, 030	7	(6)	(6)	(6)	(6)	(6)	(6)
Zinc (recoverable content of ores, etc.) [18]......	------------	------------	------------	------------	10, 812	2, 229	16, 718	3, 828
Value of items that cannot be disclosed: Clays (kaolin 1956, 1958), copper, gold, graphite (1959), iron ore (pigment material), mica, pyrites, pyrophyllite and soapstone, silver, stone (dimension basalt and shell 1956), and values indicated by footnote 6......	------------	16, 209	------------	[5] 16, 613	------------	[5] 15, 960	------------	15, 812
Total Pennsylvania [9]......	------------	1, 088, 481	------------	1, 077, 157	------------	[5] 882, 040	------------	863, 818
RHODE ISLAND								
Sand and gravel ......thousand short tons..	1, 308	$1, 263	1, 058	$1, 060	2, 038	$1, 883	1, 740	$1, 588
Stone ......do....	42	221	[8] 4	[8] 14	[8] 3	[8] 8	(6)	(6)
Value of items that cannot be disclosed: Nonmetals and values indicated by footnote 6......	------------	143	------------	295	------------	358	------------	745
Total Rhode Island......	------------	1, 627	------------	1, 369	------------	2, 249	------------	2, 333

See footnotes at end of table.

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

SOUTH CAROLINA

Mineral	1956		1957		1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
Clays .... thousand short tons	1,087	$5,450	937	$5,161	929	$5,157	1,160	$5,920
Mica (sheet) .... pounds	5,400	14	2,278	12	1,144	8	251	3
Peat	----------	----------	----------	----------	4,865	(6)	4,194	(6)
Sand and gravel .... thousand short tons	3,229	2,926	2,647	2,571	2,946	2,858	3,104	3,077
Stone .... do	3,304	4,285	[8] 3,413	[8] 4,581	[8] 3,637	[8] 5,229	[8] 6,248	[8] 8,647
Zirconium concentrate	----------	----------	(6)	(6)	141	5	----------	----------
Value of items that cannot be disclosed: Barite, cement, feldspar (1959), gem stones (1958), kyanite, scrap mica, rare-earth metal concentrates (1956–58), staurolite (1957–58), stone (dimension granite 1956–57, crushed limestone 1956–59, crushed sandstone 1959, calcareous marl 1957–59) titanium (1956–58), vermiculite, and values indicated by footnote 6	----------	9,277	----------	10,491	----------	9,586	----------	13,640
Total South Carolina [15]	----------	21,342	----------	22,168	----------	22,412	----------	30,598

SOUTH DAKOTA

Mineral	1956		1957		1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
Beryllium concentrate .... gross weight	195	$95	268	$145	240	$129	156	$84
Clays [4] .... thousand short tons	201	201	176	176	155	155	227	227
Coal (lignite) .... do	25	90	21	79	20	78	22	88
Columbium-tantalum concentrate .... pounds	237	(12)	2,311	6	4,294	10	----------	----------
Feldspar .... long tons	45,226	289	41,316	267	23,229	145	30,825	196
Gem stones	(13)	10	(13)	15	(13)	16	(13)	20
Gold (recoverable content of ores, etc.) .... troy ounces	568,523	19,898	568,130	19,885	570,830	19,979	577,730	20,221
Gypsum .... thousand short tons	16	63	13	53	12	49	19	78
Iron ore (usable) .... thousand long tons, gross weight	22	100	(17)	(6)	----------	----------	----------	----------
Mica:								
Scrap	1,268	31	1,626	43	1,003	24	158	5
Sheet .... pounds	12,494	67	9,093	46	16,772	68	38,775	158
Petroleum (crude) .... thousand 42-gallon barrels	32	(6)	54	(6)	58	(6)	[7] 119	(6)
Sand and gravel .... thousand short tons	12,539	8,423	14,758	8,001	14,705	9,179	17,775	11,058
Silver (recoverable content of ores, etc) .... thousand troy ounces	136	123	135	122	153	138	124	113
Stone .... thousand short tons	2,200	5,725	1,718	5,068	1,395	4,095	2,721	7,243
Uranium ore	35,302	475	69,800	760	35,489	530	45,734	606
Value of items that cannot be disclosed: Cement, clays (bentonite), lime, lithium minerals (1958–59), and values indicated by footnote 6	----------	7,547	----------	6,090	----------	7,555	----------	9,333
Total South Dakota [9]	----------	42,281	----------	39,997	----------	41,534	----------	48,485

TENNESSEE

Cement	thousand 376-pound barrels	8, 755	$25, 435	7, 415	$22, 806	8, 375	$26, 408	9, 153	$28, 934
Clays	thousand short tons	1, 379	4, 888	1, 154	4, 228	935	4, 210	1, 146	4, 952
Coal	do	8, 848	35, 609	7, 955	31, 147	6, 785	25, 969	5, 913	23, 581
Copper (recoverable content of ores, etc.)		10, 449	8, 882	9, 790	5, 894	9, 109	4, 791	11, 490	7, 055
Gem stones		---	---	---	---	(13)	1	(13)	(12)
Gold (recoverable content of ores, etc.)	troy ounces	189	7	172	6	124	4	99	3
Iron ore (usable)	thousand long tons, gross weight	(6)	(6)	(6)	(6)	(6)	(6)	21	111
Lead (recoverable content of ores, etc.)		5	1	---	---	---	---	---	---
Lime	thousand short tons	125	1, 436	94	1, 134	(6)	(6)	(6)	(6)
Manganese ore (35 percent or more Mn)	gross weight	17, 821	1, 417	12, 938	1, 007	5, 935	452	7, 586	589
Manganiferous ore (5 to 35 percent Mn)	do	---	---	---	---	---	---	56	1
Natural gas	million cubic feet	45	6	38	6	54	9	[7] 60	[7] 10
Petroleum (crude)	thousand 42-gallon barrels	9	(6)	7	(6)	7	(6)	[7] 6	(6)
Phosphate rock	thousand long tons	1, 685	11, 643	1, 812	12, 514	1, 903	13, 041	1, 755	13, 255
Sand and gravel	thousand short tons	5, 629	6, 480	5, 617	6, 641	5, 612	6, 671	6, 221	7, 570
Silver (recoverable content of ores, etc.)	thousand troy ounces	65	59	54	49	44	40	60	54
Stone	thousand short tons	[8] 15, 556	[8] 23, 796	[8] 15, 354	[8] 24, 155	[8] 16, 850	[8] 26, 814	18, 767	29, 094
Zinc (recoverable content of ores, etc.)		46, 023	12, 610	58, 063	13, 470	59, 130	12, 062	89, 932	20, 684
Value of items that cannot be disclosed: Barite, fluorspar (1956–57), scrap mica (1956–59), pyrites, stone (crushed sandstone 1956–58, crushed granite 1957, dimension limestone 1958) and values indicated by footnote 6		---	8, 772	---	8, 029	---	[5] 6, 884	---	7, 392
Total Tennessee [9]		---	137, 846	---	128, 739	---	[5] 124, 934	---	140, 739

TEXAS

Cement	thousand 376-pound barrels	25, 966	$75, 695	22, 144	$68, 541	25, 875	$79, 756	27, 991	$88, 067
Clays [4]	thousand short tons	3, 146	4, 765	2, 992	4, 934	3, 720	5, 424	3, 870	5, 703
Gem stones		(13)	115	(13)	100	(13)	100	(13)	100
Gypsum	thousand short tons	1, 157	3, 623	1, 043	3, 343	1, 240	4, 120	1, 351	4, 770
Helium	thousand cubic feet	145, 830	2, 364	204, 286	3, 353	294, 452	4, 807	238, 113	3, 918
Lime	thousand short tons	592	6, 938	796	7, 489	691	7, 146	809	8, 530
Natural gas	million cubic feet	4, 999, 889	434, 990	5, 156, 215	500, 153	5, 178, 073	517, 807	[7] 5, 600, 300	[7] 560, 400
Natural-gas liquids:									
Natural gasoline and cycle products	thousand gallons	2, 964, 609	216, 378	2, 944, 381	201, 423	2, 871, 589	204, 501	2, 790, 155	209, 238
LP-gases	do	3, 731, 047	144, 745	3, 831, 664	147, 618	3, 786, 575	151, 896	4, 353, 368	181, 148
Petroleum (crude)	thousand 42-gallon barrels	1, 107, 808	3, 131, 225	1, 073, 867	3, 338, 119	940, 166	2, 872, 389	[7] 983, 840	[7] 2, 931, 843
Salt (common)	thousand short tons	3, 963	14, 370	4, 612	17, 104	3, 843	15, 115	4, 519	17, 498
Sand and gravel	do	29, 336	27, 213	23, 685	23, 427	32, 871	30, 808	35, 295	34, 726
Stone	do	32, 773	36, 350	31, 248	36, 153	36, 076	40, 912	42, 172	47, 787
Sulfur (Frasch-process)	thousand long tons	3, 437	91, 026	2, 879	70, 226	2, 616	61, 621	2, 970	68, 998
Talc and soapstone		41, 332	244	47, 780	199	60, 827	168	60, 945	283
Value of items that cannot be disclosed: Abrasive stones (1956–57, 1959), native asphalt, bromine, clay (fuller's earth), coal (lignite), feldspar 1957–59), graphite, iron ore, magnesium chloride (for metal), magnesium compounds (except for metal), mercury, pumice (1956–58), sodium sulfate, and uranium ore		---	62, 354	---	71, 510	---	[5] 46, 891	---	48, 544
Total Texas [9]		---	4, 241, 258	---	4, 484, 538	---	[5] 4, 033, 311	---	4, 201, 203

See footnotes at end of table.

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

UTAH

Mineral	1956		1957		1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value[7] (thousands)
Asphalt and related bitumens, native: Gilsonite	(6)	(6)	207,704	$4,259	317,280	$4,864	379,362	$9,385
Carbon dioxide, natural ... thousand cubic feet	(6)	(6)	(6)	(6)	90,207	6	69,625	5
Clays [4] ... thousand short tons	227	$492	164	473	157	488	185	484
Coal ... do	6,522	34,436	6,858	40,263	5,328	30,340	4,545	27,982
Copper (recoverable content of ores, etc.)	250,604	213,013	237,857	143,190	189,184	99,511	144,715	88,855
Fluorspar	10,581	265	11,087	387	16,109	564	(6)	(6)
Gem stones	(13)	10	(13)	12	(13)	40	(13)	134
Gold (recoverable content of ores, etc.) ... troy ounces	416,031	14,561	378,438	13,245	307,824	10,774	239,517	8,383
Iron ore (usable) ... thousand long tons, gross weight	4,002	27,508	4,156	30,383	3,514	25,202	2,842	19,979
Lead (recoverable content of ores, etc.)	49,555	15,560	44,471	12,719	40,355	9,443	36,630	8,425
Lime ... thousand short tons	55	830	53	821	80	1,513	90	1,773
Manganese ore (35 percent or more Mn) ... gross weight	-----	-----	142	12	1,043	84	1,511	124
Mica (sheet) ... pounds	-----	-----	-----	-----	12	(12)	-----	-----
Natural gas ... million cubic feet	17,268	2,435	16,824	2,473	19,247	2,829	[7] 31,000	[7] 4,600
Natural gasoline ... thousand gallons	(6)	(6)	(6)	(6)	240	15	(6)	(6)
Perlite	2,271	9	(6)	(6)	(6)	(6)	(6)	(6)
Petroleum (crude) ... thousand 42-gallon barrels	2,466	5,302	4,367	9,913	24,811	74,185	[7] 40,109	114,712
Phosphate rock ... thousand long tons	125	772	114	756	(6)	(6)	(6)	(6)
Pumice ... thousand short tons	45	330	36	148	41	84	39	81
Salt (common) ... do	184	1,471	221	2,013	184	2,275	209	2,453
Sand and gravel ... do	5,836	4,476	26,958	15,485	25,304	14,379	8,843	6,436
Silver (recoverable content of ores, etc.) ... thousand troy ounces	6,572	5,948	6,199	5,610	5,278	4,777	3,734	3,380
Stone ... thousand short tons	2,322	3,298	7,854	8,540	13,126	13,949	3,338	4,048
Tungsten ore and concentrate ... 60-percent WO_3 basis	11	41	-----	-----	-----	-----	-----	-----
Uranium ore	926,273	25,214	1,075,759	32,501	1,239,767	38,583	1,210,654	37,310
Vanadium ... thousand pounds	1,099	(6)	1,017	(6)	752	(6)	1,072	(6)
Zinc (recoverable content of ores, etc.)	42,374	11,610	40,846	9,476	44,982	9,176	35,223	8,101
Value of items that cannot be disclosed: Barite (1959), cement, clay (kaolin), gypsum, molybdenum, LP-gases (1959), potassium salts, pyrites (1959), and values indicated by footnote 6	-----	33,352	-----	27,651	-----	[5] 25,214	-----	27,396
Total Utah [15]	-----	399,759	-----	359,335	-----	[5] 367,232	-----	373,017

VERMONT

Copper (recoverable content of ores, etc.)	3,403	$2,893	3,405	$2,050	475	$250	---	---
Gem stones	---	---	---	---	(13)	1	(13)	$1
Gold (recoverable content of ores, etc.) troy ounces	(6)	(6)	62	2	---	---	---	---
Pyrites thousand long tons	23	107	10	56	---	---	---	---
Sand and gravel thousand short tons	1,910	905	2,216	1,051	1,882	1,316	[8] 2,320	[8] 1,590
Silver (recoverable content of ores, etc.) thousand troy ounces	(6)	(6)	37	33	5	5	---	---
Slate thousand short tons	162	3,772	(6)	3,269	(19)	(19)	(19)	(19)
Stone do	621	11,622	557	11,404	808	15,789	944	17,372
Value of items that cannot be disclosed: Asbestos, clays, lime, talc, and values indicated by footnote 6	---	3,915	---	4,058	---	4,106	---	4,420
Total Vermont [15]	---	23,131	---	21,893	---	21,443	---	23,359

VIRGINIA

Beryllium concentrate gross weight	1	(12)	---	---	---	---	---	---
Clays thousand short tons	1,000	$1,033	893	$986	1,153	$1,143	1,346	$1,396
Coal do	28,063	138,127	29,506	153,959	26,826	130,319	29,769	139,224
Gem stones	(18)	(6)	---	---	(13)	3	(13)	4
Lead (recoverable content of ores, etc.)	3,035	953	3,143	899	2,934	687	2,770	637
Lime thousand short tons	512	5,926	510	6,029	471	5,533	765	8,168
Manganese ore (35 percent or more Mn) gross weight	20,231	1,902	12,655	1,058	8,128	647	6,232	499
Manganiferous ore (5 to 35 percent Mn) do	(6)	(6)	---	---	56	1	(6)	(6)
Marl, calcareous (except for cement)	10,522	12	(16)	(16)	(16)	(16)	(16)	(16)
Mica, sheet pounds	396	6	529	6	147	2	108	1
Natural gas million cubic feet	2,926	810	2,465	661	2,521	681	[7] 1,440	[7] 400
Petroleum (crude) thousand 42-gallon barrels	4	(6)	5	(6)	4	(6)	[7] 6	(6)
Sand and gravel thousand short tons	7,783	9,420	7,047	9,877	7,158	10,834	8,452	12,369
Silver (recoverable content of ores, etc.) thousand troy ounces	2	2	(6)	(6)	2	2	1	1
Slate thousand short tons	32	1,035	(6)	1,003	(19)	(19)	(19)	(19)
Stone do	14,082	23,076	[8] 14,244	[8] 21,158	15,413	27,504	17,787	31,447
Zinc (recoverable content of ores, etc.) [23]	19,196	5,181	23,080	5,277	18,472	3,808	20,334	4,662
Value of items that cannot be disclosed: Aplite, cement, feldspar, gypsum, iron oxide pigments (1955-57), kyanite, mica (scrap 1955), pyrites, salt, stone (dimension miscellaneous, dimension sandstone and calcareous marl (1957), talc and soapstone, titanium concentrate, and values indicated by footnote 6	---	24,931	---	29,746	---	[5] 25,471	---	28,848
Total Virginia [9]	---	208,806	---	227,108	---	[5] 203,277	---	222,304

See footnotes at end of table.

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

WASHINGTON

Mineral	1956		1957		1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
Abrasive stone: Pebbles (grinding)	25	(12)	25	(12)	18	(12)	(6)	(12)
Chromite ... gross weight	30	$3	------	------	17	$2	------	------
Clays ... thousand short tons	320	440	298	$488	[4]196	[4]183	[4]180	[4]$171
Coal ... do	473	3,432	360	2,761	252	1,968	242	1,841
Copper (recoverable content of ores, etc.)	2,926	2,487	1,700	1,023	52	27	49	30
Gem stones	(13)	75	(13)	75	(13)	75	(13)	(6)
Gold (recoverable content of ores, etc.) ... troy ounces	70,669	2,473	(6)	(6)	(6)	(6)	(6)	(6)
Gypsum ... thousand short tons	(6)	(6)	6	(6)	(6)	(6)	(6)	(6)
Iron ore (usable) ... thousand long tons	2	(6)	4	(6)	4	(6)	4	5
Lead (recoverable content of ores, etc.)	11,657	3,660	12,734	3,642	9,020	2,111	10,310	2,371
Manganese ore (35 percent or more Mn) ... gross weight	------	------	------	------	------	------	83	(6)
Peat	37,043	129	39,364	153	34,642	116	32,884	124
Petroleum (crude) ... thousand 42-gallon barrels	------	------	5	(6)	4	(6)	[7]1	(6)
Pumice ... thousand short tons	5	15	(6)	(6)	(6)	(6)	9	112
Sand and gravel ... do	16,842	15,037	20,415	17,510	24,389	20,086	21,360	18,576
Silver (recoverable content of ores, etc.) ... thousand troy ounces	448	406	(6)	(6)	(6)	(6)	(6)	(6)
Stone ... thousand short tons	8,057	11,660	8,897	11,645	7,837	9,991	12,278	13,587
Talc and soapstone	(6)	(6)	4,065	25	4,000	21	4,073	23
Tungsten concentrate ... 60-percent WO_3 basis	2	(6)	(11)	(6)	------	------	------	------
Uranium ore	(6)	(6)	(6)	(6)	(6)	(6)	152,336	(6)
Zinc (recoverable content of ores, etc.)	25,609	7,017	24,000	5,568	18,797	3,835	17,111	3,936
Value of items that cannot be disclosed: Barite (1957–59), carbon dioxide, cement, fire clay (1958–59), diatomite, epsomite (1956–57), lime (1956–57), magnesite, mercury (1957–58), olivine, strontium minerals, and values indicated by footnote 6	------	17,736	------	18,950	------	24,128	------	25,054
Total Washington [9]	------	61,723	------	60,471	------	60,896	------	63,894

WEST VIRGINIA

Clays .... thousand short tons..	770	$2,449	708	$2,691	510	$1,960	596	$2,492
Coal .... do....	155,890	824,043	156,842	875,587	119,468	635,201	119,692	621,003
Gem stones	-----	-----	-----	-----	-----	-----	(13)	1
Marl, calcareous	1,685	1	(16)	(16)	(16)	(16)	(16)	(16)
Natural gas .... million cubic feet..	204,717	48,518	202,440	48,181	204,581	50,734	[7] 215,000	[7] 53,500
Natural-gas liquids:								
Natural gasoline .... thousand gallons..	35,728	2,594	30,435	2,185	27,917	5,643	29,242	1,808
LP-gases .... do....	240,989	12,031	235,881	6,543	235,524	12,806	308,316	15,534
Petroleum (crude) .... thousand 42-gallon barrels..	2,179	8,411	2,215	9,436	2,186	7,629	[7] 2,177	[7] 7,837
Salt (common) .... thousand short tons..	681	3,453	648	2,642	627	2,784	811	3,305
Sand and gravel .... do....	5,110	10,711	5,354	9,893	5,253	11,729	4,854	10,513
Stone .... do....	6,579	10,765	6,989	11,934	[8] 5,599	[8] 9,990	[8] 5,923	[8] 10,482
Value of items that cannot be disclosed: Bromine, calcium-magnesium chloride, cement, lime, manganese ore (1957), stone (crushed sandstone 1958, dimension sandstone and calcareous marl 1959)	-----	14,515	-----	14,938	-----	[5] 13,067	-----	13,318
Total West Virginia [9]	-----	934,999	-----	981,654	-----	[5] 749,747	-----	737,886

WISCONSIN

Abrasive stones	1,093	$31	1,790	$43	858	$26	770	$27
Clays .... thousand short tons..	163	172	131	136	154	167	178	192
Iron ore (usable) .... thousand long tons, gross weight..	1,488	(6)	1,576	(6)	867	(6)	701	(6)
Lead (recoverable content of ores, etc.)	2,582	811	1,900	543	800	187	745	171
Lime .... thousand short tons..	(6)	(6)	(6)	(6)	141	2,193	(6)	(6)
Marl, calcareous (except for cement)	11,074	6	(16)	(16)	(16)	(16)	(16)	(16)
Peat	-----	-----	400	(6)	(6)	(6)	7,500	(6)
Sand and gravel .... thousand short tons..	27,715	19,097	29,394	18,694	39,383	25,845	41,999	27,535
Stone .... do....	11,126	20,402	12,434	22,455	13,722	23,334	13,522	23,782
Zinc (recoverable content of ores, etc.)	23,890	6,546	21,575	5,006	12,140	2,477	11,635	2,676
Value of items that cannot be disclosed: Cement, gem stones (1957–59), and values indicated by footnote 6	-----	19,451	-----	22,590	-----	18,083	-----	18,541
Total Wisconsin [9]	-----	65,860	-----	68,644	-----	71,334	-----	71,959

See footnotes at end of table.

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

WYOMING

Mineral	1956		1957		1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
Beryllium concentrate......gross weight..	(6)	(6)	5	$3	17	$9	1	(12)
Clays......thousand short tons..	1,086	$11,864	[4] 1,069	[4] 11,973	[4] 1,075	[4] 9,968	[4] 764	[4] $9,449
Coal......do....	2,553	9,920	2,117	7,777	1,629	5,820	1,977	6,669
Copper (recoverable content of ores, etc.)......	3	3	4	2	(11)	(12)	----------	----------
Feldspar......long tons..	1,201	8	(6)	(6)	(6)	(6)	----------	----------
Gem stones......	(13)	75	(13)	55	(13)	52	(13)	76
Gold (recoverable content of ores, etc.)......troy ounces..	762	27	573	20	117	4	----------	----------
Gypsum......thousand short tons..	11	46	(6)	(6)	6	19	9	31
Iron ore (usable)......thousand long tons, gross weight..	650	(6)	736	(6)	557	(6)	503	2,923
Natural gas......million cubic feet..	84,398	7,258	117,256	10,201	121,682	10,221	[7] 123,500	[7] 10,700
Natural-gas liquids:								
Natural gasoline......thousand gallons..	48,859	3,160	47,709	2,866	49,451	3,052	64,586	4,003
LP-gases......do....	49,838	2,337	57,805	2,566	54,496	2,614	90,314	3,951
Petroleum (crude)......thousand 42-gallon barrels..	104,830	255,785	109,584	291,493	115,572	301,643	[7] 125,968	[7] 314,920
Phosphate rock......thousand long tons..	119	721	18	121	124	937	(6)	(6)
Pumice......thousand short tons..	46	38	49	41	45	40	94	77
Rare-earth metals concentrates......	----------	----------	2	5	----------	----------	----------	----------
Sand and gravel......thousand short tons..	3,904	2,935	2,425	1,905	5,333	4,760	4,692	3,982
Sodium carbonate (natural)......	337,851	8,345	(6)	(6)	(6)	(6)	(6)	(6)
Stone......thousand short tons..	1,333	2,076	1,291	2,266	1,099	1,472	1,317	1,791
Tungsten ore and concentrate......60-percent WO_3 basis..	2	7	----------	----------	----------	----------	----------	----------
Uranium ore......	156,509	2,765	274,699	4,669	651,790	13,286	864,582	17,610
Value of items that cannot be disclosed: Cement, fire clay (1957-59, miscellaneous clay 1959), sheet mica (1959), silver (1956-58), sodium sulfate, vanadium (1956-58), and values indicated by footnote 6......	----------	7,824	----------	17,527	----------	16,760	----------	15,970
Total Wyoming[9]......	----------	314,380	----------	352,532	----------	369,938	----------	391,621

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Excludes certain cement, value for which is included with "Items that cannot be disclosed".

[3] Final figure. Supersedes preliminary figure given in commodity chapter.

[4] Excludes certain clays, value for which is included with "Items that cannot be disclosed".

[5] Revised figure.

[6] Figure withheld to avoid disclosing individual company confidential data.

[7] Preliminary figure.

[8] Excludes certain stone, value included with "Items that cannot be disclosed".

[9] Total adjusted to eliminate duplicating the value of clays and stone.

[10] Less than 1,000 short tons.

[11] Less than 1 ton.

[12] Less than $1,000.

[13] Weight not recorded.

[14] Total weight of columbite-tantalite plus $(Cb\text{-}Ta)_2O_5$ content of euxenite.

[15] Total has been adjusted to eliminate duplicating the value of raw materials used in manufacturing cement and/or lime.

[16] Beginning with 1957 calcareous marl included with stone.

[17] Less than 1,000 long tons.

[18] 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.

[19] Beginning with 1958 slate included with stone.

[20] Grinding pebbles and tube-mill liners, weight of millstones not recorded.

[21] Millstones only.

[22] Grinding pebbles and tube-mill liners.

[23] Includes 45,710 short tons of concentrate produced in 1955 and 1956 from low-grade ore and concentrate stockpiled near Coquille, Oreg. during World War II.

[24] Less than 1,000 troy ounces.

[25] Excludes quantity consumed by American Chrome Co.

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

Mineral	1956		1957		1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
American Samoa:								
Stone......thousand short tons..	2	$6	34	$37	30	$59	178	$219
Canal Zone:								
Sand and gravel......thousand short tons..	40	48	------	------	41	34	14	21
Stone (crushed)......do....	177	230	59	99	140	237	223	270
Total Canal Zone......	------	278	------	99	------	271	------	291
Canton:								
Sand and gravel......thousand short tons..	------	------	------	------	------	------	(3)	(4)
Stone (crushed)......do....	2	5	------	------	------	------	(3)	1
Guam:								
Sand and gravel......thousand short tons..	19	24	1	1	9	23	28	20
Stone......do....	341	311	1,034	1,132	684	751	568	1,109
Total Guam:......	------	335	------	1,133	------	774	------	1,129
Midway: Stone (crushed)......thousand short tons..	203	304	3,875	6,700	175	476	------	------
Virgin Islands: Stone (crushed)......do....	12	32	11	31	25	81	14	51
Wake: Stone (crushed)......do....	22	22	5	6	10	37	32	34

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Production data for Canton and Wake furnished by the U.S. Department of Commerce, Civil Aeronautics Administration; Midway and Johnston, by the U.S. Department of the Navy; Guam by the Government of Guam; American Samoa, by the Government of American Samoa.

[3] Less than 1,000 short tons.

[4] Less than $1,000.

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

Mineral	1956		1957		1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
Cement thousand 376-pound barrels	4,255	$14,065	5,552	$17,232	4,748	$15,175	5,392	$16,982
Clays thousand short tons	143	129	159	140	165	83	167	83
Lime do	(2)	(2)	(2)	(2)	(2)	(2)	10	321
Salt (common) do	10	101	10	104	1	14	3	38
Sand and gravel do	183	192	497	754	476	763	530	888
Stone do	2,076	2,556	2,452	3,505	1,986	2,768	2,063	2,878
Value of items that cannot be disclosed: Other nonmetals and values indicated by footnote 2		195		180		272		
Total Puerto Rico[3]		16,395		20,265		17,689		19,700

---

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Figure withheld to avoid disclosing individual company confidential data.

[3] Total adjusted to eliminate duplicating value of stone.

TABLE 8.—Principal minerals imported for consumption in the United States

(Compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census)

Mineral	1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
METALS				
Aluminum:				
Metal	255,322	$117,297	239,571	$111,259
Scrap	9,922	2,969	10,919	3,299
Plates, sheets, bars, etc	[1] 27,946	[1] 20,184	50,638	34,876
Antimony:				
Ore (antimony content)	3,427	643	6,466	1,236
Needle or liquated	136	58	177	79
Metal	4,282	1,871	4,422	2,039
Oxide	1,634	643	2,056	825
Arsenic: White	9,524	720	19,386	1,342
Bauxite:				
Crude ... thousand long tons	[1,2] 7,915	[1] 70,107	[2] 8,107	73,203
Calcined:				
When imported for manufacture of firebrick ... long tons	29,414	715	[3] 108,457	[3] 1,750
Other ... do	100	2	200	4
Beryllium ore	4,599	1,547	8,038	2,345
Bismuth (general imports) ... pounds	637,309	1,233	457,163	825
Boron carbide ... do	47,368	133	81,459	144
Cadmium:				
Metal ... thousand pounds	1,002	1,312	1,638	1,744
Flue dust (cadmium content) ... do	1,218	661	1,544	584
Calcium:				
Metal ... pounds	15,694	24	7,425	8
Chloride	[1] 1,234	[1] 46	1,756	66
Chromate:				
Ore and concentrates (Cr_2O_3 content)	544,447	28,206	665,463	31,853
Ferrochrome (chromium content)	15,965	7,818	64,066	29,750
Metal	[1] 2,326	[1] 4,716	2,865	5,179
Cobalt:				
Metal ... thousand pounds	[1] 14,538	[1] 28,664	20,087	35,926
Oxide (gross weight) ... do	837	1,116	1,561	1,856
Salts and compounds (gross weight) ... do	234	145	278	134
Columbium ore ... pounds	2,555,942	2,346	3,395,816	2,652
Copper (copper content):				
Ore	5,926	2,357	113	34
Concentrates	84,871	37,968	9,299	5,505
Regulus, black, coarse	4,925	2,172	7,113	4,260
Unrefined, black, blister	138,633	66,320	203	126
Refined in ingots, etc	124,629	61,139	237,304	146,478
Old and scrap	5,849	2,676	2,984	1,634
Old brass and clippings	4,201	1,852	1,257	698
Ferroalloys: Ferrosilicon (silicon content)	2,398	905	5,584	1,728
Gold:				
Ore and base bullion ... troy ounces	1,099,484	38,457	444,416	15,522
Bullion ... do	7,020,242	251,298	8,040,528	288,855
Iron ore:				
Ore ... thousand long tons	[1] 27,544	[1] 231,617	35,613	312,367
Pyrites ... long tons	2,721	9	10,157	48
Iron and steel:				
Pig iron	209,743	[1] 12,026	701,775	35,593
Iron and steel products (major):				
Semimanufactures	[1] 788,922	66,930	2,263,470	230,950
Manufactures	[1] 1,030,765	[1] 152,972	2,349,400	332,982
Scrap	295,859	10,069	267,839	10,493
Tin-plate scrap	36,763	1,000	41,609	1,098
Lead:				
Ore, flue dust, matte (lead content)	[1] 237,625	[1] 50,772	136,696	26,921
Base bullion (lead content)	416	136	34	19
Pigs and bars (lead content)	351,759	71,404	262,632	54,667
Reclaimed, scrap, etc. (lead content)	8,619	1,441	7,897	1,304
Sheets, pipe, and shot	2,625	596	3,608	850
Babbitt metal and solder (lead content)	2,049	4,677	3,751	16,820
Type metal and antimonial lead (lead content)	4,525	1,190	5,020	1,204
Manufactures	1,272	446	1,398	586
Magnesium:				
Metallic and scrap	537	280	593	303
Alloys (magnesium content)	9	38	26	155
Sheets, tubing, ribbons, wire, and other forms (magnesium content)	16	97	26	121

See footnotes at end of table.

TABLE 8.—Principal minerals imported for consumption in the United States—Continued

Mineral	1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
METALS—continued				
Manganese:				
Ore (35 percent or more manganese) (manganese content)	837,100	$76,256	887,681	$74,648
Ferromanganese (manganese content)	49,521	11,046	70,232	14,067
Mercury:				
Compounds ____ pounds	9,125	29	40,522	118
Metal ____ 76-pound flasks	[1] 30,196	[1] 5,922	30,141	5,992
Minor metals: Selenium and salts ____ pounds	204,311	1,380	273,929	1,761
Molybdenum: Ore and concentrates (molybdenum content) ____ pounds	1,344	6	----------	----------
Nickel:				
Ore and matte	4,574	1,765	4,071	1,612
Pigs, ingots, shot, cathodes	62,793	87,311	82,924	110,754
Scrap	271	254	619	731
Oxide	29,622	35,106	[2] 30,062	[2] 33,816
Platinum group:				
Unrefined metals:				
Ore and concentrates ____ troy ounces	----------	----------	503	27
Grains and nuggets, including crude, dust, and residues ____ do	21,635	1,341	77,763	5,447
Sponge and scrap ____ do	[2] 13,167	[2] 823	[2] 5,666	[2] 420
Osmiridium ____ do	1,450	85	2,121	76
Refined metal:				
Platinum ____ do	[2] 247,763	[2] 15,363	[2] 260,524	[2] 17,241
Palladium ____ do	360,077	5,211	610,740	9,374
Iridium ____ do	1,156	78	7,772	402
Osmium ____ do	145	8	1,223	65
Rhodium ____ do	17,280	1,803	29,342	3,369
Ruthenium ____ do	7,758	259	14,679	492
Radium:				
Radium salts ____ milligrams	38,419	538	32,967	518
Radioactive substitutes	(4)	908	(4)	1,145
Rare earths: Ferrocerium and other cerium alloy ____ pounds	11,544	46	16,070	59
Silver:				
Ore and base bullion ____ thousand troy ounces	134,650	102,286	39,759	34,522
Bullion ____ do	31,316	27,807	29,329	26,558
Tantalum: Ore ____ pounds	1,035,588	1,838	652,839	1,166
Tin:				
Ore (tin content) ____ long tons	5,440	11,244	10,773	23,282
Blocks, pigs, grains, etc ____ do	41,149	84,624	43,493	96,666
Dross, skimmings, scrap, residues, and tin alloys, n.s.p.f. ____ long tons	3,208	5,771	3,434	6,658
Tinfoil, powder, flitters, etc	(4)	610	(4)	1,008
Titanium:				
Ilmenite	348,144	6,766	371,687	7,991
Rutile	36,563	4,513	23,228	2,943
Metal ____ pounds	4,146,896	6,287	3,126,293	3,564
Ferrotitanium ____ do	201,333	73	252,436	70
Compounds and mixtures ____ do	1,417,522	285	5,722,512	1,088
Tungsten: (tungsten content)				
Ore and concentrates ____ thousand pounds	6,542	11.960	5,435	4,235
Metal ____ pounds	101,363	230	196,053	425
Ferrotungsten ____ thousand pounds	159	154	533	526
Other ____ pounds	83	1	93,963	105
Zinc:				
Ores (zinc content)	[1] 537,699	[1] 51,121	436,009	38,568
Blocks, pigs, and slabs	185,693	[1] 35,511	164,462	33,996
Sheets	901	285	951	311
Old, dross, and skimmings	972	108	1,138	142
Dust	96	14	44	6
Manufactures	(4)	390	(4)	812
Zirconium: Ore, including zirconium sand	19,225	467	54,878	1,517

See footnotes at end of table.

TABLE 8.—Principal minerals imported for consumption in the United States—Continued

Minerals	1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
NONMETALS				
Abrasives: Diamonds (industrial) ... carats	[1] 10,070,305	[1] $39,213	13,076,172	$62,703
Asbestos	644,331	58,314	713,047	65,006
Barite:				
Crude and ground	527,571	3,754	641,241	4,881
Witherite	2,240	108	2,552	113
Chemicals	4,171	416	6,045	551
Bromine ... pounds	11,925	38	24,000	9
Cement ... 376-pound barrels	3,390,086	9,682	5,264,996	13,773
Clays:				
Raw	[1] [2] 126,692	2,835	172,986	3,193
Manufactured	35,030	65	3,494	95
Cryolite	24,186	2,332	22,102	1,994
Feldspar: Crude ... long tons	73	5	45	5
Fluorspar	392,164	9,777	555,750	13,368
Gem stones:				
Diamonds ... carats	[1] 1,848,230	[1] 140,631	2,528,419	180,665
Emeralds ... do	38,848	1,100	88,875	2,450
Other	(4)	24,212	(4)	29,421
Graphite	27,067	1,203	37,048	1,527
Gypsum:				
Crude, ground, calcined	[1] 4,047,786	[1] 6,896	6,135,636	11,917
Manufactures	(4)	967	(4)	1,287
Iodine, crude ... thousand pounds	1,561	1,329	1,466	1,083
Kyanite	1,965	95	5,633	252
Lime:				
Hydrated	1,000	21	530	9
Other	18,822	318	26,374	442
Dead-burned dolomite	5,686	322	8,474	498
Magnesium:				
Magnesite	[1] 81,684	[1] 5,210	155,634	9,871
Compounds	12,477	505	15,849	562
Mica:				
Uncut sheet and punch ... pounds	2,181,056	5,092	3,224,698	7,318
Scrap	4,064	48	4,644	57
Manufactures	[1] 5,053	8,800	5,042	7,443
Mineral-earth pigments: Iron oxide pigments:				
Natural	2,485	123	3,161	160
Synthetic	5,933	889	7,776	1,144
Ocher, crude and refined	217	10	213	13
Siennas, crude and refined	555	49	1,399	95
Umber, crude and refined	2,278	73	2,078	68
Vandyke brown	204	15	202	14
Nitrogen compounds (major), including urea	1,349,585	59,840	[3] 1,472,408	65,265
Phosphate, crude ... long tons	108,182	2,944	139,891	3,421
Phosphatic fertilizers ... do	24,562	1,711	57,230	2,543
Pigments and salts:				
Lead pigments and salts	8,557	1,770	13,233	2,694
Zinc pigments and salts	13,206	2,520	19,147	3,678
Potash	[5] 366,161	[5] 14,736	[5] 432,114	[5] 17,578
Pumice:				
Crude or unmanufactured	38,613	274	21,721	152
Wholly or partly manufactured	1,873	48	3,988	92
Manufactures, n.s.p.f	(4)	15	(4)	20
Quartz crystal (Brazilian pebble) ... pounds	473,000	356	679,836	784
Salt	611,043	3,368	1,024,629	5,438
Sand and gravel:				
Glass sand	6,516	224	101	91
Other sand	317,860	486	348,331	464
Gravel	7,619	7	102,878	93
Sodium sulfate ... thousand short tons	97	1,968	122	2,580
Stone, including slate	(4)	8,312	(4)	11,064
Strontium: Mineral	[1] 6,686	141	8,139	225
Sulfur and pyrites:				
Sulfur:				
Ore ... long tons	18,906	445	11,593	255
Other forms, n.e.s ... do	571,781	13,106	630,895	13,646
Pyrites ... do	343,060	1,194	280,638	868
Talc: Unmanufactured	22,890	785	25,351	861

See footnotes at end of table.

TABLE 8.—Principal minerals imported for consumption in the United States—Continued

Minerals	1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
COAL, PETROLEUM, AND RELATED PRODUCTS				
Carbon black:				
Acetylene black pounds	7,154,224	$1,287	7,246,932	$1,335
Gas black and carbon black do	125,958	22	346,771	69
Coal:				
Anthracite	4,363	34	2,633	22
Bituminous, slack, culm, and lignite	306,940	[1] 2,546	374,713	2,433
Briquets	184	2	185	3
Coke	121,517	1,571	123,255	1,441
Peat:				
Fertilizer grade	258,824	11,433	277,006	13,003
Poultry and stable grade	10,272	602	9,713	577
Petroleum:				
Crude thousand barrels	[1] 383,707	[1] 939,709	381,946	866,551
Gasoline [6] do	[1] 29,729	[1] 111,263	21,168	73,035
Kerosine do	34	148	125	536
Distillate oil [7] do	[1] 14,715	[1] 46,317	14,801	51,502
Residual oil [8] do	[1] 195,925	[1] 452,067	224,010	455,574
Unfinished oils do	20,510	56,316	23,135	65,823
Asphalt do	7,501	18,935	6,982	17,043
Miscellaneous do	14	222	25	333

[1] Revised figure.
[2] Adjusted by Bureau of Mines.
[3] Believed by Bureau of Mines to contain some crude bauxite.
[4] Weight not recorded.
[5] Data covers some quantities furnished by Potash Institute; values adjusted by Bureau of Mines.
[6] Includes naphtha but excludes benzol, 1958—1,060,597 barrels ($10,928,459); 1959—1,365,152 barrels ($13,783,172).
[7] Includes quantities imported free of duty for supplies of vessels and aircraft.
[8] Includes quantities imported free for manufacture in bond and export and for supplies of vessels and aircraft.

TABLE 9.—Principal minerals and products exported from the United States

(Compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census)

Mineral	1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
METALS				
Aluminum:				
Ingots, slabs, crude	52,711	$24,220	121,081	$53,518
Scrap	18,906	5,595	32,388	10,485
Plates, sheets, bars, etc	9,183	10,240	9,015	9,977
Castings and forgings	1,633	3,022	1,216	2,842
Antimony: Metals and alloys, crude	39	23	9	4
Arsenic: Calcium arsenate pounds	1,274,000	81	122,920	12
Bauxite, including bauxite concentrates long tons	11,868	968	[1] 17,403	[1] 1,825
Aluminum sulfate	9,864	423	14,487	573
Other aluminum compounds	32,803	4,438	32,049	4,286
Beryllium pounds	57,636	247	164,460	1,530
Bismuth: Metals and alloys do	316,318	389	179,744	261
Cadmium thousand pounds	580	771	900	1,024
Calcium chloride	37,632	1,325	39,929	1,377

See footnotes at end of table.

TABLE 9.—Principal minerals and products exported from the United States—Continued

Mineral	1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
METALS—continued				
Chrome:				
Ore and concentrates:				
Exports	717	$49	[2] 72,645	[2] $3,084
Reexports	52,303	2,158	24,467	976
Chromic acid	486	281	596	349
Ferrochrome	1,920	1,012	6,127	2,096
Cobalt ... pounds	1,757,600	1,102	694,641	543
Columbium metals, alloys, and other forms ... do	54,711	42	15,414	21
Copper:				
Ores, concentrates, composition metal, and unrefined copper (copper content)	11,475	5,865	2,982	1,808
Refined copper and semimanufactures	428,015	[3] 229,535	196,012	128,577
Other copper manufactures	2,302	1,567	4,352	3,280
Copper sulfate or blue vitriol	7,248	1,176	2,672	675
Copper base alloys	36,565	26,906	37,607	30,002
Ferroalloys:				
Ferrosilicon ... pounds	4,353,279	392	21,115,496	981
Ferrophosphorus ... do	89,006,784	1,468	99,806,945	1,799
Gold:				
Ore and base bullion ... troy ounces	26,929	945	20,498	715
Bullion, refined ... do	859,042	30,077	29,104	1,218
Iron ore ... thousand long tons	[3] 3,573	[3] 34,898	2,967	33,831
Iron and steel:				
Pig iron	103,348	6,725	10,444	549
Iron and steel products (major):				
Semimanufactures	[3] 1,693,877	[3] 300,570	1,069,848	213,297
Manufactured steel mill products	[3] 1,531,261	[3] 406,467	886,371	238,757
Advanced products	(4)	156,072	(4)	165,871
Iron and steel scrap: Ferrous scrap, including rerolling materials	[3] [5] 2,927,860	[3] [5] 95,412	4,849,076	165,464
Lead:				
Ore, matte, base bullion (lead content)	1,012	252	224	54
Pigs, bars, anodes	1,359	467	2,756	751
Scrap	1,015	237	1,141	291
Magnesium:				
Metal and alloys and semifabricated forms, n.e.c	1,041	1,280	2,377	2,028
Powder	11	16	12	32
Manganese:				
Ore and concentrates	4,833	700	5,702	819
Ferromanganese	1,406	464	947	388
Mercury:				
Exports ... 76-pound flasks	320	95	640	92
Reexports ... do	934	199	553	119
Molybdenum:				
Ore and concentrates (molybdenum content) pounds	[3] 11,966,204	[3] 14,965	18,852,279	24,778
Metals and alloys, crude and scrap ... do	14,151	5	15,172	22
Wire ... do	11,346	215	12,395	250
Semifabricated forms, n.e.c ... do	20,878	63	8,921	91
Powder ... do	4,841	16	11,314	36
Ferromolybdenum ... do	226,246	245	248,012	280
Nickel:				
Ore	10	1	------------	------------
Alloys and scrap (including Monel metal), ingots, bars, sheets, etc	[3] 12,820	[3] 16,043	11,818	11,967
Catalysts	485	1,023	597	1,162
Nickel-chrome electric resistance wire	154	678	139	598
Semifabricated forms, n.e.c	563	2,491	519	2,314
Platinum:				
Ore, concentrates, metal and alloys in ingots, bars, sheets, anodes, and other forms, including scrap ... troy ounces	35,075	1,233	18,560	1,147
Palladium, rhodium, iridium, osmiridium, ruthenium, and osmium (metal and alloys including scrap) ... troy ounces	12,293	379	12,845	390
Platinum group manufactures, except jewelry	(4)	2,103	(4)	2,306
Radium metal (radium content) ... milligrams	[3] 140	[3] 5	2,207	40

See footnotes at end of table.

TABLE 9.—Principal minerals and products exported from the United States—Continued

Mineral	1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
METALS—continued				
Rare earths:				
Cerium ores, metals, and alloys……pounds..	29,998	$24	27,500	$17
Lighter flints……do….	7,720	47	13,343	50
Silver:				
Ore and base bullion…thousand troy ounces..	1,640	1,456	103	93
Bullion, refined……do….	1,093	1,000	9,077	8,381
Tantalum:				
Ore, metal, and other forms……pounds..	20,076	302	16,478	242
Powder……do….	5,773	212	1,988	76
Tin:				
Ingots, pigs, bars, etc.:				
Exports……long tons..	917	1,336	943	1,890
Reexports……do….	424	899	428	970
Tin scrap and other tin bearing material except tinplate scrap……do….	2,291	992	7,713	1,231
Tin cans finished or unfinished……do….	35,849	18,322	36,320	19,027
Titanium:				
Ores and concentrates	1,246	172	4,656	290
Sponge (including iodide titanium) and scrap	97	172	496	543
Intermediate mill shapes	192	1,772	380	2,770
Mill products, n.e.c.	144	3,456	119	2,391
Ferrotitanium	323	138	321	146
Dioxide and pigments	37,016	11,347	36,282	10,558
Tungsten: Ore and concentrates:				
Exports	22	17	1	5
Reexports	162	207	98	119
Vanadium ore and concentrates (vanadium content)……pounds..	1,261,083	2,625	2,480,343	4,668
Zinc:				
Ores and concentrates (zinc content)	----	----	1	(6)
Slabs, pigs, or blocks	[3] 2,073	[3] 704	11,629	2,673
Sheets, plates, strips, or other forms, n.e.c.	3,818	2,637	3,529	2,708
Scrap (zinc content)	5,344	364	11,332	1,053
Dust	519	170	521	182
Semifabricated forms, n.e.c.	1,168	542	1,071	612
Zirconium:				
Ores and concentrates	1,994	336	1,511	263
Metals and alloys and other forms……pounds..	100,556	757	89,819	661
NONMETALS				
Abrasives:				
Grindstones	280	45	401	52
Diamond dust and powder……carats..	123,194	378	172,787	440
Diamond grinding wheels……do….	203,095	1,294	249,950	1,518
Other natural and artificial metallic abrasives and products	(4)	[3] 20,752	(4)	21,088
Asbestos: Unmanufactured:				
Exports	2,937	407	4,317	763
Reexports	89	17	144	30
Boron: Boric acid, borates, crude and refined……pounds..	471,167,767	18,292	507,347,292	21,047
Bromine, bromides, and bromates……do….	10,071,033	3,129	9,171,539	2,594
Cement……376-pound barrels…	641,159	2,975	277,267	1,595
Clay:				
Kaolin or china clay	66,419	1,602	74,734	2,206
Fire clay	125,923	1,880	137,389	2,468
Other clays	257,436	8,646	276,715	8,800
Cryolite	164	46	176	53
Fluorspar	3,374	191	1,144	69
Graphite:				
Amorphous	767	97	1,003	126
Crystalline flake, lump or chip	164	52	169	61
Natural, n.e.c.	235	43	196	36
Gypsum:				
Crude, crushed, or calcined……thousand short tons..	29	921	14	641
Manufactures, n.e.c.	(4)	1,544	(4)	655
Iodine, iodide, iodates……thousand pounds..	199	314	175	249
Kyanite and allied minerals	2,493	127	2,734	167
Lime	45,844	[3] 1,047	52,780	1,000

See footnotes at end of table.

TABLE 9.—Principal minerals and products exported from the United States—Continued

Mineral	1958		1959	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
NONMETALS—continued				
Mica:				
Unmanufactured .... pounds..	1,030,540	$91	1,072,894	$126
Manufactured:				
Ground or pulverized .... do....	8,198,367	431	8,915,109	459
Other .... do....	254,198	696	216,040	653
Mineral-earth pigments: Iron oxide, natural and manufactured	3,914	1,065	4,337	1,040
Nitrogen compounds (major)	704,492	38,938	747,024	37,415
Phosphate rock .... long tons..	2,818,073	25,234	3,239,722	28,602
Phosphatic fertilizers .... do....	514,227	23,388	413,867	19,539
Pigments and salts (lead and zinc):				
Lead pigments	3,446	1,095	3,178	1,054
Zinc pigments	3,156	912	3,054	864
Lead salts	1,050	412	699	276
Potash:				
Fertilizer	496,805	16,478	560,001	16,502
Chemical	9,871	1,799	11,658	1,994
Quartz crystal (raw)	(4)	285	(4)	166
Radioactive isotopes, etc .... curie..	156,191	1,534	112,204	1,283
Salt:				
Crude and refined	363,009	2,273	424,348	2,660
Shipments to noncontiguous Territories	12,790	1,026	13,652	1,031
Sodium and sodium compounds:				
Sodium sulfate	20,193	786	21,527	805
Sodium carbonate .... thousand short tons..	104	4,279	153	5,644
Stone:				
Limestone, crushed, ground, broken	767,757	1,390	1,085,553	1,999
Marble and other building and monumental cubic feet..	349,366	1,236	425,194	1,262
Stone, crushed, ground, broken	173,340	3,697	157,911	3,388
Manufactures of stone	(4)	432	(4)	643
Sulfur:				
Crude .... long tons..	[3] 1,577,919	[3] 39,507	1,611,908	39,967
Crushed, ground, flowers of .... do....	[3] 24,207	[3] 1,932	23,699	2,033
Talc:				
Crude and ground	58,647	1,358	58,751	1,532
Manufactures, n.e.c	212	93	197	175
Powders-talcum (face and compact)	(4)	1,341	(4)	1,276
COAL, PETROLEUM, AND RELATED PRODUCTS				
Carbon black .... thousand pounds..	440,542	39,748	513,143	45,798
Coal:				
Anthracite	2,279,859	35,762	1,787,558	28,931
Bituminous	[3] 50,293,382	[3] 490,028	37,226,766	349,273
Briquets	54,961	899	33,458	495
Coke	392,817	7,127	460,222	8,674
Petroleum:				
Crude .... thousand barrels..	4,345	14,748	2,524	6,990
Gasoline [7] .... do....	[3] 20,374	[3] 142,646	15,518	108,766
Kerosine .... do....	1,140	5,369	934	4,926
Distillate oil .... do....	17,115	63,638	12,681	46,153
Residual oil .... do....	[3] 22,782	[3] 54,104	21,319	45,685
Lubricating oil .... do....	[3] 12,464	185,807	13,536	181,931
Asphalt .... do....	1,083	6,013	813	4,623
Liquefied petroleum gases .... do....	2,854	8,423	2,251	6,791
Wax .... do....	905	19,861	1,031	22,202
Coke .... do....	4,406	18,026	4,680	19,608
Petroleum .... do....	256	6,084	260	6,361
Miscellaneous .... do....	518	13,655	563	14,656

---

[1] Adjusted by Bureau of Mines.
[2] Believed to be mostly foreign exports.
[3] Revised figure.
[4] Weight not recorded.
[5] Excludes circles strip and scroll shear butts, due to this exclusion, plus revisions, the 1958 data will differ from that shown in 1958 Minerals Yearbook, t. 23, p. 615.
[6] Less than $1,000.
[7] Includes naptha, but excludes benzol: 1958—273,428 barrels ($3,562,974), 1959—173,935 barrels ($2,340,389).

TABLE 10.—Comparison of world and United States[1] production of principal metals and minerals, 1958–59

[Compiled by Augusta W. Jann and Berenice B. Mitchell]

Mineral	1958			1959		
	World	United States		World	United States	
	Thousand short tons		Percent of world	Thousand short tons		Percent of world
Fuels:						
Coal:						
Bituminous	1,836,437	408,019	22	1,902,134	409,248	22
Lignite	678,265	2,427	(2)	687,771	2,780	(2)
Pennsylvania anthracite	175,100	21,171	12	186,000	20,649	11
Coke (excluding breeze):						
Gashouse [3]	51,308	(4)	(4)	49,960	(4)	(4)
Oven and beehive	281,459	53,604	19	289,795	55,863	19
Fuel briquets and packaged fuel	117,610	1,071	(2)	114,650	900	(2)
Natural gas (marketable) million cubic feet	(5)	11,030,298	(5)	(5)	12,046,115	(5)
Peat	65,510	328	(2)	70,600	419	(2)
Petroleum (crude) thousand barrels	6,607,856	2,449,016	37	7,127,310	2,574,590	36
Nonmetallic minerals:						
Asbestos	2,060	44	2	2,270	45	2
Barite	2,600	486	19	3,000	867	29
Cement thousand barrels	1,543,394	326,352	21	1,720,526	355,734	21
Cordundum	11	---	---	8	---	---
Diamonds thousand carats	28,400	---	---	26,800	---	---
Diatomite	1,090	450	41	1,060	450	42
Feldspar [6] thousand long tons	1,050	470	45	1,150	548	48
Fluorspar	1,830	320	17	1,855	185	10
Graphite	350	(4)	(4)	410	(4)	(4)
Gypsum	38,740	9,600	25	42,320	10,900	26
Magnesite	6,000	493	8	6,150	594	10
Mica (including scrap) thousand pounds	315,000	187,355	59	340,000	200,588	59
Nitrogen, agricultural [6] [7]	8,700	2,360	27	9,700	2,675	28
Phosphate rock thousand long tons	34,770	14,879	43	36,530	15,869	43
Potash (K_2O equivalent)	8,800	2,148	24	9,400	2,383	25
Pumice	9,200	1,973	21	10,300	2,276	22
Pyrites thousand long tons	18,300	974	5	16,700	1,057	6
Salt	82,200	21,911	27	88,900	25,163	28
Strontium [6]	12	---	---	14	(4)	(4)
Sulfur, elemental thousand long tons	8,405	5,286	63	9,075	5,326	59
Talc, pyrophyllite, and soapstone	2,000	718	36	2,400	795	33
Vermiculite [6]	246	191	78	260	207	80
Metals, mine basis:						
Antimony (content of ore and concentrate) [6] short tons	44,000	705	2	52,000	678	1
Arsenic [6]	39	12	31	47	5	11
Bauxite thousand long tons	20,900	1,311	6	22,500	1,700	8
Beryllium concentrates short tons	7,400	463	6	7,300	328	4
Bismuth thousand pounds	4,600	(4)	(4)	5,200	(4)	(4)
Cadmium thousand pounds	19,900	9,673	49	19,700	8,602	44
Chromite	4,165	144	3	4,255	105	2
Cobalt (contained) short tons	14,600	2,012	14	17,700	1,165	6
Columbium-tantalum concentrates thousand pounds	4,990	428	9	6,170	189	3
Copper (content of ore and concentrate)	3,780	979	26	4,020	825	21
Gold thousand fine ounces	40,600	1,759	4	42,800	1,635	4
Iron ore thousand long tons	398,439	67,709	17	429,018	60,276	14
Lead (content of ore and concentrate)	2,560	267	10	2,530	256	10
Manganese ore (35 percent or more Mn)	13,663	327	2	14,042	229	2
Mercury thousand 76-pound flasks	251	38	15	232	31	13
Molybdenum (content of ore and concentrate) thousand pounds	57,700	41,069	71	70,300	50,956	72
Nickel (content of ore and concentrate)	249	12	5	312	12	4
Platinum groups (Pt, Pd, etc.) thousand troy ounces	890	14	2	1,000	15	2
Silver thousand fine ounces	238,500	36,800	15	216,800	23,000	11
Tin (content of ore and concentrate) thousand long tons	153	---	---	161	(4)	(4)
Titanium concentrates:						
Ilmenite	1,722	563	33	1,909	635	33
Rutile	103	7	7	105	9	9
Tungsten concentrate (60 percent WO_3) short tons	55,500	3,788	7	56,850	3,649	6

See footnotes at end of table.

TABLE 10.—Comparison of world and United States[1] production of principal metals and minerals, 1958–59—Continued

Mineral	1958			1959		
	World	United States		World	United States	
	Thousand short tons		Percent of world	Thousand short tons		Percent of world
Metals, mine basis—Continued						
Vanadium (content of ore and concentrate) [6] short tons	4,231	3,030	72	5,325	3,719	70
Zinc (content of ore and concentrate)	3,330	412	12	3,390	425	13
Metals, smelter basis:						
Aluminum	3,880	1,566	40	4,510	1,953	43
Copper	3,950	1,069	27	4,170	842	20
Iron, pig (incl. ferroalloys)	216,700	58,867	27	246,300	62,135	25
Lead	2,500	469	19	2,420	341	14
Magnesium	104	30	29	104	31	30
Selenium thousand pounds	1,533	727	47	1,866	799	43
Steel ingots and castings	298,600	85,255	29	336,100	93,446	28
Tellurium thousand pounds	224	171	76	357	196	55
Tin thousand long tons	158	[8] 5	3	154	[8] 11	7
Uranium oxide (U_3O_8) [6]	36	13	36	43	16	37
Zinc	2,990	781	26	3,140	799	25

[1] Including noncontiguous territories.
[2] Less than 1 percent.
[3] Includes low- and medium-temperature and gashouse coke.
[4] Bureau of Mines not at liberty to publish U.S. figure separately.
[5] Data not available.
[6] World total exclusive of U.S.S.R.
[7] Year ended June 30 of year stated (United Nations).
[8] U.S. imports of tin concentrates (tin content).

Employment and Injuries in the Metal and Nonmetal Industries

By John C. Machisak[1]

◆

THIS CHAPTER reports employment data and injury experience in the metal, nonmetal, quarrying, sand and gravel, and slag (iron blast furnace) industries of the United States in 1959. Each industry is treated separately, and no attempt has been made to combine data to show an overall total for this group of mineral industries. The slag canvass is included for the first time (data on employment and injuries were not collected before 1958), and, like other canvasses included in this chapter, data are voluntary. Employment and injury experience for all mineral industries can be found in volume III.

The employment and injury information in this chapter came from reports submitted to the Bureau of Mines before May 31, 1960; therefore, figures are preliminary and subject to revision.

Voluntary reports submitted by operators have contributed substantially to safety promotion since 1911, when the Federal Bureau of Mines started collecting employment and injury facts.

METAL MINES

Preliminary data indicate that the safety record for metal mines improved when compared with 1958. The number of fatal and nonfatal injuries decreased 20 and 18 percent, respectively. Decline in injuries was accompanied by a reduction in man-hours of exposure. The preliminary combined injury-frequency rate was 3 percent lower than the final rate for the preceding year. Number of active mine days also decreased, and each employee worked an average of 1,711 hours in 1959 based on an average 8-hour day.

Copper.—Fewer injuries in the copper mining industry during 1959 caused by an 11-percent decrease in the combined (fatal and nonfatal) injury-frequency rate (shown in preliminary figures). The number of men working daily decreased 7 percent, and man-hours of employment dropped 17 percent. The average employee worked a total of 1,864 hours, 226 hours less per worker than reported in the final 1958 figures. An 8-hour shift was maintained during the year.

---

[1] Chief, Branch of Accident Analysis, Division of Accident Prevention and Health.

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

Industry and year	Men working daily	Average active mine days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries: Fatal	Number of injuries: Nonfatal	Injury rate per million man-hours
Copper:							
1950–54 (average)	15,707	303	4,754	37,987	24	1,194	32.06
1955	17,000	299	5,091	40,500	26	1,482	37.23
1956	18,147	317	5,756	45,981	28	1,463	32.43
1957	17,664	294	5,188	41,452	19	1,276	31.24
1958	14,972	261	3,912	31,295	20	911	29.75
1959 [1]	13,937	232	3,238	25,975	15	673	26.49
Gold placer:							
1950–54 (average)	2,636	214	565	4,526	1	161	35.79
1955	1,301	214	279	2,368	---------	132	55.75
1956	1,539	206	317	2,698	---------	138	51.16
1957	1,551	186	288	2,380	2	140	59.67
1958	1,793	172	309	2,549	1	120	47.48
1959 [1]	1,587	160	254	2,199	1	99	45.48
Gold-silver:							
1950–54 (average)	3,849	256	985	7,748	10	854	111.52
1955	2,894	266	771	6,161	10	485	80.35
1956	2,631	259	682	5,454	4	473	87.46
1957	3,411	267	910	7,276	6	327	45.77
1958	3,687	248	914	7,306	2	304	41.88
1959 [1]	3,301	256	847	6,772	8	321	48.58
Iron:							
1950–54 (average)	29,753	257	7,640	61,332	23	1,060	17.66
1955	24,954	245	6,105	48,941	15	776	16.16
1956	26,817	234	6,281	50,376	19	723	14.73
1957	25,669	252	6,480	51,958	13	617	12.13
1958	21,382	206	4,411	35,374	14	432	12.61
1959 [1]	21,739	180	3,911	31,378	14	471	15.46
Lead-zinc:							
1950–54 (average)	13,912	262	3,639	29,097	27	2,260	78.60
1955	11,656	256	2,984	23,880	16	1,583	66.96
1956	11,041	269	2,967	23,745	23	1,548	66.16
1957	11,777	246	2,897	23,168	14	1,320	57.58
1958	8,298	244	2,023	16,160	19	834	52.79
1959 [1]	7,213	256	1,845	14,767	10	793	54.38
Miscellaneous: [2]							
1950–54 (average)	4,875	252	1,229	9,895	10	726	74.38
1955	7,338	257	1,884	15,101	12	1,379	92.11
1956	8,098	249	2,014	16,153	15	1,130	70.88
1957	8,385	237	1,988	15,946	17	874	55.88
1958	9,476	221	2,094	16,840	14	898	54.16
1959 [1]	5,776	228	1,317	10,551	8	495	47.67
Total:							
1950–54 (average)	70,732	266	18,812	150,585	95	6,255	42.17
1955	65,143	263	17,113	136,950	79	5,837	43.20
1956	68,273	264	18,017	144,407	89	5,475	38.53
1957	68,457	259	17,751	142,181	71	4,554	32.53
1958	59,608	229	13,665	109,523	70	3,499	32.59
1959 [1]	53,553	213	11,412	91,643	56	2,852	31.73

[1] Preliminary figures.

[2] Includes antimony, bauxite, chromite, cobalt, manganese, mercury, molybdenum, platinum, titanium, tungsten, vanadium-uranium, magnesium, and minor metals.

Gold Placer.—Preliminary data for placer operations indicated a decline in both employment and the number of injuries. Employment and man-hours decreased 11 and 14 percent, respectively, compared to the preceding year. The number of fatalities remained the same in both years, and, there was a notable decrease in the number of nonfatal injuries (18 percent), resulting in a 4-percent decline in the overall frequency rate. The average employee worked 1,385 hours, 36 hours less than the final data for 1958.

Gold-Silver Lode.—According to preliminary data, men employed and the number of man-hours worked in the gold-silver lode mines declined. The combined injury-frequency rate of 48.58 revealed an increase of 16 percent over the preceding year. Although the average number of men employed at gold-silver lode mines decreased approximately 10 percent from 1958, each employee accumulated a total of 2,052 hours for the year, or 70 more hours than in 1958, while working an 8-hour shift daily.

Iron.—Preliminary figures indicated a 2-percent gain in number of men employed, while man-hours and average active mine days declined, 11 and 13 percent, respectively. The number of fatalities (14) were the same in 1958. Of 14 fatalities reported, 6 occurred at the Sherwood underground mine in Michigan (classed as a major disaster because 5 or more men were killed in a single accident). A slight increase was reported in nonfatal injuries. The average employee at iron mines worked a total of 1,443 hours, compared with 1,654 hours in 1958. An 8-hour workshift was maintained in both 1958 and 1959.

Lead-Zinc.—Total employment and number of injuries at lead-zinc mines declined according to preliminary data. A 47-percent decrease in fatal and a 5-percent decrease in nonfatal injuries resulted in a preliminary combined injury-frequency rate of 54.38. A decline in both the number of men employed and man-hours worked was noted; however, the average active days worked increased slightly. The average employee worked a total of 2,047 hours—100 hours more than in 1958.

Miscellaneous Metals.—Included in this group were mines that yielded antimony, bauxite, chromite, cobalt, columbium-tantalum, magnesium, manganese, mercury, molybdenum, platinum, pyrite, titanium, tungsten, uranium-vanadium, and minor metals. Injury experienced at miscellaneous metal mines was considerably lower, according to preliminary data. Fatalities were 6 less than reported in 1958—a decrease of 43 percent; nonfatal injuries declined 45 percent. Employment and man-hours also revealed a decrease from 1958; however, the average active days worked increased slightly. The average employee at miscellaneous metal mines worked approximately 1,827 hours, or a daily shift of 8.01 hours, compared with 1,777 hours of employment on an 8-hour shift in 1958.

NONMETAL MINES (EXCEPT STONE QUARRIES)

Annual reports for 1959 received from operators of nonmetal mines included those producing abrasives, asbestos, asphalt, barite, clays, feldspar-mica-quartz, fluorspar, gypsum, magnesite, phosphate rock, potash, pumice, salt, sulfur, talc and soapstone, and minor nonmetals. Preliminary data revealed a 9-percent decrease in employment and a 6-percent decrease in man-hours. The safety record was not as good as the preceding year, since the combined (fatal and nonfatal) injury-frequency rate per million man-hours of work increased 4 percent. Average days active per employee increased by 7. Employees averaged an 8.17-hour shift and each worker accumulated approximately 2,000 hours during the year.

Nonmetal Mills.—The number of men employed and man-hours worked at nonmetal mills was 6 percent more than 1958. Injuries, both fatal and nonfatal, increased also, resulting in a rise of 16 percent in the combined injury-frequency rate. Mills operated an 8.13-hour shift, and each employee had slightly over 2,100 hours of work to his credit.

Clay Mines and Mills.—Principal industrial clays are kaolin (china clay), bentonite, fuller's earth, ball clay, and fire clay. Table 4 shows only annual comparisons of injury experience and employment data for mines and their accompanying mills. Preliminary data for clay mines indicated improvement in the safety record over that of 1958,

TABLE 2.—Employment and injury experience at nonmetal mines (except stone quarries) in the United States[1]

Year	Men working daily	Average active mine days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
1950-54 (average)	12,500	291	3,639	29,519	16	1,227	42.11
1955[2]	14,504	264	3,836	31,093	19	1,156	37.79
1956	15,595	268	4,178	33,963	17	1,036	31.00
1957	17,921	262	4,691	37,877	9	1,112	29.60
1958	17,820	239	4,258	34,648	15	955	28.00
1959[3]	16,255	246	4,006	32,737	10	940	29.02

[1] Includes abrasives, asbestos, asphalt, barite, clay, feldspar-mica-quartz, fluorspar, gypsum, magnesite, phosphate rock, potash, pumice, salt, sulfur, talc and soapstone, and minor nonmetals.

[2] Includes clay mines not compiled before 1955.

[3] Preliminary figures.

TABLE 3.—Employment and injury experience at nonmetal mills (except stone quarries) in the United States

Year	Men working daily	Average active mill days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
1955[1]	8,723	283	2,467	19,843	3	451	22.88
1956	17,585	288	5,056	40,675	7	1,157	28.62
1957	27,081	274	7,415	59,765	10	1,512	25.47
1958	32,401	272	8,809	71,161	9	1,490	21.06
1959[2]	34,330	269	9,246	75,128	10	1,821	24.37

[1] Shown separately for the first time in 1955—beginning 1956, clay mill figures included.

[2] Preliminary figures.

TABLE 4.—Employment and injury experience at clay mines and mills in the United States

Year	Men working daily	Average active mine days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
Mine:							
1955	3,501	223	779	6,343	7	247	40.05
1956	4,419	202	891	7,266	8	251	35.64
1957	5,024	208	1,046	8,355	3	320	38.66
1958	5,890	193	1,134	9,277	6	322	35.36
1959[1]	5,307	194	1,032	8,667	4	257	30.11
Mill:							
1955[2]	---------	---------	---------	---------	---------	---------	---------
1956	7,759	280	2,176	17,552	2	709	40.51
1957	15,516	258	3,996	32,079	5	949	29.74
1958	16,530	255	4,221	34,096	5	896	26.43
1959[1]	18,580	258	4,788	38,903	7	1,092	28.25

[1] Preliminary figures.

[2] No figures for clay mills compiled in 1955.

and the overall injury-frequency rate declined 15 percent. Fewer men were employed, and fewer man-hours were worked; each man averaged 1,633 hours of work during the year. Clay mills (from preliminary figures) had a 7-percent increase in the overall injury-frequency rate from that of 1958. More men were employed in milling operations, and more man-hours were worked, averaging an 8.12-hour shift; each mill employee had 2,094 hours of work to his credit.

SAND AND GRAVEL PLANTS

Employment at sand and gravel plants (commercial and noncommercial) declined from 1958 in both number of men employed and number of man-hours worked according to preliminary figures, or 15 and 13 percent, respectively. The combined injury-frequency rate, however, was 9 percent higher than in 1958. The average employee worked 5 more days and accumulated 1,853 man-hours of work.

TABLE 5.—Employment and injury experience at sand and gravel operations in the United States

Year	Men working daily	Average active mine days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
1957 [1]	31, 531	221	6, 954	59, 764	35	1, 763	30. 09
1958	51, 122	211	10, 763	92, 456	25	1, 698	18. 64
1959 [2]	43, 597	216	9, 403	80, 770	20	1, 622	20. 33

[1] Employment data from Branch of Construction and Chemical Materials, Division of Minerals.
[2] Preliminary figures.

SLAG (IRON BLAST-FURNACE) PLANTS

The data in table 6 pertain only to those plants that produce the nonmetallic product commonly referred to as slag.

Reports from operators showed a decline of 5 percent in the number of men employed and a 3-percent decrease in the number of man-hours worked. Injuries reported were the same as the preceding year, but a decline in man-hours worked caused a 3-percent increase in the allover injury-frequency rate per million man-hours of worktime. Each employee worked an approximate 8-hour shift and accumulated 2,058 hours of work.

TABLE 6.—Employment and injury experience at slag plants (iron blast-furnace) in the United States

Year	Number of plants	Men working daily	Average active days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
						Fatal	Nonfatal	
1958	70	1. 882	248	467	3, 776	1	43	11. 65
1959	71	1, 789	254	455	3, 681	1	43	11. 95

METALLURGICAL PLANTS

Employment and injuries at metallurgical plants (ore-dressing and nonferrous reduction and refinery plants combined) declined considerably, according to preliminary data. A 17-percent decrease in fatalities was recorded, and nonfatal injuries dropped 45 percent, resulting in a combined injury rate 28 percent lower than 1958. Some of the decrease could be the effect of less than average coverage of lead and miscellaneous nonferrous smelter and refinery groups on or before the June 15th cut-off date. Man-hours recorded for those two groups decreased 44 and 34 percent, respectively, reflecting an overall reduction of 24 percent in the total metallurgical plant man-hours. Each employee averaged a total of 2,190 hours of work and worked a daily 8-hour shift. Final 1958 figures revealed a total of 2,414 hours worked by each man on an 8-hour shift.

TABLE 7.—Employment and injury experience at metallurgical plants in the United States

Year	Men working daily	Average active plant days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
1950-54 (average)	50, 601	315	15, 946	127, 194	18	2, 709	21. 44
1955	57, 741	314	18, 150	145, 840	11	2, 694	18. 55
1956	65, 681	327	21, 470	171, 578	20	2, 543	14. 94
1957	65, 212	322	21, 003	167, 489	21	2, 280	13. 74
1958	52, 109	302	15, 733	125, 773	12	1, 698	13. 60
1959 [1]	43, 927	273	12, 012	96, 217	10	926	9. 73

[1] Preliminary figures.

ORE-DRESSING PLANTS

Plants in this group were those in which ores of all metals were processed by various methods, including crushing, screening, washing, jigging, magnetic separation, and flotation. Preliminary figures for 1959 revealed an 18-percent decrease in the frequency of injuries (fatal and nonfatal combined). A decrease of 15 percent in employment and 11 percent in average days worked resulted in a 24-percent decline in man-hours. The average employee worked a total of 1,894 hours—230 less than in 1958. An 8-hour shift was maintained in both 1958 and 1959.

NONFERROUS REDUCTION PLANTS AND REFINERIES

Plants in this group were engaged in primary extraction of nonferrous metals from ores and concentrates and refining crude primary nonferrous metals. Preliminary figures indicated a decrease in fatal and nonfatal injuries of 33 and 48 percent, respectively, from the final figures reported for 1958. Man-hours of productive work declined 23 percent, and employment dropped 16 percent. The average worker accumulated a total of 2,373 hours on a daily 8-hour shift. Final 1958 figures revealed 2,589 hours worked per man on an 8-hour shift.

TABLE 8.—Employment and injury experience at ore-dressing plants in the United States, by industry groups

Industry and year	Men working daily	Average active mill days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
Copper:							
1950–54 (average)	6,268	330	2,071	16,572	2	252	15.33
1955	6,222	314	1,952	15,854	----------	209	13.18
1956	6,683	344	2,301	18,400	3	184	10.16
1957	7,083	319	2,261	18,095	4	279	15.64
1958	6,468	283	1,828	14,618	1	140	9.65
1959 [1]	5,572	251	1,400	11,199	----------	81	7.23
Gold-silver:							
1950–54 (average)	606	291	176	1,389	1	48	35.28
1955	408	298	121	971	----------	43	44.27
1956	367	295	108	866	----------	24	27.72
1957	468	267	125	1,001	----------	20	19.99
1958	399	255	102	814	----------	25	30.71
1959 [1]	357	269	96	770	----------	14	18.18
Iron:							
1950–54 (average)	3,933	236	929	7,498	2	73	10.00
1955	4,055	258	1,044	8,383	2	87	10.62
1956	5,114	241	1,231	9,937	1	92	9.36
1957	5,218	262	1,367	11,004	1	67	6.18
1958	5,857	246	1,441	11,536	2	60	5.37
1959 [1]	6,196	197	1,222	9,889	1	54	5.56
Lead-zinc:							
1950–54 (average)	3,662	261	957	7,659	2	204	26.90
1955	3,667	223	817	6,615	----------	153	23.13
1956	2,977	274	817	6,532	1	86	13.32
1957	3,280	252	826	6,609	----------	104	15.74
1958	2,380	260	618	4,945	----------	50	10.11
1959 [1]	1,625	261	425	3,388	1	48	14.46
Miscellaneous metals: [2]							
1950–54 (average)	3,070	315	967	7,742	1	237	30.74
1955	3,279	305	1,001	8,013	1	303	37.94
1956	4,120	294	1,211	9,704	4	293	30.60
1957	5,517	296	1,635	13,087	4	273	21.17
1958	4,573	270	1,236	9,886	----------	192	19.42
1959 [1]	2,994	269	805	6,465	2	91	14.38
Total:							
1950–54 (average)	17,540	291	5,100	40,860	6	814	20.07
1955	17,631	280	4,935	39,837	3	795	20.03
1956	19,261	294	5,668	45,440	9	679	15.14
1957	21,566	288	6,214	49,795	9	743	15.10
1958	19,677	266	5,225	41,799	3	467	11.24
1959 [1]	16,744	236	3,948	31,711	4	288	9.21

[1] Preliminary figures.

[2] Includes antimony, bauxite, chromite, manganese, mercury, molybdenum, titanium, tungsten, uranium-vanadium, magnesium, columbium-tantalum, and minor metals.

STONE QUARRIES

Preliminary data from the quarrying industries showed a decline from 1958 of 4 percent in the combined injury-frequency rate, according to reports received by the Bureau of Mines, Washington Office, before June 15, 1960. These reports covered approximately 88 percent (based on men employed) of the canvass of the quarry industry reported in 1958. The number of men working daily decreased as did total man-hours worked, 12 and 9 percent, respectively. The average employee accumulated 2,188 hours of worktime, an increase of 4 percent from the 2,112 hours worked per employee in 1958. Man-days reported for all stone quarries was calculated on an 8-hour workday.

Cement.—The preliminary work-injury report for the cement industry (including quarry and mill employees) was slightly less favorable than that of the preceding year. Fatal injuries decreased 33

TABLE 9.—Employment and injury experience at primary nonferrous reduction and refinery plants in the United States, by industry groups

Industry and year	Men working daily	Average active smelter days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries: Fatal	Number of injuries: Nonfatal	Injury rate per million man-hours
Copper:							
1950–54 (average)	11, 347	320	3, 628	29, 073	4	410	14. 24
1955	11, 691	312	3, 651	29, 661	5	401	13. 69
1956	12, 194	323	3, 937	31, 497	2	469	14. 95
1957	11, 826	323	3, 821	30, 583	5	375	12. 43
1958	10, 801	312	3, 370	26, 966	4	426	15. 95
1959 [1]	11, 204	262	2, 939	23, 516	4	230	9. 95
Lead:							
1950–54 (average)	3, 707	306	1, 134	9, 067	2	111	12. 46
1955	3, 506	284	997	7, 976	1	137	17. 30
1956	3, 758	314	1, 181	9, 449	6	138	15. 24
1957	3, 439	314	1, 079	8, 629	1	137	15. 99
1958	2, 999	297	890	7, 120	2	118	16. 85
1959 [1]	2, 477	202	500	3, 997	1	30	7. 76
Zinc:							
1950–54 (average)	9, 305	350	3, 254	25, 882	4	785	30. 48
1955	9, 067	339	3, 075	24, 438	---------	692	28. 32
1956	9, 619	326	3, 134	24, 983	1	666	26. 70
1957	9, 263	326	3, 023	24, 083	4	632	26. 41
1958	7, 323	322	2, 361	18, 891	2	379	20. 17
1959 [1]	6, 287	330	2, 076	16, 598	---------	279	16. 81
Miscellaneous metal: [2]							
1950–54 (average)	8, 702	325	2, 831	22, 313	2	588	26. 44
1955	15, 846	347	5, 491	43, 929	2	669	15. 27
1956	20, 849	362	7, 550	60, 209	2	591	9. 85
1957	19, 118	359	6, 866	54, 398	2	393	7. 26
1958	11, 309	344	3, 886	30, 998	1	308	9. 97
1959 [1]	7, 215	353	2, 549	20, 395	1	99	4. 90
Total:							
1950–54 (average)	33, 062	328	10, 846	86, 335	12	1, 894	22. 08
1955	40, 110	329	13, 214	106, 004	8	1, 899	17. 99
1956	46, 420	340	15, 802	126, 138	11	1, 864	14. 86
1957	43, 646	339	14, 789	117, 694	12	1, 537	13. 16
1958	32, 432	324	10, 508	83, 974	9	1, 231	14. 77
1959 [1]	27, 183	297	8, 064	64, 507	6	638	9. 98

[1] Preliminary figures.
[2] Includes aluminum, antimony, bauxite, chromite, cobalt, magnesium, titanium, and minor metals.

percent, and nonfatal injuries increased 6 percent, resulting in a combined injury-frequency rate increase of 14 percent in relation to 1958. The number of active days worked increased, and the average employee accumulated 2,524 hours of worktime—an increase of 6 percent from the 2,371 hours for 1958.

Granite.—Injury experience at granite quarries and their related plants improved. The combined injury-frequency rate decreased 20 percent from that in 1958, according to preliminary data. Fewer men worked more man-hours with more days active in 1959 than in 1958. Each employee worked 2,093 hours, an increase of 8 percent, compared with 1,940 hours in 1958.

Lime.—Quarries that produced limestone, chiefly for the manufacture of lime, reported a very favorable safety record in 1959. The combined injury-frequency rate was 19 percent lower than that of 1958, man-hours worked declined 25 percent, and the number of men working decreased 24 percent. Approximately the same number of work-hours were accumulated as in 1958.

Limestone.—The overall safety record of the limestone industry, indicated by preliminary reports, was more favorable than in 1958. A decrease of 348 (17 percent) in the number of injuries reported,

TABLE 10.—Employment and injury experience at stone quarries in the United States, by industry groups

Industry and year	Men working daily	Average active mine days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
Cement:[1]							
1950–54 (average)	28,625	326	9,334	74,027	14	444	6.19
1955	29,141	320	9,328	74,735	9	287	3.96
1956	27,923	329	9,183	73,554	12	318	4.49
1957	29,167	317	9,254	73,940	14	277	3.94
1958	29,908	296	8,864	70,910	9	297	4.32
1959[2]	25,691	316	8,106	64,852	6	314	4.93
Granite:							
1950–54 (average)	6,842	247	1,691	14,025	5	551	39,64
1955	6,222	239	1,487	12,319	4	499	40.83
1956	6,052	233	1,409	11,658	8	472	41.17
1957	7,017	238	1,668	13,890	8	592	43.20
1958	7,522	242	1,824	14,590	4	708	48.80
1959[2]	7,379	262	1,931	15,444	2	600	38.98
Lime:[1]							
1950–54 (average)	8,861	295	2,610	20,999	7	576	27.76
1955	8,416	292	2,456	19,786	6	417	21.38
1956	9,040	290	2,621	21,079	6	423	20.35
1957	8,220	284	2,332	18,683	1	447	23.98
1958	6,948	292	2,027	16,216	1	354	21.89
1959[2]	5,250	291	1,526	12,212	6	210	17.69
Limestone:							
1950–54 (average)	27,408	237	6,498	54,525	20	1,931	35.78
1955	24,472	236	5,773	48,484	28	1,657	34.75
1956	26,398	231	6,088	51,164	17	1,660	32.78
1957	28,692	230	6,603	55,637	21	1,960	35.61
1958	29,649	245	7,266	58,128	23	2,026	35.25
1959[2]	25,921	252	6,538	52,307	25	1,676	32.52
Marble:							
1950–54 (average)	2,512	251	630	5,229	1	175	33.66
1955	2,221	251	557	4,670	1	210	45.18
1956	2,523	253	639	5,304	2	191	36.39
1957	3,160	258	814	6,750	1	188	28.00
1958	3,126	246	771	6,164	1	219	35.69
1959[2]	2,685	264	710	5,680	----------	235	41.37
Sandstone:							
1950–54 (average)	3,986	240	957	7,851	2	350	44.84
1955	3,410	241	821	6,718	2	369	55.23
1956	3,522	234	824	6,754	1	327	48.56
1957	2,980	206	613	4,989	1	259	52.12
1958	3,504	215	752	6,017	1	281	46.87
1959[2]	3,124	217	679	5,434	2	219	40.67
Slate:							
1950–54 (average)	1,786	267	477	3,998	----------	207	51.77
1955	1,599	255	408	3,413	1	159	46.87
1956	1,395	250	349	2,936	----------	126	42.92
1957	1,357	254	345	2,871	1	169	59.21
1958	1,429	255	364	2,915	----------	128	43.91
1959[2]	1,393	253	352	2,818	1	152	54.29
Traprock:							
1950–54 (average)	2,972	231	686	5,904	3	265	45.39
1955	2,757	232	640	5,651	2	213	38.05
1956	3,240	205	664	5,833	4	237	41.31
1957	2,883	215	620	5,332	6	277	53.08
1958	4,130	230	950	7,597	6	331	44.36
1959[2]	4,742	228	1,080	8,639	3	430	50.12
Miscellaneous Stone:[3]							
1957	650	248	161	1,302	----------	41	31.49
1958	2,232	240	535	4,284	----------	228	53.22
1959[2]	1,871	225	420	3,363	3	161	48.76
Total:[4]							
1950–54 (average)	82,992	276	22,883	186,559	52	4,499	24.39
1955	78,238	274	21,470	175,775	53	3,811	21.98
1956	80,093	272	21,776	178,281	50	3,754	21.34
1957	84,126	266	22,410	183,394	53	4,210	23.25
1958	88,448	264	23,353	186,821	45	4,572	24.71
1959[2]	78,056	273	21,344	170,750	48	3,997	23.69

---

[1] Includes burning or calcining and other mill operations.

[2] Preliminary figures.

[3] Not compiled before 1957.

[4] Stones do not always add to totals due to rounding of figures.

caused the combined injury-frequency rate to decline 8 percent. The number of days active increased, and the average number of man-hours worked increased 3 percent, from 1,961 in 1958 to 2,018 in 1959.

Marble.—Preliminary reports indicated less favorable injury experience for marble quarries and their associated plants than in 1958. No fatalities were reported; however, the increase in nonfatal lost-time injuries resulted in an increase of 16 percent in the combined injury-frequency rates per million man-hours of worktime. More days active were indicated; each man worked 2,116 hours, compared with 1,972 hours in 1958, an increase of 7 percent.

Sandstone.—Preliminary figures indicated decreased employment in the sandstone quarries—10 percent in the number of man-hours worked, and 11 percent in the number of men employed. This decline was also reflected in decreased nonfatal injuries. One more fatality was reported than in 1958; however, the combined injury-frequency rate decreased 13 percent. Hours of work per man averaged 1,739—1 percent more than the 1,717 worked in 1958.

Slate.—Preliminary data indicated that overall injury experience in the slate industry was less favorable than in 1958. The total number of injuries increased 20 percent increasing by 24 percent the combined injury-experience rate. The number of men working daily (with 2 less work days) and total man-hours of worktime was not materially changed.

Traprock.—Preliminary figures for the traprock industry reflected an overall increase in the injury experience rate. Although the number of fatalities decreased 50 percent, the number of nonfatal injuries increased 30 percent, resulting in an overall increase in the combined injury-frequency rate of 13 percent. Men employed and man-hours worked showed approximately a 14 percent gain. A slight decrease was noted in the days active and a decline of 1 percent in the average hours of worktime for each man—from 1,839 hours in 1958 to 1,822 hours.

Miscellaneous Stone.—This group includes all stones not otherwise classified, and was shown separately for the first time in 1957. Preliminary figures showed a decline in the overall injury experience from 1958. The combined injury-frequency rate per million man-hours decreased 8 percent, and the number of men employed declined 16 percent; fewer days active were reported, and the average man worked 1,797 days, compared with 1,919 days in 1958, a 6 percent decrease.

Abrasive Materials

By Henry P. Chandler [1] and Gertrude E. Tucker [2]

Contents

TONNAGE of natural abrasives sold or used in the United States in 1959 increased 12 percent. Artificial abrasives produced in the United States and Canada jumped 24 percent. Imports, exports, and reexports of abrasive materials also showed gains. Sales of grinding wheels were up 33 percent and coated abrasives 17 percent.

FOREIGN TRADE [3]

Imports of abrasive materials totaled $91 million, an increase of nearly 51 percent over 1958. Chief commodities contributing to

TABLE 1.—Salient statistics of the abrasives industries in the United States

Kind	1950–54 (average)	1955	1956	1957	1958	1959
Natural abrasives (domestic) sold or used by producers:						
Tripoli: [1]						
Short tons	38, 893	49, 662	45, 009	50, 717	47, 044	52, 968
Value, thousands	$1, 184	$213	$203	$195	$183	$219
Special silica-stone products: [2]						
Short tons	7. 785	4, 929	6. 180	5. 847	4, 023	3, 672
Value, thousands	$385	$264	$411	$331	$305	$315
Garnet:						
Short tons	11, 889	11, 835	9, 812	9, 776	[3] 12, 303	14, 568
Value, thousands	$996	$1, 191	$1, 073	$1, 080	[3] $869	$1, 211
Emery:						
Short tons	9, 651	10, 735	12, 153	11, 893	7, 687	8, 555
Value, thousands	$131	$151	$174	$184	$126	$150
Artificial abrasives: [4]						
Short tons	426, 381	428, 243	431, 461	484. 702	334, 483	416, 362
Value, thousands	$44, 803	$51, 081	$55. 692	$65, 634	$48, 806	$62, 346
Foreign trade (natural and artificial abrasives):						
Imports (value) thousands	$66, 300	$89, 795	$99, 968	$85, 097	[3] $60, 733	$91, 464
Exports (value) do	$19, 964	$24, 876	$26, 845	$27, 589	[3] $22, 469	$23, 098
Reexports (value) do	[5] $6, 264	$6, 444	$7, 755	$8, 702	$12, 964	$13, 700

[1] Figures are for processed tripoli sold or used in 1950–54 and for crude tripoli sold or used in 1955–59.

[2] Includes grindstones, pulpstones (1950–52), oilstones and other sharpening stones (1956 and 1958–59), value of millstones (1950–53 and 1956–59), grinding pebbles, and tube-mill liners (1950–54 and 1956–59).

[3] Revised figure.

[4] Production of silicon carbide and aluminum oxide (United States and Canada); shipments of metallic abrasives (United States).

[5] Data for 1954 only.

---

[1] Commodity specialist.

[2] Statistical assistant.

[3] Figures of imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

this increase were industrial diamond and artificial abrasives. The value of abrasive materials exported was about 3 percent above 1958.

Diatomaceous earth exports that formerly appeared in this section now appear in the Diatomite chapter.

Reexports showed a gain of 6 percent over 1958 and consisted almost entirely of industrial diamond of various types. Of the industrial diamond reexports, 39 percent went to Canada, 30 percent to Belgium, and 23 percent to the United Kingdom. The remainder was divided among 10 countries.

TABLE 2.—Abrasive materials (natural and artificial) imported for consumption in the United States, by kinds

[Bureau of the Census]

Kind	1958		1959	
	Quantity	Value	Quantity	Value
Burrstones: Unmanufactured____________short tons__	------------	------------	133	$1,519
Hones, oilstones, and whetstones___________number__	90,763	$40,781	102,754	51,385
Corundum (including emery):				
Corundum ore______________________short tons__	4,685	180,355	3,335	125,954
Emery ore_______________________________do____	12	713	1,120	13,500
Grains, ground, pulverized, or refined______do____	517	130,403	1,259	266,906
Paper and cloth coated with sand, emery, or corundum_________________________________	(1)	728,975	(1)	1,021,513
Wheels, files, and other manufactures of emery short tons__	49	58,148	70	83,338
Wheels of corundum or silicon carbide_____do____	36	49,256	120	161,146
Garnet in grains, or ground, pulverized, etc____do____	------------	------------	2	495
Tripoli, rottenstone, and diatomaceous earth___do____	43	3,558	17	4,668
Diamonds:				
Bort, manufactured____________________carats__	752	97,111	2,504	173,671
Crushing bort (including all types of bort suitable for crushing)______________________carats__	5,171,390	13,940,946	5,153,730	14,379,554
Other industrial diamonds (including glaziers' and engravers' diamonds unset and miners') carats__	[2] 4,317,896	[2] 23,547,561	7,429,682	46,485,610
Carbonado and ballas____________________do____	11,346	107,190	820	12,973
Dust and powder________________________do____	568,921	1,520,168	489,436	1,651,134
Flint, flints, and flintstones, unground___short tons__	8,637	209,671	13,932	326,275
Grit, shot, and sand, of iron and steel_________do____	1,012	329,523	1,887	569,557
Artificial abrasives:				
Crude, not separately provided for:				
Carbides of silicon (carborundum, crystalon, carbolon, and electrolon)_______short tons__	73,134	10,986,026	83,926	12,009,600
Aluminous abrasives, alundum, aloxite, exolon, and lionite_____________short tons__	81,214	8,258,897	137,345	13,253,642
Other________________________________do____	3,382	317,591	4,249	409,473
Manufactures:				
Grains, ground, pulverized, refined, or manufactured________________short tons__	892	201,881	1,186	305,551
Wheels, files, and other manufactures, not separately provided for________short tons__	18	24,574	102	156,057
Total___________________________________	------------	[2] 60,733,328	------------	91,463,521

[1] Quantity not recorded.
[2] Revised figure.

TRIPOLI[4]

The combined sales of processed tripoli, amorphous silica, and rottenstone increased 13 percent in tonnage and 18 percent in value over 1958. Imports were negligible. Of the domestic sales 72 percent was for abrasive purposes. A notable development in the sales pat-

---

[4] Tripoli is the only natural silica abrasive included in the abrasive materials canvass. Information on sands used for abrasive purposes, formerly given in the Abrasive Materials chapter, can be found in the Sand and Gravel chapter. Information on abrasive quartz, quartzite, and sandstone can be found in the Stone chapter.

TABLE 3.—Abrasive materials exported from the United States

[Bureau of the Census]

Kind	1958		1959	
	Quantity	Value	Quantity	Value
Natural abrasives:				
Diamond grinding wheels, sticks, hones, and laps .... carats..	203,095	$1,294,444	249,950	$1,518,210
Diamond dust and powder .... do....	123,194	378,326	172,787	439,940
Diamond suitable only for industrial use .... do....	96,014	536,744	178,595	843,848
Grindstones and pulpstones ...... short tons..	280	44,616	401	51,849
Emery powder, grains, and grits (natural) .... pounds..	2,203,925	181,238	2,724,781	198,844
Corundum grains and grits (natural) .. do....	332,848	53,540	182,534	40,250
Whetstones, sticks, etc. (natural) ...... do....	204,705	119,028	339,815	141,649
Natural abrasives not elsewhere classified .... do....	23,916,613	1,182,063	21,051,629	1,130,505
Manufactured abrasives:				
Aluminum oxide, fused, crude, and grains .... do....	18,268,725	2,921,457	18,257,566	2,973,804
Silicon carbide, fused, crude, and grains .... do....	21,292,813	3,557,565	16,456,790	3,147,419
Alumina, unfused .... do....	152,260	28,407	132,972	37,149
Manufactured abrasives, not elsewhere classified .... do....	199,889	65,346	208,565	56,885
Abrasive pastes, compounds, and cake (except chemical) .... do....	585,097	138,568	814,426	214,698
Grinding wheels, except diamond wheels .... do....	3,439,036	3,691,605	3,003,754	3,694,510
Pulpstones of manufactured abrasives . do....	2,080,734	571,141	2,718,054	744,129
Whetstones, etc., of manufactured abrasives .... do....	276,382	687,977	296,853	804,001
Abrasive paper and cloth (natural abrasives) .... reams..	38,162	773,687	34,967	692,227
Abrasive paper and cloth (artificial abrasives) .... do....	139,643	5,222,503	135,733	5,122,203
Metallic abrasives (except steel wool) .... pounds..	11,678,965	1,021,205	12,989,766	1,245,770
Total	------	[1] 22,469,460	------	23,097,890

[1] Excludes diatomaceous earth and products.

TABLE 4.—Abrasive materials reexported from the United States, by kinds

[Bureau of the Census]

Kind	1958		1959	
	Quantity	Value	Quantity	Value
Natural abrasives:				
Diamond grinding wheels, sticks, hones, and laps .... carats..	------	------	264	$1,360
Diamond dust and powder .... do....	129,534	$344,647	252,035	715,595
Diamond suitable only for industrial use ... do....	1,795,786	12,608,371	1,890,292	12,942,306
Manufactured abrasives:				
Aluminum oxide, fused, crude, and grains .... pounds..	136,960	6,643	------	------
Alumina, unfused .... do....	------	------	12,860	948
Grinding wheels, except diamond wheels .. do....	1,000	684	5,826	3,830
Abrasive paper and cloth (natural abrasives) .... reams..	7	1,702	580	780
Abrasive paper and cloth (artificial abrasives) .... do....	10	770	1,090	27,804
Whetstones, etc., of manufactured abrasives .... pounds..	800	562	------	------
Manufactured abrasives, not elsewhere classified .... do....	800	562	10,814	7,079
Total	------	12,963,941	------	13,699,702

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

Year	Abrasives		Filler		Other, including foundry facings		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1950-54 (average)	28,783	$928	7,293	$165	2,817	$91	38,893	$1,184
1955	32,870	1,376	[3] 8,189	[3] 189	[4] 5,910	[4] 237	46,969	1,802
1956	32,189	1,328	7,274	173	3,875	116	43,338	1,617
1957	31,326	1,300	7,429	171	5,533	194	44,288	1,665
1958	29,994	1,257	7,385	178	4,778	159	42,157	1,594
1959	34,389	1,527	8,199	192	5,061	169	47,649	1,888

[1] Includes amorphous silica and Pennsylvania rottenstone.
[2] Partly estimated.
[3] Includes some tripoli used for abrasive purposes.
[4] Includes some tripoli for filter block.

tern of amorphous silica has been caused by its increasing consumption by the fiberglass industry.

Companies mining and processing tripoli, amorphous silica, or rottenstone were: Ozark Minerals Co., Elco, Ill. (amorphous silica); Tamms Industries Co., Tamms, Ill. (amorphous silica); American Tripoli Division, The Carborundum Co., Seneca, Mo., and Ottawa County, Okla. (tripoli); Penn Paint & Filler Co., Antes Fort, Pa. (rottenstone); and Keystone Filler & Manufacturing Co., Muncy, Pa. (rottenstone).

Price quotations on tripoli in E&MJ Metal and Mineral Markets were as follows (per short ton, paper bags, minimum carlot 30 tons, f.o.b. Missouri): Once-ground through 40-mesh, rose and cream, $50; double-ground through 110-mesh, rose and cream, $52; and air-floated through 200-mesh, $55.

SPECIAL SILICA-STONE PRODUCTS

Grindstone sales were reported from Ohio; grinding pebbles from Arkansas, Minnesota, North Carolina, Texas, Washington, and Wisconsin; tube-mill liners from Minnesota, North Carolina, and Wisconsin; natural material for oilstones and other sharpening stones from Arkansas and Indiana; and millstones from North Carolina.

TABLE 6.—Special silica-stone products sold or used by producers in the United States

Year	Grindstones		Grinding pebbles		Tube-mill liners		Millstones[1]
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Value (thousands)
1950-54 (average)	3,733	$225	2,797	$83	1,233	$67	[2] $9
1955	2,799	196	2,130	68	(3)	(3)	(3)
1956	[4] 2,789	[4] 262	2,330	71	1,061	74	4
1957	1,505	132	2,902	86	1,440	108	5
1958	852	83	1,985	97	(3)	(3)	2
1959	1,081	101	1,695	82	(3)	(3)	(3)

[1] Produced in New York (1953-54), North Carolina, and Virginia (1950). Quantity data not available.
[2] Data for 1950-53 only.
[3] Figure withheld to avoid disclosing individual company confidential data.
[4] Includes oilstones and other sharpening stones.

NATURAL SILICATE ABRASIVES

Garnet.—Domestic sales of garnet increased 18 percent in tonnage and 39 percent in value over 1958. Domestic producers of garnet were Idaho Garnet Abrasive Co., Fernwood, Idaho; Porter Brothers, Valley County, Idaho; J. R. Simplot Co., Boise, Idaho; Spokane Sand & Garnet Sales Co., Fernwood, Idaho; Barton Mines Corp., North Creek, N.Y.; and Cabot Carbon Co., Willsboro, N.Y. New York was the leading garnet-producing State.

In grinding the main mirror of the 120-inch telescope at the Lick Observatory, California, a sludge of 25-micron garnet and water was used in an intermediate finishing operation.[5]

New techniques in the preparation of abrasive garnet have increased its hardness and durability for wood sanding and finishing.[6]

Industrial garnet production was reported from Tanganyika,[7] Morocco,[8] and Madagascar.[9]

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

Year	Short tons	Value (thousands)	Year	Short tons	Value (thousands)
1950–54 (average)	11,889	$996	1957	9,776	$1,080
1955	11,835	1,191	1958	[1] 12,303	[1] 869
1956	9,812	1,073	1959	14,568	1,211

[1] Revised figure.

NATURAL ALUMINA ABRASIVES

Corundum.—Lower production of corundum in Southern Rhodesia and the Union of South Africa resulted in a drop of over 3,000 short tons in the estimated world output.

The discovery of a corundum deposit in Tanganyika was reported.[10]

An article [11] describing a corundum deposit in Southern Rhodesia gives an estimate of 300,000 tons as its probable ore reserve. The ore is described as a massive fine-grained corundum. Jet piercing is used for sinking blastholes, the material being too hard to allow conventional percussion drilling. Ore is sorted into refractory and abrasive material.

Emery.—The quantity of domestic emery sold or used was greater than in 1958 but below the average for the past 10 years. Its chief application was in the construction of nonskid concrete floors and pavements. Emery imports were the largest since 1951. The European market for emery was supplied by Turkey and Greece.

---

[5] Hill, C. H., Sr., Grinding the Lick Observatory Mirror: Grinding and Finishing, vol. 5, No. 3, July 1959, pp. 26–27.

[6] The Wood-Worker, The Garnet You Use on Wood: Vol. 78, No. 6, August 1959, pp. 26–27.

[7] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 4, October 1959, p. 35.

[8] Mining Journal (London), Mining Projects in Morocco: Vol. 253, No. 6482, Nov. 13, 1959, p. 473.

[9] U.S. Consulate, Tananarive, Madagascar, State Department Dispatch 52: Dec. 21, 1959, p. 1.

[10] South African Mining and Engineering Journal (Johannesburg), vol. 70, No. 3450, Mar. 30, 1959, p. 613.

[11] Rhodesian Mining and Engineering, Concession Corundum Mine: Vol. 24, No. 9, September 1959, pp. 59–61.

TABLE 8.—World production of corundum by countries,[1] in short tons [2]

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country [1]	1950-54 (average)	1955	1956	1957	1958	1959
Argentina	63	----------	----------	----------	----------	----------
Australia	12	10	----------	----------	----------	----------
India	511	269	395	497	435	236
Malaya, Federation of	12	[3] 2	[3] 100	----------	----------	----------
Mozambique	4	9	----------	----------	----------	----------
Rhodesia and Nyasaland, Federation of:						
Nyasaland	77	20	----------	----------	----------	----------
Southern Rhodesia	736	1,168	4,448	4,506	4,594	2,799
South-West Africa	2	----------	----------	----------	----------	----------
Union of South Africa	3,209	834	2,068	1,539	2,118	622
World total (estimate) [1] [2]	10,400	8,000	11,000	10,000	11,000	8,000

[1] In addition to countries listed, corundum is produced in U.S.S.R., but data on production are not available, and estimate is included in the total.

[2] This table incorporates some revisions.

[3] Exports.

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

Year	Short tons	Value (thousands)	Year	Short tons	Value (thousands)
1950-54 (average)	9,651	$131	1957	11,893	$184
1955	10,735	151	1958	7,687	126
1956	12,153	174	1959	8,555	150

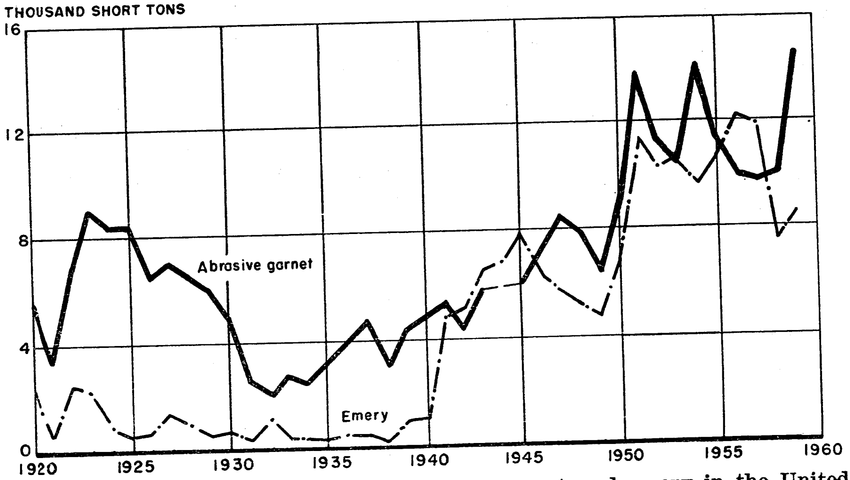

FIGURE 1.—Marketed production of abrasive garnet and emery in the United States, 1920–59.

INDUSTRIAL DIAMOND

A comprehensive coverage of the diamond industry throughout the world was published.[12] This edition enlarges upon the information

---

[12] Moyar, A., The Diamond Industry in 1957–58: Vlaams Economist Verbond, Antwerp, 1959, 130 pp.

given in the previous year's issue. Editions are issued in French, Dutch, and English.

World Review.—As reported by the Central Selling Organization in London,[13] diamond sales reached an alltime high. The value of sales of gem and industrial material totaled $255.2 million, a 39-percent increase over sales in 1958 and 18 percent over 1957, the previous alltime high. Natural industrial diamond sales totaled $78.7 million, a gain of 74 percent over 1958.

World production of industrial diamond totaled about 20.9 million carats, a decline of 7 percent from the record production of 1958. A reduction of 1.7 million carats in the Belgian Congo production was the principal cause for the decline. To offset this decrease there were increases in the diamond outputs of Angola French West Africa (Guinea and the Ivory Coast), Tanganyika, and the Union of South Africa.

Production.—*Africa.*—Industrial diamond production in Angola was 500,000 carats, an increase over 1958. At the beginning of 1959 more than one-half of the diamondiferous gravel treated was mined by 22 mechanical excavators, and several more started operation during the year. The operating company has as many as 13 prospecting parties in the field, and several new diamond deposits were found. Of 19 kimberlite formations discovered in Angola, only 1 near the Caixepa River appears to contain diamond.[14]

A slowing down of industrial activity in the United States and Europe during 1958 and the appearance of manufactured diamond in commercial quantities at competitive prices reduced the demand for crushing bort. Therefore, production of industrial diamond in the Belgian Congo during 1959 was reduced by over 1.7 million carats from 1958. Over 98 percent of the diamondiferous material in the Bakwanga area was handled mechanically.[15]

Five European companies were operating in the basin of the Birim River in the Oda District of Ghana, the Consolidated African Selection Trust being the largest producer. Mechanization was increased, and the diamond yield of the gravels improved. Diamond mining in the Bonsa Field in the Tarkwa District was done exclusively by native African miners whose number is estimated as high as 35,000. Primitive working and recovery methods were used, and it was reported that much of the diamond was not recovered.[16]

During March the Government of Guinea opened a diamond market at Kankan, operating on a similar basis as the Government diamond market at Accra in Ghana. Fourteen buyers licenses were issued.[17]

The Sierra Leone Government on August 1, 1959, established the Government Diamond Office and appointed the Diamond Corporation, Ltd., to act as manager of this office for a period of 5 years. All diamond produced in Sierra Leone under the Alluvial Diamond Mining Ordinance in the future will be exported and marketed solely

---

[13] Jewelers' Circular-Keystone, Diamond Sales Hit a New All-Time High in 1959: Vol. 130, No. 5, February 1960, p. 144.

[14] Mining Magazine (London), Diamonds From Angola: Vol. 101, No. 3, September 1959, p. 84.

[15] Mining Journal (London), Société Miniére du Bécéka: Vol. 252, No. 6459, June 5, 1959, p. 632.

[16] Work cited in footnote 12.

[17] Mining Journal (London), Illicit Diamond Mining in Guinea: Vol. 253, No. 6475, Sept. 25, 1959, pp. 288–289.

through this new agency. A provision of the agreement is that any producer dissatisfied with the prices offered by the Government Diamond Office may have his diamond sent to London for sale. It is hoped that the arrangement will bring stability to licensed alluvial diamond mining in Sierra Leone.[18]

An account was published of the Williamson mine in Tanganyika describing the geology of that area, history of the property, and its mining and diamond recovery methods.[19]

By achieving full capacity operations at the new treatment plant of Williamson Diamonds, Ltd., production reached a new high of 624,292 carats in Tanganyika in 1959. Of this output about 350,000 carats was industrial material.[20]

On June 10, 1959, the De Beers Consolidated Mines, Ltd., announced that an arrangement had been made with Jack Scott of Johannesburg that gave De Beers an interest in his diamond concession in Basutoland. Diamond prospecting and mining is to continue under the direction of Scott, with technical help from the De Beers company.[21]

Other Areas.—Reports from Borneo state that a new diamond field began operations during October 1958 near Bohot in the central part of that island. Some 2,000 miners were said to be at work there.[22]

At Marabá, Pará, Brazil, mining on the Tocantins River was done by divers. An account of these operations appeared in a magazine article.[23]

An article reviewed the possibilities of diamond mining in Brazil. While diamond is mined in 12 States in Brazil, Minas Gerais, Matto Grosso, Goiaz, and Bahia are the principal producers.[24]

Reports from the new diamond fields in Siberia indicate the discovery of several more kimberlite pipes in the Yakutia S.S.R. and that the largest diamond so far found weighed 54 carats. Mining activity is mainly concentrated near the mining camp of Mirny in the valley of the Vilyui River. Opencut operations were also in progress at the Udachnaya pipe, 300 miles north of Mirny in a remote area, and completion of the development of this new diamond mine by 1965 was planned. Alluvial diamond workings are said to have begun along several of the river valleys in Yakutia. Six of the geologists responsible for the discovery of these Siberian diamond fields were awarded Lenin prizes.[25]

An agreement to market the diamond produced in the U.S.S.R. has been made between the Central Selling Organization (Diamond Corporation) and the Soviet Trade Delegation, London.[26]

---

[18] Mining Journal (London), Marketing of Sierra Leone Diamonds: Vol. 252, No. 6462, June 26, 1959, p. 702.

[19] Du Toit, G. J., The Williamson Mine: Mine and Quarry Eng., vol. 25, No. 3, March 1959, pp. 98–103; No. 4, April 1959, pp. 147–152; No. 5, May 1959, pp. 194–200.

[20] De Beers Consolidated Mines, Ltd., 72nd Annual Report, 1959, Kimberly, May 17, 1960, p. 37.

[21] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 3, September 1959, p. 43.

[22] Mining Journal (London), Indonesia Mining News: Vol. 252, No. 6447, Mar. 13, 1959, p. 281.

[23] Glowka, Art, I Found a Million in the Mud: True, vol. 40, No. 264, May 1959, pp. 48–51, 81–83.

[24] Mieritz, R. E., Brazil: An Untapped Diamond Source: Min. World, vol. 21, No. 1, January 1959, pp. 41–43.

[25] Mining Magazine (London), Siberian Diamonds: Vol. 100, No. 1, January 1959, pp. 2–3.

[26] South African Mining and Engineering Journal (Johannesburg), Diamond Agreement: Vol. 71, No. 3495, pt. 1, Jan. 29, 1960, p. 225.

TABLE 10.—World production of industrial diamond, in thousand carats[1]

Country	1957	1958	1959
Africa:			
Angola	350	400	500
Belgian Congo	15,100	15,900	14,200
French Equitorial Africa	70	60	60
French West Africa	150	[2] 260	400
Ghana (Gold Coast)	1,950	[2] 2,200	2,200
Sierra Leone [3] [4]	1,000	1,400	1,150
South-West Africa	100	60	90
Tanganyika	200	290	350
Union of South Africa:			
"Pipe" mines:			
Premier	1,150	960	950
DeBeers Group	400	480	500
Others	90	70	70
"Alluvial" mines	40	100	150
Total Africa	20,600	[2] 22,200	20,620
Other areas:			
Brazil [4]	150	150	170
British Guiana	15	20	40
Venezuela	70	75	80
Australia, Borneo, India, and U.S.S.R. [4]	5	5	10
World total [4]	20,800	[2] 22,400	20,900

[1] Prepared jointly by the Bureau of Mines and Dr. George Switzer, Smithsonian Institution.
[2] Revised figure.
[3] Includes unofficial production of Liberia.
[4] Estimate.

TABLE 11.—Industrial diamond (excluding diamond dust and manufactured bort) imported for consumption in the United States

[Bureau of the Census]

Year	Thousand carats	Thousand dollars	Year	Thousand carats	Thousand dollars
1950–54 (average)	12,641	$45,828	1957	12,220	$50,063
1955	14,952	65,672	1958	[1] 9,500	[1] 37,596
1956	16,166	73,291	1959	12,584	60,879

[1] Revised figure.

In connection with the operations of the Siberian diamond fields, Soviet engineers are studying diamond mining methods in Ghana.[27]

Foreign Trade.—Because of increased industrial activity, imports of industrial diamond into the United States increased 32 percent in quantity and 62 percent in value over 1958. Exports of industrial diamond increased 42 percent in quantity and 27 percent in value. Reexports increased 11 percent in quantity and 5 percent in value.

An industrial firm in Newark, N.J., established a new division to import, process, and distribute natural industrial diamond in the United States and to provide technical research in its use. The company will also crush and grade diamond into commercial grit sizes. It will buy its supply of industrial diamond through the Central Selling Organization.[28]

Technology.—Previous shortages of industrial diamond, which discouraged large-scale use of diamond grinding and cutting wheels, are being eliminated by a greater production at the African mines and

---

[27] Jewelers' Circular-Keystone, Briefly: Vol. 129, No. 10, July 1959, p. 113.
[28] Mining Journal (London), New Diamond Distributors: Vol. 253, No. 6486, Dec. 11, 1959, p. 609.
Steel, Engelhard Adds New Line: Vol. 145, No. 26, Dec. 28, 1959, p. 71.

TABLE 12.—Industrial diamond (including diamond dust and manufactured bort) imported for consumption in the United States, by countries

[Bureau of the Census]

Country	Bort manufactured (diamond dies)		Crushing bort (including all types of bort suitable for crushing)		Other industrial diamond (including glaziers' and engravers' diamond, unset, and miners')		Carbonado and ballas		Dust and powder	
	Carats	Value	Carats	Value	Carats	Value	Carats	Value	Carats	Value
1958										
North America: Canada	1	$103	72,080	$189,454	536,369	$3,494,099			15,597	$35,381
South America:										
Argentina					470	9,104				
Brazil					7,608	240,284	11,291	$106,720		
Venezuela					4,481	90,322				
Total					12,559	339,710	11,291	106,720		
Europe:										
Belgium-Luxembourg					682,356	4,312,499			9,751	28,613
France	390	47,699			[1] 17,147	[1] 250,134				
Germany, West	158	15,609			10,436	189,868				
Netherlands	50	10,033	590	1,623	47,202	287,639			5,175	14,140
Sweden	32	10,788							350	400
Switzerland	89	9,348			7,350	26,328				
United Kingdom	6	556	876,728	2,459,130	[1] 2,278,559	[1] 11,159,642	55	470	252,092	708,639
Total	725	94,033	877,318	2,460,753	[1] 3,043,050	[1] 16,226,110	55	470	267,368	751,792
Asia:										
Israel	26	2,975			221	2,498				
Japan					221	1,554				
Total	26	2,975			442	4,052				
Africa:										
Belgian Congo			4,036,492	10,761,796	108,222	601,327			247,256	599,777
British West Africa, n.e.c.			11,600	32,548						
French Equatorial Africa					35,505	311,466				
Ghana					6,190	28,036				
Liberia					2,733	3,967				
Union of South Africa			173,900	496,395	572,826	2,538,794			36,508	130,906
Total			4,221,992	11,290,739	725,476	3,483,590			283,764	730,683

Oceania: Australia									2,192	2,312
Grand total	752	97,111	5,171,390	13,940,946	[1] 4,317,896	[1] 23,547,561	11,346	107,190	568,921	1,520,168
1959										
North America:										
Canada	58	1,247	119,368	341,136	524,307	3,039,969			19,484	69,797
Mexico			110	275	56	3,352				
Total	58	1,247	119,478	341,411	524,363	3,043,321			19,484	69,797
South America:										
Brazil					7,263	127,012	820	12,973		
British Guiana					1,913	43,195				
Venezuela					13,218	155,513				
Total					22,394	325,720	820	12,973		
Europe:										
Belgium-Luxembourg	476	3,401			1,311,217	12,429,877			11,884	33,176
France	962	85,385			22,981	259,754				
Germany, West	182	11,794	400	1,210	27,518	212,204				
Netherlands	423	42,447			91,486	876,103			1,024	2,506
Sweden	105	6,703							355	425
Switzerland	201	20,306			5,408	18,987			202,328	523,273
United Kingdom	97	2,388	579,680	1,620,761	3,953,640	22,730,180			86,766	532,926
Total	2,446	172,424	580,080	1,621,971	5,412,250	36,527,105			302,357	1,092,306
Asia: Israel					237,668	2,039,437			2,478	4,335
Africa:										
Belgian Congo			4,132,396	11,405,031	130,047	515,656			54,217	173,449
British West Africa, n.e.c.			23,600	66,264	12,000	33,779				
French West Africa and Republic of Togo					1,033	25,271				
Ghana					30,140	218,337				
Union of South Africa			298,176	944,877	1,059,787	3,756,984			110,900	311,247
Total			4,454,172	12,416,172	1,233,007	4,550,627			165,117	484,696
Grand total	2,504	173,671	5,153,730	14,379,554	7,429,682	46,485,610	820	12,973	489,436	1,651,134

---

[1] Revised figure.

by the availability of manufactured industrial diamond. Metal-bonded diamond grinding wheels combine faster cutting action with greater durability for so-called pencil edging or making a smooth rounded edge on a plate of glass. The work is simplified and production rates increased by doing an entire job in one operation. Newly developed cutting blades, extremely thin, with an electroformed diamond periphery, were widely used to slice and dice germanium, synthetic quartz, and other crystals. Resinoid and metal-bonded diamond grinding wheels have been available for years, but vitrified bonded diamond wheels are a more recent development.[29]

The friability of manufactured diamond enables its use in making fine diamond powder.[30]

Abrasion tests of grinding wheels made from natural and manufactured diamond showed that the manufactured material is superior in resinoid and vitrified grinding wheels. Suggested reasons for the better performance of the manufactured diamond were that its rough surfaces offer a good anchorage between the bond and diamond and its friability causes it to break down, thus presenting new cutting edges to the work. Friability seems to induce faster and cooler cutting. The natural material seemed to have the advantage in metal bonds, especially in the coarser sizes. With relatively high unit grinding pressures the greater strength of the natural diamond crystals seems to offer an advantage.[31]

The General Electric Research Laboratory released details of its process for making diamond. Graphite seems to be the preferred form of carbon, and apparently several elements can be used as a catalyst. The material is subjected simultaneously to pressures ranging from 800,000 to 1,800,000 p.s.i., and temperatures ranging from 2,200° to 4,400° F.[32]

De Beers Consolidated Mines announced that synthetic diamond had been produced at the Adamant Laboratory in Johannesburg.[33]

A new method of selecting natural bort particles for use in resinoid grinding wheels uses the irregular and rough-surfaced material, which is claimed to cut faster and is less liable to be torn from the wheel than the more blocky diamond. It is emphasized that this selected natural bort would be advantageous only for resinoid wheels. For metal and vitrified bonds, the stronger blocky shapes of diamond are superior.[34]

ARTIFICIAL ABRASIVES

Production of all types of crude artificial abrasive in the United States and Canada increased over 1958. Most of the aluminum oxide

---

[29] Maziliauskas, Stasys, Recent Developments Increase Usefulness of Diamond Wheels for Ceramic Applications: Ceram. Age, vol. 73, No. 6, June 1959, pp. 47–50.

[30] Kay, Stanley, and Warren, E. F., Man-Made Vs. Natural Diamond Powders: Grinding and Finishing, vol. 5, No. 8, December 1959, pp. 35–36.

[31] Sinclair, E. L., Man-Made Diamonds, A Progress Report: Grits and Grinds, vol. 50, No. 5, May 1959, pp. 3–11.

[32] Bovenkerk, H. P., and others, Preparation of Diamond: Nature, vol. 184, No. 4693, Oct. 10, 1959, pp. 1094–1098.

[33] Mining Journal (London), De Beers Can Make Synthetic Diamonds: Vol. 253, No. 6483, Nov. 20, 1959, p. 516.

[34] Weavind, R. G., Factors Affecting the Efficiency of Resin-Bonded Diamond Grinding Wheels: Pres. at 14th Ann. Meeting, Ind. Diamond Assoc. of America, Inc., Williamsburg, Va., May 11–14, 1959.

and silicon carbide produced in Canada was shipped to the United States for processing. None was processed in Canada. Aluminum oxide production included 22,193 short tons of white high-purity material valued at $3,960,000. Silicon carbide production was at 93 percent of capacity; aluminum oxide, 53 percent; and metallic abrasives, 41 percent.

Sales value of domestically produced bonded grinding wheels was nearly $173 million, which was 33 percent higher than in 1958. This amount was slightly less than 1956 or 1957 sales of corresponding material. Sales of vitrified bonded grinding wheels were 43 percent of the total; resinoid and shellac bonded grinding wheels, 39 percent; rubber bonded grinding wheels, 5 percent; and all other types, including diamond grinding wheels, 13 percent.

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

Year	Silicon carbide [1]		Aluminum oxide [1] (abrasive grade)		Metallic abrasives [2]		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1950–54 (average)	77,261	$9,611	200,100	$19,489	149,020	$15,703	426,381	$44,803
1955	74,805	11,027	195,822	22,142	157,616	17,912	428,243	51,081
1956	95,778	14,937	195,228	22,554	140,455	18,201	431,461	55,692
1957	124,688	19,152	228,511	28,202	131,503	18,280	484,702	65,634
1958	110,456	17,597	122,868	16,870	101,159	14,339	334,483	48,806
1959	132,458	21,987	158,392	22,072	125,512	18,287	416,362	62,346

[1] Figures include material used for refractories and other nonabrasive purposes.
[2] Shipments from U.S. plants only.

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

Product	Manufactured during year		Sold or used during year		Stocks on hand Dec. 31		Annual capacity (short tons)
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	
1958							
Chilled iron shot and grit	46,499	$4,903	45,959	$4,872	8,452	$883	177,834
Annealed iron shot and grit	28,045	3,532	27,145	3,601	2,620	291	68,564
Steel shot [1]	[2] 27,102	5,088	27,454	5,765	6,762	1,218	77,780
Other types (including cut wire shot)	689	111	601	101	61	16	2,360
Total	[2] 102,335	13,634	101,159	14,339	[3] 17,895	[3] 2,408	326,538
1959							
Chilled iron shot and grit	48,101	5,034	48,905	5,304	7,648	745	162,634
Annealed iron shot and grit	37,262	4,853	38,149	4,986	1,733	225	58,244
Steel shot [1]	37,925	7,135	37,930	7,863	6,757	1,336	78,000
Other types (including cut wire shot)	535	134	528	134	68	18	1,410
Total	123,823	17,156	125,512	18,287	16,206	2,324	300,238

[1] Includes steel grit.
[2] Revised figure.
[3] Includes inventory adjustments for all products, as reported by producers.

Coated abrasive sales by domestic manufacturers totaled 2,276,000 reams valued at $117 million, an advance of 17 percent in quantity and 20 percent in value over 1958. Percentages of the abrasives used in their manufacture were: Aluminum oxide, 41 percent; silicon carbide, 30 percent; garnet, 14 percent; flint, 12 percent; and emery, 3 percent. Of the total production 65 percent was made with glue as an adhesive, and nearly equal amounts of the remaining 35 percent were bonded with either resin or waterproof adhesives.

World Review.—Abstracts from State Department dispatches covering the abrasive industries of certain foreign countries were pub-

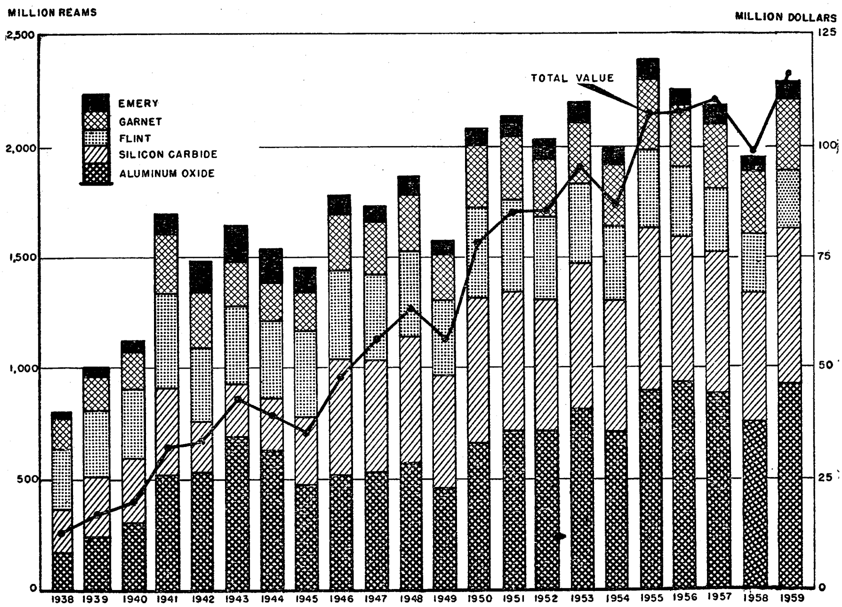

FIGURE 2.—Coated abrasives industry in the United States, 1938–59.

TABLE 15.—Stocks of crude artificial abrasives and capacity of manufacturing plants, as reported by producers in the United States and Canada, in 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
1950–54 (average)	18.5	106.6	34.0	259.2	10.7	238.2
1955	11.0	118.8	39.9	282.2	14.6	264.3
1956	10.3	118.9	38.6	283.5	16.5	290.5
1957	14.0	131.9	36.7	298.7	16.5	297.6
1958	10.4	141.9	36.4	299.5	[2] 17.9	326.5
1959	10.6	142.0	29.2	299.5	16.2	300.3

[1] United States only.
[2] Revised figure.

lished.[35] The information included names of the principal abrasive manufacturers in each country, production data for crude artificial and natural abrasives, domestic consumption of abrasive products, and the imports and exports of various abrasive materials. The capacity of each of the countries included in the study to meet its market demand for artificial abrasive grain is shown in table 16.

The annual aluminum oxide output of Yugoslavia has been estimated at 1,500 tons, with some available for export.[36]

Technology.—An enlarged revision of a 1951 edition of "The Grinding Wheel" by the late Kenneth B. Lewis was published. Additional information is included on automation, electroassist grinding, filtering or grinding fluids, and grinding of ceramics.[37]

An investigation of the chemical reactions between metals and abrasives during grinding, their effect on abrasive wear, and their modification by grinding fluids showed relationships between the shape, toughness, and sizes of the abrasive grain studied. The degree of chemical reactivity between abrasive and work material was found to be directly related to the surface finish obtained in the grinding process.[38]

Methods for testing grinding wheels by their tone or sound, density and penetration, and comments regarding their use become important when a variety of grinding wheels from various sources are used in a manufacturing plant.[39]

Cryolite is used successfully as an active filler in snagging wheels. It melts and lubricates the surface beneath the abrasive grain and also reacts chemically with the chip to prevent it from melting back into the material being ground.[40]

Use of abrasive belts as a substitute for setup wheels is increasing. A wide choice of abrasives, adhesives, backings, and sizes is now available.[41]

Silicone coating of the abrasive grain used in grinding wheels is reported to have increased wheel efficiency at a comparatively insignificant additional cost. Added wheel strength is achieved because the silicone coating reacts chemically with both the bond and grit to produce a stronger wheel.[42]

Grinding as an economical method of stock removal warrants its consideration in part design. Often both the final size and desired finish of a part can be achieved in one grinding operation.[43]

---

[35] Bureau of Mines, Mineral Trade Notes: Vol. 48, No. 2, February 1959, Argentina, pp. 24–25; Denmark, pp. 25–26; India, pp. 26–27; Spain, p. 28. No. 3, March 1959, France, pp. 23–25; Japan, pp. 28–33; Mexico, pp. 25–27; Switzerland, pp. 34–37. No. 4, April 1959, Australia, pp. 23–26; Brazil, pp. 26–30; Germany, West, pp. 30–36; Italy, pp. 37–38. Vol. 49, No. 3, September 1959, Canada, pp. 28–31; Norway, p. 31; United Kingdom, pp. 31–39.

[36] Chemical Trade Journal and Chemical Engineering (London), Yugoslavia Making Synthetic Abrasives: Vol. 144, No. 3749, Apr. 10, 1959, p. 806.

[37] Schleicher, W. F., The Grinding Wheel, Kenneth B. Lewis, Revised Edition: Grinding Wheel Institute, Cleveland, Ohio, 1959, 532 pp.

[38] Goepfert, G. J., and Williams, J. L., The Wear of Abrasives in Grinding: Mech. Eng., vol. 81, No. 4, April 1959, pp. 69–73.

[39] Leaman, P. R., Basic Tests of Grinding Wheel Hardness: Tooling and Production, vol. 24, No. 12, March 1959, pp. 63–64.

[40] Gregor, J. R., Effects of Materials on Snagging Wheel Performance: Grinding and Finishing, vol. 4, No. 10, February 1959, pp. 28–31.

[41] Spencer, L. F., Abrasive Sheets and Belts: Metal Ind. (London), vol. 94, No. 12, Mar. 20, 1959, pp. 223–224.

[42] Grinding and Finishing, Coating for Abrasive Grains Increases Wheel Efficiency: Vol. 5, No. 1, May 1959, p. 57.

[43] Patterson, M. M., How to Design for Grinding: Grinding and Finishing, vol. 5, No. 2, June 1959, pp. 26–29.

TABLE 16.—Statistics covering silicon carbide grain and all types of aluminum oxide grain, by countries,[1] 1957, in short tons

Country	Silicon carbide			Aluminum oxide		
	Production [2]	Imports	Exports	Production [2]	Imports	Exports
Argentina	----------	842	----------	----------	1,145	(3)
Australia	----------	1,030	----------	----------	1,527	(3)
Austria	----------	1,262	----------	5,940	1,943	1,109
Belgium	----------	1,363	----------	----------	1,337	----------
Brazil	----------	1,081	----------	5,139	132	(3)
Canada	68,549	2,937	68,549	179,540	5,315	179,540
Denmark	----------	(3)	(3)	----------	241	----------
France	6,160	2,003	1,738	37,136	963	6,099
Germany, West	20,426	1,198	3,908	55,440	558	14,401
India	----------	242	----------	----------	993	(3)
Italy	1,584	2,461	207	4,418	3,104	224
Japan	5,700	559	376	17,930	641	194
Netherlands	----------	774	----------	----------	1,521	----------
Norway	11,005	12	10,428	----------	495	----------
Spain	----------	275	----------	990	828	----------
Sweden	440	2,803	194	660	3,953	18
Switzerland	2,200	216	1,870	3,740	2,634	----------
United Kingdom	----------	6,513	451	4,400	27,500	1,379
United States	33,000	67,048	8,105	9,758	155,387	10,736
Union of South Africa	----------	853	----------	----------	902	(3)
Yugoslavia	----------	153	(3)	1,000	273	----------
Others	----------	2,356	155	----------	4,119	1,811
Total [1]	149,064	95,981	95,981	326,091	215,511	215,511

[1] Countries comprising the Soviet Bloc are not included.
[2] Grain equivalent of the crude silicon carbide and crude aluminum oxide manufactured.
[3] Data not available.

Artificial and other types of abrasives are used successfully in open-top vibrators for the finishing of metal and plastic parts. Owing to the efficient action of these vibrators, additional finishing operations are often unnecessary, and on delicate work piece-distortion is avoided. Artificial abrasive shapes especially designed for vibratory use are fracture resistant and long wearing. The open-top feature of these vibrators permits inspection of parts during processing.[44]

A series of two articles on the manufacture of abrasive grinding wheels explain the various raw materials used and how the different types of wheel are made to achieve desired results.[45]

For certain grinding operations fused zirconia and zirconia-titania types of abrasives have proved superior to conventional types, but much experimental work is still necessary to explore the possible uses for these new abrasive products.[46]

Abrasion resistance is often one of the most important factors in the service performance of protective coatings, especially in airplanes. A patent was issued relating to an apparatus for measuring such resistance.[47]

---

[44] Brandt, W. E., Controlled Vibration: Grinding and Finishing, vol. 5, No. 3, July 1959, pp. 30–31.

[45] Gormly, M. W., What You Should Know About Wheel Manufacturing: Grinding and Finishing, vol. 5, No. 5, September 1959, pp. 30–34; No. 6, October 1959, pp. 41–45.

[46] Jacobs, C. W. F., What's the Status of Zirconium Type Abrasives? Grinding and Finishing, vol. 5, No. 5, September 1959, pp. 41–42.

[47] Roberts, A. G., and others (assigned to United States as represented by the Secretary of the Navy), Apparatus for Measuring Abrasive Resistance: U.S. Patent 2,907,200, Oct. 6, 1959.

Barrel tumbling with abrasives not only rounds the corners of metal articles and improves their surface finish but also adds to the metal's fatigue strength.[48]

Choice of the proper sized abrasive is influenced by the size and characteristics of the work piece and the type of finish desired. Recommended sizes were shown in a trade journal article.[49]

While manufactured chiefly for use as an abrasive, silicon carbide has desirable physical properties as a refractory. It is one of the hardest of substances and does not decompose until 4,000° F.[50]

A survey of the literature and developments in silicon carbide includes its crystallographic, material, electrical, optical, and device aspects.[51]

Silicon carbide foam, a new lightweight corrosion-resistant material with high porosity and thermal insulation up to 4,000° F., is now in pilot-plant production. It is easily machined with standard steel cutting tools and can be fabricated into complex shapes at close tolerances.[52]

New uses for silicon carbide include high-temperature applications and materials for withstanding oxidation and erosion at high temperature and speeds. It is also used as an impermeable ceramic for lining pipes, fittings, and valves used for corrosive liquids and high temperature gases, and for wear-resistant parts.[53]

MISCELLANEOUS MINERAL-ABRASIVE MATERIALS

In addition to the natural and manufactured abrasive materials for which data are included, many other minerals were used for abrasive purposes. A number of oxides, including tin oxides, magnesia, iron oxides (rouge and crocus), and cerium oxide, were employed as polishing agents. Certain carbides, such as boron carbide and tungsten carbide, were used for their abrasive properties, especially when extreme hardness was demanded. Other substances with abrasive applications included finely ground and calcined clays, lime, talc, ground feldspar, river silt, slate flour, and whiting.

---

[48] Iron Age, Improve Fatigue Strength With Abrasive Tumbling: Vol. 183, No. 8, Feb. 19, 1959, pp. 129–131.

[49] Iron Age, Recommended Sizes of Shot and Grit: Vol. 183, No. 23, June 4, 1959, pp. 136–138.

[50] Spitzer, Edward, Report on Silicon Carbide: U.S. Govt. Res. Repts., Off. Tech. Services, U.S. Dept. of Commerce, vol. 32, No. 2, Aug. 14, 1959, pp. 216–217.

[51] Minamoto, M., A Survey on Silicon Carbide: U.S. Govt. Res. Repts., Off. Tech. Services, U.S. Dept. of Commerce, vol. 32, No. 2, Aug. 14, 1959, p. 250.

[52] Ceramic Age, New Silicon Carbide Foam: Vol. 73, No. 5, May 1959, p. 37.

[53] Steel, Look Where Silicon Carbide is Going: Vol. 144, No. 14, Apr. 6, 1959, p. 115.

Aluminum

By R. August Heindl,[1] Clarke I. Wampler,[2] and Mary E. Trought[2]

❖

PRIMARY ALUMINUM production in the United States in 1959 reached a peak and was 25 percent above that of 1958 and 16 percent over the previous record set in 1956. World production of 4.5 million short tons represented an increase of more than 15 percent over 1958 and continued the upward trend begun in 1947.

A significant development in the United States was the production of a compact car having an aluminum engine. The sharp increase in the activity of U.S. producers in foreign countries was also expected to be of long-range importance. Domestic productive capacity, which at the beginning of the year was 2.2 million tons, increased to 2.4 million tons at yearend.

TABLE 1.—Salient statistics of the aluminum industry

	1950-54 (average)	1955	1956	1957	1958	1959
United States:						
Primary production..short tons..	1,041,082	1,565,721	1,678,954	1,647,709	1,565,557	1,953,175
Value..................thousands..	$394,905	$684,038	$805,782	$836,944	$773,610	$955,309
Average ingot price per pound cents..	19.8	23.7	26.0	27.5	26.9	26.9
Secondary recovery [1] short tons..	300,281	335,994	339,768	361,819	289,555	359,920
Imports (crude and semicrude) short tons..	234,299	239,475	264,975	258,006	[2] 293,190	301,128
Exports (crude and semicrude) short tons..	22,824	33,834	68,032	62,552	82,470	163,820
Apparent consumption.....do.....	1,552,646	2,111,224	2,127,523	2,136,526	[2] 2,092,152	2,486,842
World: Production thousand short tons..	2,356	3,460	3,720	3,725	[2] 3,880	4,510

[1] The 1950-53 data are recoverable aluminum-alloy content; subsequent years' data are recoverable aluminum content.

[2] Revised figure.

LEGISLATION AND GOVERNMENT PROGRAMS

Two companies shipped aluminum to the Government under supply contracts negotiated during 1950-52. At the end of the year the production phase of all contracts except that with Harvey Aluminum, Inc., had expired.

The aluminum supply contracts between the Government and Aluminum Co. of America, Kaiser Aluminum & Chemical Corp., and Harvey were amended. Under prior amendments made with the companies, 35 percent of the expanded production, instead of 25 percent,

---

[1] Assistant chief, Branch of Light Metals.

[2] Statistical assistant.

was to be made available to nonintegrated consumers for 15 years after the completion of the production phase of the contracts. To help assure a supply of metal for small businesses, the 1959 amendments provided that part of the 35 percent should be made available specifically to nonintegrated consumers qualifying as small business concerns.

TABLE 2.—Shipments of aluminum to the Government under aluminum supply contracts, in short tons

Year	Alcoa [1]	Kaiser [1]	Reynolds [2]	Harvey [3]	Total
1957	104,998	116,804	102,509		324,311
1958	97,497	95,272	130,359		323,128
1959			45,320	27,915	73,235
Total	202,495	212,076	278,188	27,915	720,674

[1] Contract expired in 1958.
[2] Contract expired in 1959.
[3] Contract to expire by 1963.

Under the defense materials system effective since July 1953, aluminum supply in the United States above the quantity set aside for defense and atomic-energy requirements and the national stockpile was available for civilian consumption. Metal set aside, exclusive of the stockpile, consisted of an "A" allotment for specifically designed military equipment and a "B" allotment for aluminum required by manufacturers of civilian-type items incorporated in end products for military use. The two allotments totaled 54,000 tons a quarter, as announced by U.S. Department of Commerce, Business and Defense Services Administration. The grand total of 216,000 tons was a decrease of 5,500 tons (2.5 percent) from 1958.

The U.S. Department of the Interior and the Federal Power Commission approved a 5-year extension of the Bonneville power rates in the Pacific Northwest. The base rate of $17.50 per kilowatt-year, equivalent to 2 mills per kilowatt-hour, was extended until December 1964.

On December 31, 1959, Government stocks of aluminum in Defense Production Act inventories were 685,000 tons, compared with 632,000 tons at the beginning of the year. There had been no barter for aluminum, so there were no Commodity Credit Corporation inventories. Inventories acquired under the Strategic and Critical Materials Stock Piling Act are security classified.

DOMESTIC PRODUCTION

PRIMARY

As a result of starting new potlines and reactivating old lines, the primary aluminum industry increased its output 25 percent over 1958. The record production of 1,953,000 tons was 16 percent above that of 1956, the previous high year. Monthly records were established five times during the year. The highest production was reported in July when the industry operated at 90 percent capacity and at an annual rate of more than 2.1 million tons. Production during the year averaged 86 percent of capacity. Shipments of 1,987,000 tons from producing plants were also 25 percent more than in 1958. This sharp rise was especially remarkable in view of the fact that shipments to the Government of 73,000 tons were down 250,000 tons from 1958. The rate of shipping was highest in June and July, when consumers were increasing inventories in anticipation of a strike in August.

TABLE 3.—Production and shipments of primary aluminum in the United States,[1] in short tons

Quarter	1958		1959	
	Production	Shipments	Production	Shipments
First	395,909	377,052	456,005	442,914
Second	366,652	388,555	486,393	556,958
Third	369,896	413,718	520,216	499,763
Fourth	433,100	411,653	490,561	487,832
Total	1,565,557	1,590,978	1,953,175	1,987,467

[1] Quarterly production and shipments adjusted to final annual totals.

TABLE 4.—Primary-aluminum productive capacity in the United States

(Short tons per year)

Company and plant	End of 1959	Being built in 1959	Total
Aluminum Co. of America:			
Alcoa, Tenn	157,100		157,100
Badin, N.C	47,150		47,150
Massena, N.Y	118,000	32,000	150,000
Point Comfort, Tex	120,000	20,000	140,000
Rockdale, Tex	150,000		150,000
Vancouver, Wash	97,500		97,500
Wenatchee, Wash	108,500		108,500
Evansville, Ind		150,000	150,000
Total	798,250	202,000	1,000,250
Reynolds Metals Co.:			
Arkadelphia, Ark	55,000		55,000
Jones Mills, Ark	109,000		109,000
Listerhill, Ala	190,000		190,000
Longview, Wash	60,500		60,500
San Patricio, Tex	95,000		95,000
Troutdale, Oreg	91,500		91,500
Massena, N.Y	[1] 100,000		100,000
Total	701,000		701,000
Kaiser Aluminum & Chemical Corp.:			
Chalmette, La	247,500		247,500
Mead, Wash	176,000		176,000
Tacoma, Wash	41,000		41,000
Ravenswood, W. Va	145,000		145,000
Total	609,500		609,500
Anaconda Aluminum Co.: Columbia Falls, Mont	60,000		60,000
Harvey Aluminum, Inc.: The Dalles, Oreg	54,000		54,000
Ormet Corp.: Clarington, Ohio	180,000		180,000
Grand total	2,402,750	202,000	2,604,750

[1] At end of 1959 the plant was complete, but only 1 potline of 33,300-ton capacity was operating.

During the year new primary aluminum production facilities were activated by three companies. In January Ormet Corp. started the fifth and last line at its 180,000-ton-annual-capacity plant at Clarington, Ohio. Kaiser activated a new potline in May and one in June to complete its 145,000-ton, four-line reduction plant at Ravenswood, W. Va. The first of three 33,300-ton lines at Reynolds Metals Co.'s new reduction facility at Massena, N.Y., was started in July. The remaining two lines were completed by the end of the year but were not placed in operation.

By December 31 Alcoa was the only company with new facilities under construction. The largest of these, a plant near Evansville, Ind., will have a capacity of 150,000 tons a year and was scheduled to begin production from one line in July 1960. Construction of a new 20,000-ton potline at Point Comfort, Tex., was completed but the line was not placed in operation.

Domestic primary aluminum capacity at the beginning of the year was 2.2 million tons, increased to 2.4 million tons by yearend, and upon completion of new facilities was to total 2.6 million tons.

U.S. capacity to produce superpurity aluminum (99.99 percent or higher) was increased during the year. Kaiser, with the addition of two refining cells at its Mead, Wash., plant, increased capacity from 150 to 425 tons per year. Aluminum Foils, Inc., Jackson, Tenn., operated a refining plant with 10 cells and a capacity of 725 tons per year. An addition of 16 cells was to increase the plant's capacity to approximately 1,800 tons per year.[3] The third and only other known producer of superpurity aluminum in the United States was Reynolds, with six cells having a total capacity of 270 tons a year at its Listerhill, Ala., plant.

Kaiser began constructing a plant at Purvis, Miss., for calcining petroleum coke. The coke is to be used in manufacturing carbon electrodes for the company's reduction plants. The plant, reported to cost about $500,000, was to have a capacity of 70,000 tons of coke per year.

Alcoa's research, product development, promotion, and sales activities were described.[4]

The Anaconda Co. combined its aluminum operations into a single operation, Anaconda Aluminum Co. The new company has a primary reduction plant in Montana, an experimental pilot plant for producing alumina, and plants making semifabricated shapes in Kentucky and Indiana.[5]

The most significant trend during the year was the increase in foreign activity of the three principal U.S. producers. This activity, involving all aspects of the aluminum industry from bauxite production through fabrication, is discussed in detail in the world review section.

Labor contracts of the four major producers in the United States expired on July 31, but the companies and unions extended the agreements pending settlement of the steel strike. However, when the steel strike had not ended by December, negotiations were reopened. A new contract was signed retroactive to August 1, and reportedly included a raise of 28 to 30 cents an hour graduated over a 3-year period.

---

[3] Modern Metals, With Super-Pure Aluminum: Vol. 16, No. 3, April 1960, pp. 62, 64, 66.
[4] Modern Metals, A Billion Dollar Baby: Vol. 15, No. 5, June 1959, pp. 30–68.
[5] Steel, Anaconda Aluminum Bows In: Vol. 144, No. 11, Mar. 16, 1959, pp. 64–65.

SECONDARY

According to reports to the Bureau of Mines, domestic recovery of aluminum alloys (including all constituents) from 476,000 tons of nonferrous scrap totaled 387,000 tons, only 1,000 tons below the record recovery of 1957. The Bureau estimates that the reports represent approximately 85 percent of the total scrap consumption. The value of the 360,000 tons of recovered aluminum (excluding alloying ingredients) was $176 million computed from the average value of primary aluminum pig of 24.46 cents per pound.

Aluminum-alloy ingot production totaled 341,000 tons, 41 percent more than was reported in 1958. Data on remelt ingots exclude the alloys made from purchased scrap by the primary producers. Shipments of many casting alloys increased sharply in 1959. Shipments of AXS 679 rose 47 percent to 129,000 tons, and alloys in the miscellaneous category nearly doubled to 28,000 tons. Increases in shipments of pure Al (97.0 percent), No. 319 alloy and variations, and of deoxidizing alloys ranged from 7,800 to 8,800 tons.

It was predicted that the total recovery of aluminum from scrap would reach 668,000 tons by 1965 and that old scrap would supply 30 percent. In 1959 old scrap was the source of only 22 percent of the aluminum recovered. In 1970 an estimated 880,000 tons will be recovered from all scrap; an estimated percent will come from old scrap. As supplies of old scrap grow, the relative proportion of secondary aluminum recovered from such scrap will increase, until by 1985, old scrap will account for an estimated 52 percent of the 1,780,000 tons of aluminum to be recovered from scrap.[6]

In April, American Smelting & Refining Co. (ASARCO) placed a new secondary-aluminum smelter in operation at Alton, Ill. The plant has an annual capacity of 36,000 tons of alloys and is reported to be the largest single unit built specifically for converting aluminum scrap into alloy ingot. Melting facilities comprise four 40-ton and

TABLE 5.—Aluminum recovered from scrap processed in the United States, by kind of scrap and form of recovery, in short tons

Kind of scrap	1958	1959	Form of recovery	1958	1959
New scrap:					
Aluminum-base	[1] 224,983	[2] 281,315	As metal	7,924	16,079
Copper-base	64	52	Aluminum alloys	277,197	338,933
Zinc-base	240	249	In brass and bronze	217	166
Magnesium-base	141	200	In zinc-base alloys	2,001	2,279
Total	225,428	281,816	In magnesium alloys	242	329
			In chemical compounds	1,974	2,134
Old scrap:			Total	289,555	359,920
Aluminum-base	[1] 62,995	[2] 76,911			
Copper-base	105	136			
Zinc-base	653	677			
Magnesium-base	374	380			
Total	64,127	78,104			
Grand total	289,555	359,920			

[1] Aluminum alloys recovered from aluminum-base scrap in 1958, including all constituents, amounted to 238,985 tons from new scrap and 71,240 tons from old scrap; total, 310,225 tons.

[2] Aluminum alloys recovered from aluminum-base scrap in 1959, including all constituents, amounted to 299,872 tons from new scrap and 87,063 tons from old scrap; total, 386,935 tons.

---

[6] Burton, Carl, Tough Problems Peril Aluminum Scrap's Bright Future: Modern Metals, vol. 15, No. 11, December 1959, pp. 42, 44, 46.

one 15-ton gas-fired reverberatory furnaces. The plant has equipment for removing fumes from furnace exhaust gases. ASARCO operates two other smelting plants, one at Perth Amboy, N.Y., and one at Los Angeles, Calif.[7]

Subject to working out details, the leading Canadian producer, Aluminium Ltd., was authorized by the boards of directors of the two companies to purchase the assets of Apex Smelting Co., which produces foundry alloys from scrap and primary aluminum at plants in Chicago, Cleveland, and Los Angeles.

TABLE 6.—Stocks and consumption of new and old aluminum scrap in the United States in 1959 [1]

(Gross weight in short tons)

Class of consumer and type of scrap	Stocks, beginning of year [2]	Receipts	Consumption			Stocks, end of year
			New scrap	Old scrap	Total	
Secondary smelters: [3]						
Segregated 2S and 3S sheet and clips, less than 1.0 percent Cu	859	16,686	16,333	----------	16,333	1,212
Segregated 51S, 52S, 61S, etc., sheet and clips, less than 1.0 percent Cu	548	16,028	15,623	----------	15,623	953
Segregated 14S, 17S, 24S, 25S, etc., sheet and clips, more than 1.0 percent Cu	2,070	24,796	25,278	----------	25,278	1,588
Mixed alloy sheet and clips	3,534	56,865	50,781	5,802	56,583	3,816
Cast scrap	291	9,040	8,823	----------	8,823	508
Borings and turnings	2,670	85,716	84,253	----------	84,253	4,133
Dross and skimmings	3,492	62,548	59,462	----------	59,462	6,578
Foil	155	3,393	3,293	----------	3,293	255
Wire and cable	215	1,770	----------	1,745	1,745	240
Pots and pans	543	16,907	----------	17,005	17,005	445
Aircraft	613	9,145	----------	9,299	9,299	459
Castings and forgings	1,203	26,228	----------	26,496	26,496	935
Pistons	201	4,630	----------	4,683	4,683	148
Irony aluminum	1,097	15,802	----------	15,665	15,665	1,234
Miscellaneous	3,182	40,848	10,757	29,208	39,965	4,065
Total	20,673	390,402	274,603	109,903	384,506	26,569
Primary producers and fabricators:						
Segregated 2S and 3S sheet and clips, less than 1.0 percent Cu	591	15,511	15,588	----------	15,588	514
Segregated 51S, 52S, 61S, etc., sheet and clips, less than 1.0 percent Cu	1,446	18,973	20,054	----------	20,054	365
Segregated 14S, 17S, 24S, 25S, etc., sheet and clips, more than 1.0 percent Cu	184	4,288	4,333	----------	4,333	139
Mixed alloy sheet and clips	302	5,924	5,777	----------	5,777	449
Cast scrap	1	542	538	----------	538	5
Borings and turnings	53	1,191	1,190	----------	1,190	54
Dross and skimmings	1	583	540	----------	540	44
Foil	295	7,976	7,695	----------	7,695	576
Wire and cable	13	101	----------	113	113	1
Castings and forgings	4	142	----------	134	134	12
Miscellaneous	452	7,166	6,954	1	6,955	663
Total	3,342	62,397	62,669	248	62,917	2,822

See footnotes at end of table.

---

[7] Modern Metals, Big Smelter at Alton Now Producing Aluminum Ingot: Vol. 15, No. 3, April 1959, p. 54.

TABLE 6.—Stock and consumption of new and old aluminum scrap in the United States in 1959—Continued

Class of consumer and type of scrap	Stocks, beginning of year [2]	Receipts	Consumption			Stocks, end of year
			New scrap	Old scrap	Total	
Foundries and miscellaneous manufacturers:						
Segregated 2S and 3S sheet and clips, less than 1.0 percent Cu	170	7,775	7,036		7,036	909
Segregated 51S, 52S, 61S, etc., sheet and clips, less than 1.0 percent Cu		726	726		726	
Segregated 14S, 17S, 24S, 25S, etc., sheet and clips, more than 1.0 percent Cu	64	468	475		475	57
Mixed alloy sheet and clips	278	4,726	4,861	28	4,889	115
Cast scrap	773	6,259	6,464		6,464	568
Borings and turnings	366	1,226	1,589		1,589	3
Dross and skimmings	47	18	60		60	5
Foil		1	1		1	
Wire and cable		16		15	15	1
Pots and pans	356	129		407	407	78
Aircraft	2	33		28	28	7
Castings and forgings	90	931		945	945	76
Pistons	7	224		218	218	13
Irony aluminum	3	17		20	20	
Miscellaneous	230	1,693	1,218	162	1,380	543
Total	2,386	24,242	22,430	1,823	24,253	2,375
Chemical plants:						
Borings and turnings	2	5	7		7	
Dross and skimmings	718	4,087	4,038		4,038	767
Foil	134	18	99		99	53
Miscellaneous	81	133	138	6	144	70
Total	935	4,243	4,282	6	4,288	890
Grand total of all scrap consumed:						
Segregated 2S and 3S sheet and clips, less than 1.0 percent Cu	1,620	39,972	38,957		38,957	2,635
Segregated 51S, 52S, 61S, etc., sheet and clips, less than 1.0 percent Cu	1,994	35,727	36,403		36,403	1,318
Segregated 14S, 17S, 24S, 25S, etc., sheet and clips, more than 1.0 percent Cu	2,318	29,552	30,086		30,086	1,784
Mixed alloy sheet and clips	4,114	67,515	61,419	5,830	67,249	4,380
Cast scrap	1,065	15,841	15,825		15,825	1,081
Borings and turnings	3,091	88,138	87,039		87,039	4,190
Dross and skimmings	4,258	67,236	64,100		64,100	7,394
Foil	584	11,388	11,088		11,088	884
Wire and cable	228	1,887		1,873	1,873	242
Pots and pans	899	17,036		17,412	17,412	523
Aircraft	615	9,178		9,327	9,327	466
Castings and forgings	1,297	27,301		27,575	27,575	1,023
Pistons	208	4,854		4,901	4,901	161
Irony aluminum	1,100	15,819		15,685	15,685	1,234
Miscellaneous	3,945	49,840	19,067	29,377	48,444	5,341
Total	27,336	481,284	363,984	111,980	475,964	32,656

---

[1] Includes imported scrap.
[2] Revised figure.
[3] Excludes secondary smelters owned by primary aluminum companies.

TABLE 7.—Production and shipments of secondary aluminum ingot by independent smelters and recovery of metal from aluminum scrap [1]

(Gross weight in short tons)

Product	1958		1959	
	Production [2]	Shipments [3]	Production [2]	Shipments [3]
Secondary-aluminum ingot: [4]				
Pure aluminum (Al min., 97.0 percent)	7,924	7,586	16,079	16,336
Aluminum-silicon (maximum Cu, 0.6 percent)	25,129	24,624	28,566	28,169
Aluminum-silicon (Cu, 0.6 to 2 percent)	6,658	6,434	9,904	9,580
No. 12 and variations	5,421	5,463	5,844	5,818
Aluminum-copper (maximum Si, 1.5 percent)	1,529	1,384	1,649	1,659
No. 319 and variations	35,016	34,735	43,877	43,263
AXS 679 and variations	87,652	87,778	129,835	128,914
Aluminum-silicon-copper-nickel	16,828	17,314	23,101	22,860
Deoxidizing and other destructive uses [5]	24,190	24,470	33,617	32,245
Aluminum-base hardeners	7,714	7,589	9,847	9,873
Aluminum-magnesium	2,696	2,610	2,944	2,794
Aluminum-zinc	6,034	6,280	6,803	6,683
Miscellaneous	14,611	14,811	28,444	27,827
Total	241,402	241,078	340,510	336,021
Secondary-aluminum alloys recovered by primary producers and independent fabricators	74,109		59,689	
Secondary-aluminum-alloy castings	17,003		22,542	
Secondary-aluminum in chemicals	[6] 1,974		2,134	

[1] Includes companies and military establishments producing aluminum "remelt" or "scrap pig."
[2] No allowance was made for consumption by producing plants.
[3] No allowance was made for receipts by producing plants.
[4] Gross weight, including copper, silicon, and other alloying elements, at independent secondary smelters; total secondary aluminum and aluminum-alloy ingot contained 12,725 tons primary aluminum in 1958 and 15,024 tons in 1959.
[5] Uses which consume the metal in such way as to preclude future recovery.
[6] Revised figure.

CONSUMPTION AND USES

The total apparent consumption of aluminum, including domestic primary metal, net imports of crude, semicrude, and scrap, and recovery from scrap, increased almost 20 percent over 1958. Shipment of primary metal and recovery of aluminum from scrap increased, but net imports declined sharply. As shipments to the Government in 1959 were only 73,200 tons, compared with 323,100 tons in 1958, the increase in industrial consumption probably was even greater than the increase in apparent consumption.

Net shipments of wrought and cast aluminum products by producers gained 29 percent over 1958. Of these shipments, wrought products accounted for 81 percent, virtually the same proportion as in 1958. Plate, sheet, and foil represented 52 percent of the total wrought products shipped and die castings 47 percent of all cast aluminum shipped.

TABLE 8.—Apparent consumption of aluminum in the United States, in short tons

Year	Primary sold or used by producers [1]	Imports (net) [2]	Recovery from old scrap [3]	Recovery from new scrap [3]	Total apparent consumption
1950–54 (average)	1,042,674	209,691	72,629	227,652	1,552,646
1955	1,571,845	203,385	76,372	259,622	2,111,224
1956	1,591,478	196,277	71,673	268,095	2,127,523
1957	1,579,063	195,644	72,459	289,360	2,136,526
1958	1,590,978	[4] 211,619	64,127	225,428	[4] 2,092,152
1959	1,987,467	139,455	78,104	281,816	2,486,842

[1] Includes shipments to the Government: 1957, 324,311 tons; 1958, 323,128 tons; 1959, 73,235 tons.

[2] Crude and semicrude. Includes ingot equivalent of scrap imports and exports (weight × 0.9).

[3] The 1950–53 data are recoverable aluminum-alloy content; data for subsequent years are recoverable aluminum content.

[4] Revised figure.

TABLE 9.—Net shipments[1] of aluminum wrought and cast products by producers, in short tons

[Bureau of the Census]

	1958	1959		1958	1959
Wrought products:			Castings:		
Plate, sheet, and foil	[2] 676,540	884,214	Sand	[2] 62,744	70,994
Rolled structural shapes, rod, bar, and wire	[2] 172,858	223,139	Permanent mold	[2] 112,046	137,428
Extruded shapes, rod, bar, tube blooms, and tubing	[2] 410,931	540,943	Die	[2] 145,137	184,050
Powder, flake, and paste	12,814	17,442	Other	(3)	(3)
Forgings	[2] 25,415	26,926	Total	[2] 320,850	393,200
Total	[2] 1,298,558	1,692,664	Grand total	[2] 1,619,408	2,085,864

[1] Net shipments are total shipments less shipments to other metal mills for further fabrication.

[2] Revised figure.

[3] Figure withheld because estimates did not meet publication standards of the Bureau of the Census because of the associated standard error.

The Aluminum Association survey compared the percentage distribution of aluminum end uses for selected periods from 1957 through 1959. The largest part of wrought products, 23.3 percent in 1959, went to the building-materials industry. The transportation equipment industry used 13.4 percent, manufacturers of containers and packaging used 9.7 percent, and the electrical equipment industry used 9.2 percent of the total wrought-product shipments. Members of the Aluminum Foundry Division of The Aluminum Association shipped 59.5 percent of their permanent mold castings to motor-vehicle industries (other than military) and 36.6 percent of their sand castings to industrial and commercial machines, equipment, and tool manufacturers.[8]

---

[8] American Metal Market, The Aluminum Association End-Use Statistics on Aluminum Wrought Products: Vol. 67, No. 85, May 4, 1960, p. 10; The Aluminum Association End-Use Statistics on Aluminum Sand Castings: P. 10; The Aluminum Association End-Use Statistics on Aluminum Permanent Mold Castings: P. 10.

The following distribution for wrought products was obtained from the figures published by the Bureau of the Census:

	Percent 1958	Percent 1959
Plate, sheet, and foil:		
Non-heat-treatable	36.4	37.9
Heat-treatable	8.0	6.8
Foil	7.7	7.5
Rolled rod, bar, and wire:		
Rod, bar, etc.[1]	2.9	3.7
Bare wire, conductor and nonconductor	1.7	1.9
Cable, bare (including steel-reinforced)	6.7	5.8
Wire and cable, covered or insulated	2.0	1.8
Extruded shapes:		
Alloys other than 2000 and 7000 series	[2] 26.7	27.5
Alloys in 2000 and 7000 series	[3] 1.9	1.4
Tubing:		
Drawn, soft and hard alloys	2.3	2.2
Welded tube, non-heat-treatable[4]	.7	.9
Powder, flake, and paste:		
Atomized	.3	.3
Flaked	.1	.2
Paste	.6	.5
Forgings (including impact extrusions)	2.0	1.6
	100.0	100.0

[1] Includes small amount of rolled structural shapes.
[2] Soft alloys; includes 1100, 3003, 5052, 6061, 6062, and 6063 series.
[3] Hard alloys; includes all alloys not listed in footnote 2.
[4] Includes small amount of heat-treatable welded tube.

Widespread acceptance by the consumer of the 1960 Corvair, the first car built in the United States with an aluminum engine, was expected to lead to a rapid increase in the consumption of aluminum by the automotive industry. The engine, which weighs approximately 300 pounds, contains about 90 pounds of aluminum. It is a horizontally opposed six-cylinder engine, air cooled and mounted in the rear of the car. The major aluminum parts are permanent mold castings of 355–T6 alloy. The cylinders are shell-molded gray iron.[9]

The use of aluminum in other automobile parts also increased. It was reported that the average 1959 automobile contained 50 pounds of aluminum and that the average 1960 automobile contained 56 pounds. On the basis of production of 6 million cars in 1960, the automotive industry will consume an estimated 170,000 tons of aluminum.[10]

The specific uses of aluminum in automobile parts were also tabulated. It was estimated that the engine accounts for 37 percent of the consumption and the transmission for an additional 33 percent. Hardware and trim account for an estimated 15 percent.[11]

---

[9] Bond, John R., Inside the Corvair: Road and Track, vol. 11, No. 3, November 1959, pp. 22–27, 92–93.
Darby, H. K., 1960 Autos Promise Record Aluminum Consumption: Modern Metals, vol. 15, No. 12, January 1960, pp. 37–38, 42, 44, 46.
Metal Progress, Aluminum Gains in the Automotive Field: Vol. 77, No. 2, February 1960, p. 65.
Foundry, An Exploded View of the Corvair 80-hp., Horizontally Opposed, Six-Cylinder Engine: Vol. 88, No. 3, March 1960, p. 133.

[10] Light Metal Age, Aluminum in Autos—1960 Forecast: Vol. 18, Nos. 11 and 12, December 1959, pp. 26, 28:
Light Metal Age, Autos—1 Million Pounds of Aluminum Per Day: Vol. 18, Nos. 1 and 2, February 1960, pp. 28–29.

[11] James, B., Aluminum in Motor Cars: Light Metals (London), vol. 22, No. 250, January 1959, p. 30.
Iron Age, Automakers Use More Aluminum, Compact Cars Help Boost the Average in a 1960 Model: Vol. 185, No. 2, Jan. 14, 1960, p. 30.

A patent was granted National Lead Co. for a die-cast eight-cylinder aluminum engine block. It was stated that the weight of the die-cast aluminum block for a V–8 engine is 55 pounds, or 150 pounds less than a similar block made of cast iron. Earlier the company had designed a four-cylinder block and a six-cylinder block which it produced experimentally.[12]

New uses of aluminum expected in the automotive industry within 2 or 3 years were aluminum bumpers and cast-aluminum mufflers.[13]

Aluminium Ltd. and the American Association of Railroads announced that the association had given conditional approval to the use of all-aluminum welded hopper cars for interchange on U.S. railroads. It was estimated that payloads could be increased 10 to 15 percent by using aluminum instead of steel. Reynolds reported that it was to supply 9,350 tons of plate and extrusions for the manufacture of 1,205 railroad cars ordered by the Southern Railway system. Of the total, 455 were to be covered hopper cars and the remainder gondola cars.[14]

Two large British passenger ships being built, the *Oriana* and *Canberra*, 40,000 tons in gross weight and 800 feet long, each utilized more than 1,000 tons of aluminum in all-welded aluminum superstructures. Use of aluminum resulted in a saving of about 1,500 tons of structural weight.[15]

The first large-tonnage, oversea shipments of liquefied methane in aluminum tanks were made. Because a temperature of minus 260° F. is required to keep methane in a liquid state, aluminum, which has better strength, ductility, and shock resistance at low temperatures, was used for the tanks. The use of aluminum in cryogenic equipment, estimated at 1,500 tons annually, is expected to expand sharply as the production, transportation, storage, and utilization of liquefied gases increases.[16]

Use of aluminum in military and space equipment increased. The Army's new M–113 personnel carrier has 4 tons of aluminum and the M–60 tank 3½ tons. Aluminum powder in missile propellants increases the boost velocity of rockets 10 to 30 percent and the range or altitude 20 to 60 percent. It was estimated that 10 to 20 percent of the weight of the propellant was aluminum powder. The Navy's Polaris, a sea-to-air missile, is powered by an aluminized propellant.[17]

The development of new and more efficient methods of producing aluminum cans expanded markets for aluminum packaging in the oil and brewing industries and extended markets for aluminum in the food industry. A nationally known brand of frozen orange juice

---

[12] Modern Metals, Die Cast Eight-Cylinder Engine Block Patented: Vol. 15, No. 6, July 1959, p. 74.

[13] White, E. P., Next Breakthrough in Autos? Aluminum in Bumpers: Modern Metals, vol. 15, No. 7, August 1959, pp. 34, 36, 38.

Steel, Aluminum Muffler Ready: Vol. 145, No. 18, Nov. 2, 1959, p. 56.

[14] Starin, F. J., More Aluminum Freight Cars, Railroads Like the Bigger Payload They Carry: Iron Age, vol. 184, No. 5, July 30, 1959, p. 78.

[15] Light Metals (London), Oriana—The Aluminium Superstructure: Vol. 22, No. 258, November 1959, pp. 256–257.

Metal Industry (London), Aluminium in "Canberra": Vol. 95, No. 16, Nov. 27, 1959, p. 346.

[16] Steel, Aluminum Beats the Cold: Vol. 145, No. 25, Dec. 21, 1959, pp. 86–87.

Fellom, Roy, Jr., Aluminum in Cryogenics: Light Metal Age, vol. 18, Nos. 1 and 2, February 1960, pp. 6–12, 14–17.

[17] Chemical and Engineering News, Plastisol Propellant Unveiled: Vol. 37, No. 30, July 27, 1959, pp. 22–23.

Chemical Engineering, Aluminum Adds Whoosh to Propellant: Vol. 66, No. 16, Aug. 10, 1959, p. 56.

was to be packed in aluminum cans. It was estimated that 7,500 tons of aluminum was used in cans in 1959 and that 25,000 tons may be used in making about 300 million cans in 1960.[18]

The market for aluminum in electrical equipment showed significant gains during the year. Coils made from aluminum foil and insulated with paper or an anodized coating were being made experimentally in an attempt to enter a market previously dominated by copper. One company used aluminum foil instead of copper wire in producing 1 million automobile horns.[19] The use of aluminum in electrical conduits, a relatively new market for aluminum, was expected to expand.[20] Uses of aluminum in the electrical engineering field were discussed.[21]

The building and construction industry provided the largest market for aluminum in 1959. New products were expected to result in wider use of aluminum in housing. These products include aluminum duct sheet, for heating and ventilating systems priced to compete with galvanized steel, and low-cost aluminum building sheet, intended for various housing uses. The low-cost sheet, made by the primary producers, sold for 34 to 35 cents a pound, compared with 42 to 43 cents for some alloys it was designed to replace.[22]

Siding for remodeling and home improvement was the largest single use of aluminum sheet. However, it was expected that larger quantities of siding would be used in new homes, especially prefabricated ones.[23]

Primarily because of aluminum's high strength-to-weight ratio and corrosion resistance, it has many applications in mining. The use of aluminum in mining equipment was described.[24]

The capacity of plants producing superpurity aluminum was being expanded rapidly. The metal, which is refined from commercially pure aluminum by electrolysis in a three-layer cell of Hoopes type, has high corrosion resistance and electrical conductivity. In addition, it has a high luster and, when electrochemically polished and anodized, has an extremely brilliant surface. The superpure metal is used in the chemical and processing industries, in jewelry, automobile and appliance trim, and hardware. High-purity alumina

---

[18] Gotch, L. P., Eike, E. F., and Brighton, K. W., The Status of Aluminum for Food Cans: Light Metal Age, vol. 17, Nos. 3 and 4, April 1959, pp. 8–15.

Rohan, T. M., Can Market: New Aluminum Bid; Bliss Machine Makes 120 Aluminum Beer Cans Per Minute: Iron Age, vol. 184, No. 25, Dec. 17, 1959, p. 126.

American Metal Market, Can Making to Require 25,000 Tons of Aluminum for 1960: Vol. 67, No. 17, Jan. 26, 1960, p. 9.

[19] Business Week, Electrical Market for Aluminum: No. 1593, Mar. 12, 1960, pp. 92, 97.

Lee, J. J., Aluminium Foil and Strip for Electrical Windings: Elec. Rev. (London), vol. 164, No. 15, Apr. 10, 1959, pp. 667–671.

[20] Darby, H. K., Primary Producers Put Pressure Behind Aluminum Conduit Sales: Modern Metals, vol. 15, No. 9, October 1959, pp. 78, 80, 82, 84, 86.

[21] Parish, A. R., Aluminium in Electrical Engineering, Its Standing as an Alternative to Copper: Elec. Rev. (London), vol. 164, No. 9, Feb. 27, 1959, pp. 399–402.

Thomas, A. G., The Electrical Industry as a Market for Aluminium: Light Metals (London), vol. 22, No. 254, May 1959, pp. 150–153.

[22] Darby, H. K., Price Controversy Simmers as Producers Probe for New Sheet Markets: Modern Metals, vol. 15, No. 11, December 1959, pp. 68, 70, 72.

Wall Street Journal, New Alcoa Building Sheet Forces Price Cuts, Troubles Independent Processors: Vol. 154, No. 81, Oct. 22, 1959, p. 7.

[23] Engineering News-Record, Housing: Aluminum Is Moving In: Vol. 162, No. 24, June 18, 1959, p. 291.

Modern Metals, Roofing and Siding, Aluminum's Biggest Market for Sheet: Vol. 15, No. 10, November 1959, pp. 74, 76, 78, 79, 82, 84.

[24] Edmond, H. J., Aluminum Products Finding Big Market in Canadian Mines: Precambrian (Winnipeg, Canada), vol. 31, No. 12, December 1958, pp. 12–17, 20, 22–23.

is made from this metal for use as a catalyst in producing high octane gasoline.[25]

STOCKS

Inventories of primary aluminum at reduction plants on December 31, 1959, were 111,600 tons, a decrease of 24 percent or 34,400 tons from stocks on December 31, 1958. From 146,100 tons at the beginning of 1959, stocks climbed sharply to 183,800 tons at the end of February. For the next 5 months shipments exceeded production, and stocks declined to 80,400 tons at the end of July. It then appeared that there would be no strike in the industry, and with the exception of December, production for the rest of the year exceeded shipments and stocks increased. Based on December production, stocks at yearend were equivalent to 21 days' output. In addition to the primary aluminum stocks reported, reduction plants also had inventories of ingot and aluminum in process.

Stocks of secondary aluminum of 22,900 tons on December 31, 1959, were 22 percent or 4,200 tons more than at the end of 1958. The increase in stocks was due largely to a decrease in demand by the automotive industry as a result of the steel strike. Consumer's stocks of aluminum-base scrap increased 5,400 tons in 1959 to 32,700 tons. At the rate of consumption in December, stocks of scrap represented a 27-day supply.

PRICES

On January 1, 1959, the price of aluminum pig, 99.5 percent guaranteed minimum, was 24.7 cents per pound, and that of aluminum ingot, 99.5 percent plus, was 26.8 cents per pound. Under a new price policy effective July 1, primary aluminum prices included delivery. The allowance previously made if the purchaser accepted delivery of the metal at the producer's plant was discontinued. In December the price of aluminum pig and ingot was raised 1.3 cents a pound. The new prices, 26.0 cents per pound for pig and 28.1 cents for ingot, were the same as the prices in effect from August 1957 to April 1958. This was the first price change since August 1958.

Prices of smelters' alloys were increased 1/4 to 1 1/4 cents per pound in May and June. In December, after the increase in primary prices, smelters' alloy prices rose 1 1/4 cents per pound. The American Metal Market listed the following closing market prices on December 31, 1959: Alloy 195, 27.75 to 28.75 cents per pound; No. 12, 24.75 to 25.25 cents; and No. 380 (1 percent Zn), 25.00 to 26.00 cents. These prices were 2 3/4 to 3 1/4 cents per pound higher than prices at the end of 1958. The prices applied to 20,000-pound lots delivered to buyers' plants.

Scrap prices increased in May, June, and December. The closing market prices for scrap on December 31, 1959, according to the American Metal Market, were: 2S, 3S, 51S, and 52S clips, 18 to 19 cents per pound; 75S clips, 13 to 14 cents; and aluminum borings and turnings, 15 to 16 cents per pound. These prices were 1 cent to 2 cents more per pound than prices at the end of 1958.

---

[25] Modern Metals, With Super-Pure Aluminum: Vol. 16, No. 3, April 1960, pp. 62, 64, 66.

FOREIGN TRADE[26]

U.S. trade in aluminum was at a high level. Imports of 51,000 tons of plates, sheets, and bars set a record and were 81 percent above 1958. Imports of crude metal and alloys declined 6 percent from 1958. Imports of crude metal from Canada declined 22 percent to 166,400 tons, but the decline was partly offset by large increases in imports from Norway, Italy, and Austria. For the first time crude metal (9,400 tons) was imported from Africa.

Exports of crude aluminum in 1959 were exceeded only by exports in 1944. More than 45 percent of the crude metal went to the United Kingdom and the next largest part, 16 percent, to West Germany. Only in 1954 were exports of scrap more than those in 1959. The bulk of the scrap exports were shipped to West Germany, Japan, Italy and the United Kingdom.

The net import balance for crude, semifabricated, and scrap aluminum was 137,300 tons, compared with 210,700 tons in 1958.

Suspension of the 1½-cent-per-pound duty on scrap was continued in 1959. There was no export quota on aluminum scrap.

TABLE 10.—Aluminum imported for consumption in the United States, by classes

[Bureau of the Census]

Class	1958		1959	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Crude and semicrude:				
Metal and alloys, crude	255,322	$117,297	239,571	$111,259
Plates, sheets, bars, etc	[1] 27,946	[1] 20,184	50,638	34,876
Scrap	9,922	2,969	10,919	3,299
Total	[1] 293,190	[1] 140,450	301,128	149,434
Manufactures:				
Foil less than 0.006 inch thick	2,771	3,693	4,529	5,923
Folding rules	(2)	(3)	(2)	(3)
Leaf (5½ by 5½ inches)	(4)	5	(4)	13
Powder and powdered foil (aluminum bronze)	50	53	65	62
Powder in leaf (5½ by 5½ inches)	-----	-----	(5)	6
Table, kitchen, hospital utensils, etc	2,380	3,874	2,990	4,526
Other manufactures	(6)	2,718	(6)	3,831
Total	(6)	10,343	(6)	14,361
Grand total	(6)	[1] 150,793	(6)	163,795

[1] Revised figure.
[2] Number: 1958, 422; 1959, 300; equivalent weight not recorded.
[3] Less than $1,000.
[4] Leaves: 1958, 1,721,042; 1959, 5,865,141.
[5] Leaves: 84,833.
[6] Quantity not recorded.

---

[26] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 11.—Aluminum imported for consumption in the United States, by classes and countries, in short tons

[Bureau of the Census]

Country	1958			1959		
	Metal and alloys, crude	Plates, sheets, bars, etc.	Scrap	Metal and alloys, crude	Plates, sheets, bars, etc.	Scrap
North America:						
Canada	213,862	3,118	9,089	166,392	5,436	9,090
Other North America			58			264
Total	213,862	3,118	9,147	166,392	5,436	9,354
South America			28			
Europe:						
Austria	2,849	1,109		9,517	2,003	
Belgium-Luxembourg	59	[1] 9,107			14,312	28
France	11,910	[1] 2,794	364	12,335	4,432	1,019
Germany, West	2,120	[1] 2,068	176	1,705	4,345	56
Italy	773	3,892	32	7,153	5,649	17
Norway	21,782	382	17	32,568	417	
United Kingdom	12	1,779	70	95	3,741	155
Yugoslavia	1,213	654		70	1,546	
Other Europe	191	[1] 1,071	88	353	2,873	266
Total	40,909	[1] 22,856	747	63,796	39,318	1,541
Asia:						
Japan		1,972		(2)	5,779	
Other Asia	551				85	
Total	551	1,972		(2)	5,864	
Africa				9,383		
Oceania					20	24
Grand total: Short tons	255,322	[1] 27,946	9,922	239,571	50,638	10,919
Value, thousands	$117,297	[1] $20,184	$2,969	$111,259	$34,876	$3,299

[1] Revised figure.
[2] Less than 1 ton.

TABLE 12.—Aluminum exported from the United States, by classes

[Bureau of the Census]

Class	1958		1959	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Crude and semicrude:				
Ingots, slabs, and crude	52,711	$24,220	121,081	$53,518
Scrap	18,906	5,595	32,388	10,485
Plates, sheets, bars, etc	9,183	10,240	9,015	9,977
Castings and forgings	1,633	3,022	1,216	2,842
Semifabricated forms, n.e.c	37	61	120	155
Total	82,470	43,138	163,820	76,977
Manufactures:				
Foil and leaf	295	492	567	852
Powders and pastes (aluminum and aluminum bronze) (aluminum content)	331	435	415	503
Cooking, kitchen, and hospital utensils	1,192	3,017	1,162	2,873
Sash sections, frames (door and window)	1,547	2,762	1,849	2,590
Venetian blinds and parts	1,262	1,656	1,312	1,656
Wire and cable	4,374	2,540	5,308	2,690
Total	9,001	10,902	10,613	11,164
Grand total	91,471	54,040	174,433	88,141

TABLE 13.—Aluminum exported from the United States, by classes and countries, in short tons

[Bureau of the Census]

Country	1958			1959		
	Ingots, slabs, and crude	Plates, sheets, bars, etc.[1]	Scrap	Ingots, slabs, and crude	Plates, sheets, bars, etc.[1]	Scrap
North America:						
Canada	11,322	4,726	364	714	4,523	437
Cuba	52	1,326	4	87	965	4
Mexico	3,900	102	82	6,189	140	7
Other North America	19	900	114	4	886	40
Total	15,293	7,054	564	6,994	6,514	488
South America:						
Argentina	231	20		2,573	11	
Brazil	642	125		37	109	
Colombia	2,088	371	1	2,771	147	
Venezuela	62	1,136	(2)	324	1,224	1
Other South America	403	142		236	221	
Total	3,426	1,794	1	5,941	1,712	1
Europe:						
Germany, West	1,654	6	11,094	19,183	9	14,024
Italy		35	4,626	1,497	161	5,242
United Kingdom	25,986	47	408	55,066	291	3,324
Other Europe	1,240	297	148	19,591	899	912
Total	28,880	385	16,276	95,337	1,360	23,502
Asia:						
India	720	1,049	28	69	15	
Japan	88	23	2,036	5,459	20	8,341
Philippines	2,324	34		3,241	113	5
Other Asia	1,951	300	1	2,162	299	51
Total	5,083	1,406	2,065	10,931	447	8,397
Africa	29	129		151	142	
Oceania		85		1,727	176	
Grand total: Short tons	52,711	10,853	18,906	121,081	10,351	32,388
Value, thousands	$24,220	$13,323	$5,595	$53,518	$12,974	$10,485

[1] Includes plates, sheets, bars, extrusions, castings, forgings, and unclassified "semifabricated forms."
[2] Less than 1 ton.

WORLD REVIEW

World production of aluminum was estimated at 4.5 million short tons—630,000 tons or 16 percent above 1958 and nearly double the 1952 output. The increase continued the upward trend begun in 1947. U.S. production accounted for a large part of the increase. Other countries showing substantial gains were Austria, West Germany, Hungary, Italy, Norway, U.S.S.R., China, India, Japan, Cameroun, and Australia.

During the year the four largest producers of primary aluminum in the United States were expanding their foreign interests. The most significant of the new or expanded operations, by company and country, were: Alcoa—Japan, Mexico, Surinam, United Kingdom, and Venezuela; Kaiser—Argentina, India, and Spain; Reynolds—United Kingdom; and Olin-Mathieson—Guinea. All four companies were jointly interested in Ghana. More detailed information is included under the individual countries in the following sections.

Table 14 includes information on the capacity, location, and ownership of plants producing aluminum throughout the world. The data are based on companies' annual reports, consular dispatches, newspaper and journal articles, and communications to the Bureau of Mines.

TABLE 14.—Producers of aluminum

(Short tons)

A. FREE WORLD

Country, company, and plant locations	Annual capacity, 1959	Participants
North America: Canada:		
Aluminum Co. of Canada, Ltd:		Subsidiary of Aluminium, Ltd. (Canadian).
Arvida	373,000	
Shawinigan Falls	70,000	
Isle Maligne	115,000	
Kitimat	192,000	
Chryslum, Ltd.: Beauharnois	38,000	Aluminum Co. of Canada, Ltd., and Chrysler Corp. of Canada.
Canadian British Aluminium Co. Ltd.: Baie Comeau.	90,000	Subsidiary of British Aluminium Co., Ltd.
United States total[1]	2,402,800	
Total North America	3,280,800	
South America: Brazil:		
Electro-Quimica Brasileira, S.A.: Ouro Preto (Minas Gerais).	9,700	Subsidiary of Aluminium Ltd. (Canadian).
Companhia Brasileira do Aluminio: Sao Paulo	11,000	Industrias Votorantim, S.A. (80 percent and other Brazilian interests 20 percent).
Total South America	20,700	
Europe:		
Austria:		
Salzburger Aluminium G.m.b.H.: Lend	10,000	Subsidiary of Aluminium-Industrie A.G. (AIAG), Swiss.
Vereinigte Aluminiumwerke A.G.: Ranshofen.	74,000	Government-owned.
Total	84,000	
France:		
Pechiney, Cie de Produits Chimique et Electrometallurgiques.	------------	Privately owned (French).
Chedde (Haute Savoie)	5,600	
La Praz (Savoie)	3,000	
La Saussaz (Savoie)	9,500	
St. Jean de Maurienne (Savoie)	73,300	
L'Argentiere (Hautes-Alpes)	17,500	
Riouperoux (Isere)	11,700	
Auzat (Ariege)	18,000	
Sabart (Ariege)	17,600	
Soc. d'Electro-Chimie, d'Electro-Metallurgie et des Acieries Electriques d'Ugine:		Do.
Les Clavaux (Isere)	[2] 3,900	
Venthon (Savoie)	17,600	
Lannemezan (Hautes-Pyrennes)	11,600	
Total	189,300	
Germany, West:		
Aluminium G.m.b.H.: Rheinfelden (Baden)	49,500	Subsidiary of Swiss AIAG.
Vereinigte Aluminiumwerke A.G:		Government-owned.
Erftwerk, Grevenbroich	31,000	
Innwerk, Toging	58,300	
Lippewerke, Lunen	42,000	
Total	180,800	

See footnotes at end of table.

TABLE 14.—Producers of aluminum—Continued

(Short tons)

A. FREE WORLD—Continued

Country, company, and plant locations	Annual capacity, 1959	Participants
Europe—Continued		
Italy:		
"Montecatini," Soc. Generale per l'Industria Mineraria e Chimica:		Privately owned (Italian).
Mori	13,200	
Bolzano	42,400	
Soc. Alluminio Veneto per Azioni (SAVA): Porto Marghera.	30,000	Subsidiary of Swiss AIAG.
Soc. dell [1] Alluminio Italiano (SAI): Borgofranco, d'Ivrea.	6,100	Subsidiary of Aluminium Ltd. (Canadian).
Total	91,700	
Norway:		
Aardal og Sunndal Verk A/S:		Government-owned.
Aardal	69,600	
Sunndalsora	55,000	
Det Norske Nitrid A/S:		Aluminium Ltd. (Canadian) 50 percent and British Aluminium Co. 50 percent.
Eydehavn	10,200	
Tyssedal	19,300	
Norsk Aluminium A/S: Hoyanger	14,700	Aluminium Ltd. (Canadian) 50 percent and privately owned (Norwegian) 50 percent.
Mosjøen Aluminium A/S: Mosjøen	27,500	Swiss AIAG 33⅓ percent and A/C Elektrochemisk (Norwegian) 66⅔ percent.
Total	196,300	
Spain:		
Empresa Nacional del Aluminio, S.A:		Spanish companies with majority government participation.
Valladolid	12,100	
Aviles	8,200	
Aluminio Espanol, S.A.: Sabinanigo (Huesca).	6,600	Pechiney (French) 85 percent and Kaiser Aluminum & Chemical Corp. 15 percent.
Total	26,900	
Sweden: A/B Svenska Aluminiumkompaniet:		Privately owned (Swedish) 50 percent and Aluminium Ltd. (Canadian) 50 percent.
Mansbo	2,400	
Kubikenborg	14,300	
Total	16,700	
Switzerland:		
Aluminium Industrie A.G. (AIAG): Chippis.	30,800	Privately owned (Swiss).
Usine d'Aluminium de Martigny S.A.: Martigny.	5,500	Do.
Total	36,300	
United Kingdom: British Aluminium Co., Ltd:		Tube Investments Ltd. (British) 47 percent, Reynolds Metals Co. (American) 45 percent, Reynolds Tube Investments Ltd., 4 percent, and miscellaneous shareholders 4 percent.
Kinlochleven	11,200	
Lochaber	28,000	
Total	39,200	
Yugoslavia: State Concerns:		Government-owned.
Razine	4,500	
Lozovac	4,000	
Strnisce (Kidricevo)	33,000	
Total	41,500	
Total Free Europe	902,700	
Asia: Formosa (Taiwan): Taiwan Aluminum Corp.: Takao.	10,000	Government-owned.
India:		
Aluminium Corp. of India, Ltd.: Asansol	2,800	Privately owned (Indian).
Indian Aluminium Co., Ltd.:		Aluminium, Ltd. (Canadian) 65 percent and Indian-owned 35 percent.
Alwaye	6,700	
Hirakud	11,200	
Total	20,700	

See footnotes at end of table.

TABLE 14.—Producers of aluminum—Continued

(Short tons)

A. FREE WORLD—Continued

Country, company, and plant locations	Annual capacity, 1959	Participants
Asia—Continued		
Japan:		
Showa Denko K.K. (Showa Electro-Chemical Industry Co., Ltd.):		Privately owned (Japanese).
Kitikata	21,000	
Omachi	12,000	
Nihon Keikinzoku K.K. (Japan Light Metals Co.):		Aluminium Ltd. (Canadian) 50 percent, and privately owned (Japanese) 50 percent.
Kambara	43,000	
Niigata	25,000	
Sumitomo Kagaku K.K. (Sumitomo Chemical Co., Ltd.): Kikumoto.	26,000	Privately owned (Japanese).
Total	127,000	
Total Asia	157,700	
Africa: Cameroun: Cie. Camerounaise de l'Aluminium Pechiney-Ugine (ALUCAM): Edea.	49,500	Pechiney-Ugine (French), Caisse Centrale de la France D'Outremer (French), and Cameroun Government.
Oceania: Australia: Australian Aluminium Production Commission: Bell Bay, Tasmania.	14,500	Government-owned.
Total Oceania	14,500	
Total Free World	4,425,900	
B. SOVIET BLOC[3]		
U.S.S.R.:		
Soviet Aluminum Trust	------------	Government-owned.
Kamensk-Uralskiy	132,000	
Kandalakaha	27,500	
Krasnotourinsk-Bogoslovsk	137,500	
Stalinsk	132,000	
Volkhov	49,500	
Yerevan (Erivan)	27,500	
Zaporozhye (Dneprovskiy)	110,000	
Sumgait	77,000	
Nadvoitsy	22,000	
Stalingrad	88,000	
Total U.S.S.R.	803,000	
Czechoslovakia: Svaty Kriz	55,000	Do.
Germany, East: Elektrochemisches Kombinat: Bitterfeld.	38,500	Do.
Hungary:		
Magyarsoviet Bauxit Ipar	------------	Do.
Felsogalla-Totis	16,500	
Ajka	16,500	
Inota	33,000	
Total	66,000	
Poland: Shawine Aluminium Works	38,500	Do.
Rumania	11,000	Do.
China: Nationalized plants	77,600	Do.
North Korea	(4)	
Total Soviet bloc	1,089,600	
Total World	5,515,500	

---

[1] For breakdown of companies and plants, see table 4 of this chapter.
[2] Will not produce aluminum ingot after Dec. 31, 1959.
[3] In a number of instances it was impossible to confirm the data on plants of the Soviet bloc.
[4] Data not available.

Data were reported on the consumption of aluminum in 1958 by end uses in the 10 countries of the Organisation for European Economic Cooperation. The major consuming countries were: United Kingdom, 294,000 short tons; West Germany, 277,000 tons; France, 198,000 tons; and Italy, 104,000 tons. Industries consuming the largest quantities of aluminum were: Transportation equipment, 291,000 tons; electrical equipment, 118,000 tons; mechanical equipment, 105,000 tons and packaging materials, 103,000 tons.[27]

TABLE 15.—World production of aluminum, by countries, in short tons[1]

[Compiled by Pearl J. Thompson and Berenice B. Mitchell]

Country [2]	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada	490,015	612,543	620,321	556,715	634,102	598,500
United States	1,041,082	1,565,721	1,678,954	1,647,709	1,565,557	1,953,175
Total	1,531,097	2,178,264	2,299,275	2,204,424	2,199,659	2,551,675
South America: Brazil	[3] 1,143	1,834	6,920	9,794	13,102	[4] 13,200
Europe:						
Austria	38,044	63,051	65,490	62,125	62,716	72,271
Czechoslovakia	[5] 9,976	26,900	23,400	18,400	29,100	[4] 33,000
France	108,085	142,191	165,125	176,603	186,415	190,744
Germany:						
East	10,523	29,100	37,800	[4] 38,100	[4] 37,500	[4] 38,600
West	96,694	151,089	162,439	169,576	150,756	166,631
Hungary	27,100	40,740	38,375	27,650	43,560	50,400
Italy	54,244	68,010	70,225	72,981	70,603	82,658
Norway	57,957	79,102	101,349	105,430	139,201	159,671
Poland	[6] 5,732	22,500	24,000	22,500	24,700	25,100
Rumania [4]	----------	6,200	8,800	11,000	11,200	11,000
Spain	4,174	3,466	14,283	16,721	17,769	[4] 23,300
Sweden (includes alloys)	8,669	11,063	13,734	14,958	15,113	15,102
Switzerland	28,219	33,312	33,180	34,238	34,723	37,886
U.S.S.R.[4]	281,000	475,000	500,000	550,000	605,000	715,000
United Kingdom	33,089	27,378	30,892	32,933	29,517	27,381
Yugoslavia	3,000	12,675	16,162	19,989	23,899	21,214
Total [4]	767,000	1,190,000	1,305,000	1,375,000	1,480,000	1,670,000
Asia:						
China (Manchuria) [4]	[6] 3,300	11,000	11,000	22,000	29,800	77,600
India	4,395	8,091	7,281	8,718	9,167	19,131
Japan	44,738	63,392	72,754	74,934	93,231	109,394
Taiwan	4,549	7,717	9,655	9,104	9,455	8,251
Total [2] [4]	57,000	90,200	100,700	114,800	141,700	214,400
Africa: Cameroun	----------	----------	----------	8,300	35,121	46,644
Oceania: Australia	----------	1,398	10,240	11,899	12,196	14,392
World total (estimate) [1] [2]	2,356,000	3,460,000	3,720,000	3,725,000	3,880,000	4,510,000

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] In addition to countries listed, North Korea produced a negligible quantity of aluminum.
[3] Average for 1951–54.
[4] Estimate.
[5] Average for 1953–54.
[6] Average for 1 year only as 1954 was the first year of commercial production.

NORTH AMERICA

Canada.—Aluminum Company of Canada, Ltd. (Alcan), reduced operations to 66 percent of capacity during the first half of 1959 but

---

[27] Organisation for European Economic Cooperation, Non-Ferrous Metals Statistics, Production, Consumption, Foreign Trade Breakdown of Uses—1958, Trend in 1959: Addendum to Statistical Survey on Non-Ferrous Metals Industry in 1958, pt. 2, Aluminium, First Statistical Survey of Breakdown of Consumption by End-Uses in Europe, October 1959, 4 pp.

increased production as demand for aluminum increased in the latter part of the year.

In June, Chryslum, Ltd., was formed by Aluminum Co. of Canada, Ltd., and Chrysler Corp. of Canada to produce and supply aluminum alloys for Chrysler automobile plants in Canada and the United States. The new company leased the Beauharnois, Quebec, smelter, which has a capacity of 38,000 tons. Alcan will continue to operate the smelter for Chryslum.

The first generator of the new hydroelectric station on the Peribonca River went on power in September and the fifth generator in March 1960, thus completing a 10-year program for constructing hydroelectric facilities to produce aluminum and, which more than doubled generating capacity from 2,040,000 to 4,650,000 horsepower.

On December 15 the price of aluminum in non-American markets was raised from 22.5 to 23.25 cents, and on December 18 the price of aluminum for sale in the American market was raised from 24.7 to 26 cents.

Mexico.—Aluminio, S.A., was formed by Intercontinental, S.A., and Alcoa to finance, construct, and operate Mexico's first primary aluminum smelting plant. The plant, with a planned capacity of 22,000 tons of aluminum per year, was to be built in the State of Veracruz. Alcoa will have a 35-percent interest in the company; Intercontinental, S.A., and associates, 55 percent; and European investors, 10 percent. Final execution of the plan depended upon satisfactory completion of studies that were underway at yearend.

SOUTH AMERICA

Argentina.—Kaiser joined a manufacturer of nonferrous metal products in establishing a new corporation for manufacturing aluminum mill products.

Brazil.—A new aluminum plant with an estimated capacity of 11,000 tons was under construction at Cachoeira da Fumaca. The plant is scheduled for completion by 1962. Capacity of the Companiha Brasileria do Aluminio plant at São Paulo was increased to 11,000 tons during the year, bringing the total capacity in Brazil to 20,700 tons.

Surinam.—Alcoa reported that progress had been made on the Brokopondo hydroelectric and smelting plant. Camps, offices, and shops were built, and work on a 45-mile road was more than half completed. Construction of a dam, powerhouse, and smelter was to start in the summer of 1960.

Venezuela.—Venezuelan interests, Alcoa, and Montecatini-Società Generale per l'Industria Mineraria e Chimica Anonima, of Italy, invested jointly in a new company for producing aluminum extrusions and tubing in Venezuela.

EUROPE

France.—Aluminum production reached an alltime high of 190,700 tons. Two plants under construction in the Lacq area of southwestern France were nearing completion and were expected to be in production early in 1960. The new plants were to add 80,000 tons to the country's annual capacity.

Germany, East.—The first section of the Lauta aluminum plant being built under the 7-year plan was scheduled to be completed in 1962. By 1964 the plant was to be producing at full capacity of 22,000 tons. The original Lauta plant of Vereinigte Aluminiumwerke, A.G., was dismantled after World War II, and some of the equipment was used by the Russians to build a plant at Krasno-Turinsk in the Urals.

Germany, West.—Although primary aluminum output rose 11 percent, domestic supplies were insufficient to meet requirements and 82,990 short tons of aluminum was imported. The duty-free import quota was 44,000 tons in 1959.

Italy.—Primary aluminum production in Italy reached a peak of 82,700 tons—17 percent above 1958.

An article describing the Italian aluminum industry discussed bauxite supplies, alumina and aluminum productive capacity, primary and secondary aluminum productive capacity, the semifabricating industry, and consumption.[28]

Norway.—Production of primary aluminum continued its upward trend and reached an alltime record of 159,700 tons. All companies except Det Norske Nitrid A/S worked at full capacity. Det Norske Nitrid A/S produced almost 50 percent less than in 1958, owing to a shortage of electricity and a 15-percent cutback ordered by Aluminium Ltd., the parent company.

Capacity was increased by the installation of reduction cells at Aardal and Mosjøen. Expansion projects underway were expected to raise the total capacity to 253,000 tons in 3 to 4 years.

Exports of aluminum reached an alltime peak of 140,900 tons. In 1959 China became the fourth largest importer of Norwegian aluminum, with 8,600 tons. Exports to the United Kingdom totaled 40,300 tons; to the United States, 32,300 tons; and to West Germany, 23,100 tons.

Poland.—Plans for a large aluminum plant were reported to have reached the blueprint state, and construction was to begin in 1962. The plant will have a capacity four times that of Skawina (38,500 short tons) and will be built near the electric powerplant in Maliniec near Konin.

Spain.—Aluminio de Vigo, S.A. (ALVISA), failed to obtain necessary foreign investment to increase its total capitalization to 300 million pesetas as required by the Ministry of Treasury. The company had planned to build a 22,000-ton plant in the Vigo Free Zone.

Kaiser acquired an interest in Pechiney's 6,600-ton primary aluminum plant at Sabinanigo.

The Spanish Ministry rejected a proposal by Aluminio Iberico to build an aluminum plant near Madrid.

U.S.S.R.—The Stalingrad plant began operating in January with an initial capacity of 44,000 tons, which was doubled by October. When the plant is completed in 1960, it will have an annual capacity of 220,000 tons. The Pavlodar plant is scheduled for completion in

---

[28] Baudart, G. A., l'Industrie Italienne de l'Aluminium [The Italian Aluminum Industry]: Revue de l'Aluminium (Paris), vol. 36, No. 269, October 1959, pp. 1051–1055.

1963 and the Krasnoyarsk plant in 1964. The Irkutsk plant, scheduled for completion in 1958, was still under construction in 1959. Construction of the second section of the Nadvoitsy plant was begun. The new section, scheduled for completion in 1960, will double the plant's capacity of 22,000 tons. Expansion of the Sumgait plant to double its 1959 capacity of 77,000 tons was scheduled for completion in 1960.[29]

Postwar developments of the aluminum industry were described.[30]

Exports of aluminum totaled 126,700 tons in 1958, of which 71,200 went to Communist nations and 55,500 to non-Communist countries.[31]

United Kingdom.—Imports of aluminum decreased slightly to 256,500 tons—139,900 tons from Canada, 49,900 from the United States, 38,500 from Norway, 17,200 from the U.S.S.R., and the remainder from other countries. Imports from Canada declined 24 percent, whereas imports from the United States increased 86 percent and from Norway 50 percent.

Following open market purchases it was announced that the ordinary share capital of British Aluminium Co., Ltd., was held as follows: Tube Investments, Ltd., 47 percent; Reynolds Tube Investments, Ltd., 4 percent; Reynolds Metals Co., 45 percent; and miscellaneous stockholders, the remaining 4 percent. The cost to Reynolds for its interest was reported to be approximately $47 million. British Aluminium, with two plants, was the only primary aluminum producer in the United Kingdom. Its fabricating capacity, an estimated 112,000 tons a year, represents more than 20 percent of the United Kingdom capacity. The company also had interests in bauxite deposits in Ghana and France, in a company to produce alumina in Guinea, and in a company producing rolled and extruded products in Australia. British Aluminum also owns a fabricating plant in India and a majority interest in Canadian British Aluminium, Ltd.[32]

Alcoa and Imperial Chemical Industries, Ltd. (ICI) of the United Kingdom have undertaken the formation of a new company, Imperial Aluminium Co., Ltd. (Impalco). Alcoa has a 49-percent interest in the new concern, which is producing aluminum products at facilities formerly operated by ICI in Wales.

ASIA

China.—Expansion of the Fushun plant to 66,000 tons capacity, completed late in 1958, contributed to the 160-percent increase in output in 1959. Numerous small plants also operated during the year, and two 10,000-ton-capacity plants—one at Kweiyang, Kweichow Province, and the other at Hofei, Anhwei Province—were scheduled to begin operations in 1959. An aluminum plant with an estimated

---

[29] Shabad, Theodore, Ivan and the Seven-Year Plan: 2½ Times More Aluminum: Am. Metal Market, vol. 67, No. 19, Jan. 28, 1960, pp. 1, 15.

[30] Baer, F. H., Soviets Push Ambitious Aluminum Plans: Eng. Min. Jour., vol. 160, No. 5, May 1959, pp. 102–105.

Revue de l'Aluminium (Paris), Puissance de l'Industrie Sovietique de l'Aluminium [Potential of the Soviet Aluminum Industry]: Vol. 36, No. 261, January 1959, pp. 51–55.

[31] Gakner, Alexander, The Foreign Mineral Trade of the U.S.S.R. in 1958: Bureau of Mines Mineral Trade Notes. Spec. Supp. 58, vol. 50, No. 1, January 1960, 36 pp.

[32] Fortune, How Reynolds Brought Off Its British Coup: Vol. 59, No. 6, June 1959, pp. 112–115, 230, 235–236, 238, 240.

capacity of 110,000 tons was under construction in Sian, Shensi Province.[33]

India.—The 11,200-ton plant of the Indian Aluminium Co. at Hirakud began operating in February, resulting in a 109-percent increase in output of aluminum. Plans for additional capacity during the Third Plan (1961–66) include expansion of the Hirakud plant to 22,000 tons; the Asanol plant of Aluminium Corp. to 8,300 tons, and three new plants—Hindustan Aluminium Corp.'s 22,000-ton plant at Rihand, a 22,000-ton plant at Koyna, Bombay State, and an 11,000-ton plant at Salem, Madras State.[34]

The Hindustan Aluminium Corp., Ltd., included participation by local interests and Kaiser Aluminum.

Early in 1959 the Government stated that the protective tariff on aluminum would continue until December 31, 1960, and that the 35-percent ad valorem duty would be maintained on crude aluminum and aluminum manufactures.

Japan.—Primary aluminum production in Japan was at a postwar high level but was 9 percent below the record of 120,700 tons set in 1944. Expansion goals set by the aluminum companies were accelerated in an effort to keep pace with the rapidly growing demand for aluminum.[35] Capacity at the end of 1959 was 127,000 tons, of which Japan Light Metal Co. accounted for 68,000 tons, Showa Electro-Chemical Industry Co., Ltd., for 33,000 tons, and Sumitomo Chemical Co., Ltd., for 26,000 tons. Sumitomo Chemical Co. planned to build an aluminum plant with a productive capacity of 11,000 tons at Nagoya to be completed during 1960.

The Japanese Government authorized the formation of Furukawa Aluminum Co., Ltd. This company, which fabricates aluminum and other nonferrous metals products, is jointly owned by Furukawa Electric Co., Ltd., and Alcoa. Alcoa owns one-third of the new company.

Taiwan.—The U.S. Development Loan Fund agreed to lend $1.35 million to the Taiwan Aluminium Corp. to modernize and expand its aluminum plant at Kaohsiung. Present capacity of 10,000 tons will be increased to 22,000 tons by 1961.

AFRICA

Discussions on the possibility of constructing new power facilities and reduction plants in Africa were reported periodically during the year. However, the information included in table 15, "Present and tentative African aluminum projects," of the Aluminum chapter of the 1958 Minerals Yearbook was essentially unchanged, except for Ghana.

Ghana.—Volta Aluminium Co. (VALCO) was established by Kaiser, Alcoa, Reynolds, Olin-Mathieson Chemical Corp., and Aluminium, Ltd. The new company will be responsible for carrying out further

---

[33] Wang, K. P., Vast Expansion of Aluminum-Alumina is Planned by Chinese Communists: Eng. Min. Jour., vol. 160, No. 7, July 1959, pp. 75–77, 123.

[34] Sabharwal, A. L., Expansion of the Aluminium Industry in India: Eastern Metals Review, vol. 13, No. 1, Feb. 1, 1960, pp. 71–75.

[35] Oriental Economist (Tokyo), Aluminium: Vol. 27, No. 587, September 1959, pp. 527–534.

Baudart, G. A., Situation Accuelle de l'Industrie Japonaise de l'Aluminium [Japanese Aluminum Industry]: Revue de l'Aluminium (Paris), vol. 36, No. 271, December 1959. pp. 1303–1306.

discussions and negotiations with the Government of Ghana regarding the construction of an aluminum plant with an initial capacity of 80,000 tons and an eventual capacity of 250,000 tons. The plant was to be near the Kosombo Dam and Accra. Work was begun on the dam, which is the first of three to be built as part of the Volta project.

OCEANIA

Australia.—The potentialities for expansion of the aluminum industry were discussed in a paper presented at the Symposium on Aluminium in Australia, held at Brisbane on July 16 and 17.[36]

The Federal and Tasmanian State governments, which jointly operate the Australian Aluminium Production Commission, have agreed to increase the capacity of the Bell Bay Aluminum plant from 14,500 to 18,000 tons. It was estimated that the expansion would cost £3 million.

TECHNOLOGY

The reduction cells in most aluminum-producing plants constructed since 1953 were designed to operate at 80,000 to 100,000 amperes. However, the plant operated by Reynolds Metals Co. at Corpus Christi, Tex. (completed in 1952), uses cells with Soderberg electrodes that operate at 4.5 to 5.5 volts and 130,000 to 140,000 amperes. Construction and operation of these cells was described.[37] It was reported that Pechiney, a French aluminum producer, was testing three 150,000-ampere cells. However, a new plant, which this company is constructing in Southern France, was to use 100,000-ampere cells, because some problems encountered in using the larger cells had not been solved.[38]

Modern reduction plants use either Soderberg continuous anodes or prebaked anodes. Each has certain advantages and disadvantages. Prebaked anode cells have better electrical properties than Soderberg anodes, but the prebaked system requires fabricating and rodding facilities. Kaiser's Ravenswood, W. Va., reduction plant, completed in 1959, has a highly automatic system for making and rodding the prebaked anodes. Removal of spent anodes and rerodding are performed on conveyors.[39]

Results of research were reported in which a 10,000-ampere cell was used to study the composition of effluent gases produced during operation of the cell. The cell contained four prebaked anodes. Current efficiency did not vary significantly with anode bake temperature, but the carbon dioxide content of the cell gas did vary with the anode bake temperature. Modification of the equation relating current efficiency to carbon dioxide content of cell gases was recommended.[40]

---

[36] Dunn, J. A., Dr., Australia and Aluminium: Pt. 1, The World Aluminium Picture: Min. Jour. (London), vol. 253, No. 6474, Sept. 18, 1959, pp. 258–260; pt. 2, Ore Supplies for the Aluminium Industry: Vol. 253, No. 6475, Sept. 25, 1959, pp. 291–292; pt. 3. The Future Pattern of Aluminium Production: Vol. 253, No. 6476, Oct. 2, 1959, pp. 315–316.

[37] Franklin, James W., Operating Large Aluminum Pots at Reynolds' Corpus Christi: Eng. Min. Jour., vol. 160, No. 5, May 1959, pp. 94–97.

[38] Chemical Engineering, New Aluminum Cells Reach Giant Size: Vol. 66, No. 11, June 1, 1959, p. 40.

[39] Cronan, C. S., Process Flowsheet, Automation Comes to the Aluminum Industry: Chem. Eng., vol. 66, No. 5, Mar. 9, 1959, pp. 124–127.

[40] Beck, T. R., The Relation of Gas Composition to Current Efficiency in an Aluminum Reduction Cell: Jour. Electrochem. Soc., vol. 106, No. 8, August 1959, pp. 710–713.

Studies of factors leading to the formation of compounds of carbon and fluorine in the reduction cell showed that control of the anode-cathode distance prevents concentration polarization, and the accompanying fluorocarbon formation.[41]

The literature published in 1959 on the extraction, fabrication, properties, and standardization of aluminum and its alloys was summarized. Nearly 250 references were included in the extensive bibliography.[42] Uses of aluminum for construction were described. New products, corrosion properties, and new uses of aluminum in atomic energy and in the chemical, petroleum, and power industries were reported.[43] An extensive study also was made on the properties of aluminum and aluminum alloys in steam at temperatures of 270° to 500° C. Sintered aluminum powder (SAP) with 1 percent nickel corroded least, but longer tests would be required to confirm the properties of this alloy.[44]

Industries concerned with high-temperature operations are continuously looking for new and improved refractories. The principal problems in the use of refractories in the aluminum industry were discussed at the Symposium on Aluminum Industry Refractories conducted by the American Chemical Society in 1958. Published abstracts presented information on the behavior of various types of refractories in contact with molten aluminum, the relation of such refractories to furnace design, special refractory applications, and protection of refractories from attack by molten aluminum.[45] Because silicon carbide has high thermal conductivity it was being tested as a substitute for carbon in the sidewalls of the reduction cell.[46]

Aluminum nitride was the only material that could successfully resist attack by aluminum in the range of 1,800° to 2,000° C. Aluminum nitride was produced by striking a direct-current arc between two high-purity aluminum electrodes in a nitrogen atmosphere.[47]

A new ultrafine aluminum powder with an average particle size of 0.03 micron was produced for use as a catalyst, in powder metallurgy products, and in solid propellants.[48]

Glass systems suitable for porcelain enameling of light metals were reviewed. Lead-free porcelain enamels were expected to play an important role in providing new finishes for aluminum.[49]

---

[41] Holliday, R. D., and Henry, Jack L., Anode Polarization and Fluorocarbon Formation in Aluminum Reduction Cells: Ind. Eng. Chem., vol. 51, No. 10, October 1959, pp. 1289–1292.

[42] Elliott, E., Aluminium and Its Alloys in 1959, Some Aspects of Research and Technical Progress Reported: Pt. 1, Metallurgia (Manchester), vol. 61, No. 364, February 1960, pp. 65–69; pt. 2, No. 365, March 1960, pp. 123–132.

[43] Horst, Ralph L., Jr., and Murphy, Frank B., Materials of Construction, Aluminum Alloys: Ind. Eng. Chem., vol. 51, No. 9, Pt. 2, September 1959, pp. 1157–1160.

[44] Wilkins, N. J. M., and Wanklyn, J. N., The Corrosion of Aluminum and Its Alloys in High-Pressure Steam: Jour. Inst. Metals, vol. 5, No. 3, November 1959, pp. 134–140.

[45] Industrial Heating, Symposium on Aluminum Industry Refractories: Pt. 1, vol. 26, No. 2, February 1959, pp. 359–360; pt. 2, No. 8, August 1959, pp. 1607–1608, 1610, 1612; pt. 3, No. 12, December 1959, pp. 2549–2550; pt. 4, vol. 27, No. 4, April 1960, pp. 840, 849; pt. 5. No. 5, May 1960, pp. 1060, 1062.

[46] Chemical Engineering, Aluminum Makers Eye SiC Linings: Vol. 66, No. 14, July 13, 1959, pp. 72, 74.

[47] Long, George, and Foster, L. M., Aluminum Nitride, A Refractory for Aluminum to 2,000° C.: Jour. Am. Ceram. Soc., vol. 42, No. 2, Feb. 1, 1959, pp. 53–59.

[48] Chemical and Engineering News, Ultrafine Aluminum Bids for Markets: Vol. 37, No. 1, Jan. 19, 1959, pp. 53–54.

Light Metal Age, "Superfine" Aluminum: Vol. 17, Nos. 1 and 2, February 1959, p. 13.

[49] Stradley, N. H., Porcelain Enamels for Aluminum and Magnesium: Am. Ceram. Soc. Bull., vol. 38, No. 8, August 1959, pp. 401–404.

A series of articles reviewed the methods of treating aluminum surfaces and listed proprietary cleaners in use. Except for mechanically finished aluminum, most aluminum products must be cleaned before they can be finished. Grinding, polishing, and other mechanical finishing methods were compared. The articles also discussed chemical finishing methods and listed proprietary conversion coatings. Other methods of protecting aluminum surfaces discussed in the series of articles were anodizing and plating, organic coatings, and porcelain enameling.[50]

The construction of a new aluminum diecasting plant indicated wider use of aluminum castings in the automobile industry. About 45 parts, ranging in weight from a few ounces to 15 pounds, are cast. Most parts are housings or internal castings for automatic transmissions. Such engine accessories as oil-pump covers, timing-chain case covers, and distributor housings are also produced.[51]

Closely controlled foundry techniques markedly improved the strength and ductility of aluminum sand castings. The methods of producing these castings and their properties were described.[52]

Use of two production lines, the first continuously converting aluminum pig into extrusion slugs and the second transforming the slugs into cans, reportedly made it possible to manufacture aluminum beer can that can compete with those made from tinplate. However, for such cans to be economical, the food or beverage processor must make the cans at the packaging site.[53]

Continuous casting of aluminum redraw rod of electrical conductor (EC) grade by the Properzi process was discussed critically.[54] Slabs of commercially pure aluminum are also cast continuously by using the Hazelett machine or a rotary strip-casting machine.[55] Another recently developed machine continuously casts ¼-inch-thick, 3-foot-wide sheet.[56] In addition to eliminating costly intermediate casting, cooling, soaking, and heating, the machines can be incorporated into a continuous operation leading to a finished or semifinished product.

As many applications of aluminum require good welded joints, studies were continued on methods of weldings. Recent examples of the use of welding in the fabrication of aluminum were described and new developments in fusion, resistance, and ultrasonic welding discussed.[57] Ultrasonic welding, probably the newest development,

---

[50] Modern Metals, All About Aluminum Finishing: Vol. 15, No. 8, September 1959, pp. 35–36; When Cleaning Aluminum, pp. 38, 40, 44, 46; For a Good Mechanical Finish, pp. 48, 50, 54, 56, 58, 60, 62; Chemical Finishing of Aluminum, pp. 64, 66, 71–72, 74, 76, 78; Anodizing and Plating Aluminum, pp. 80, 84, 86, 88, 90–92; Organic Coatings for Aluminum, pp. 94, 96, 98, 100, 102; What's Happening in Porcelain Enameling Aluminum, pp. 104–106, 108, 110.

[51] Herrmann, Robert H., Chrysler's New Aluminum Diecasting Plant: Foundry, vol. 87, No. 7, July 1959, pp. 72–76.

[52] Flemings, Merton C., and Taylor, H. F., High-Property Aluminum Castings: Foundry, vol. 87, No. 1, January 1959, pp. 80–81.

Herrmann, Robert H., Casting High-Property Aluminum at American Brake Shoe Co.: Foundry, vol. 87, No. 1, January 1959, pp. 82–85.

Corcoran, William B., Jr., Draper Corp. Produces High-Quality Aluminum Castings: Foundry, vol. 87, No. 1, January 1959, pp. 86–91.

[53] Steel, Continuous Casting, Impact Extrusion Spark Revolution in Aluminum Partmaking: Vol. 144, No. 2, Jan. 12, 1959, pp. 70–73.

[54] Russell, James B., and Nichols, Frank R., Equipment and Practice for Continuous Casting and Rolling by the Properzi Process: Jour. Inst. Metals, vol. 4, pt. 19, March 1959, pp. 209–219.

[55] Hamer, R. D., The Hazelett and Rotary Strip-Casting Machines for the Continuous Casting of Aluminium: Jour. Inst. Metals, vol. 4, pt. 19, March 1959, pp. 219–226.

[56] Church, F. L., Shortcut to Sheet: Modern Metals, vol. 15, No. 2, March 1959, pp. 30–32, 34, 36.

[57] Eldridge, G. W., Recent Advances in Joining Aluminium: Metallurgia (Manchester), vol. 61, No. 364, February 1960, pp. 55–60.

requires little or no prior cleaning of the metal and can be used to weld thin sections of the same or dissimilar metals.[58]

Three methods of welding aluminum were discussed in detail. These were the manual metal-arc process with flux-coated electrodes, the consumable electrode process with inert-gas shielding, and the tungsten arc process with argon shielding in which the electrode is not consumed.[59]

Honeycomb aluminum, because of its strength and lightness, is becoming increasingly important in the aircraft industry. A new high-strength honeycomb aluminum was produced in limited quantity.[60]

A high-speed method of machining, based on interrupted arcing, was developed for machining honeycomb cores, and a chemical milling process was announced.[61]

---

[58] Modern Metals, Welding Aluminum With Ultrasonic Sound Waves: Vol. 15, No. 3, April 1959, pp. 72–73.

[59] Metal Industry (London), Welding Aluminium and Its Alloys: Part 1, Manual Metal-Arc Process: Vol. 95, No. 16, Nov. 27, 1959, pp. 339–340, 343; pt. 2, The Consumable Electrode Process, No. 18, Dec. 11, 1959, pp. 407–409; pt. 3, Tungsten Arc Process, No. 19, Dec. 18, 1959, pp. 431–434.

[60] American Metal Market, Improved Type Honeycomb Put Into Production by Hexcel: Vol. 66, No. 250, Dec. 29, 1959, p. 5.

[61] Iron Age, New Method Speeds Machining of Honeycomb Core Material: Vol. 183, No. 6, Feb. 5, 1959, pp. 94–95; Low-Cost Chemical Milling Shapes Honeycomb Cores: Vol. 184, No. 18, Oct. 29, 1959, pp. 122–123.

Antimony

By G. Richards Gwinn [1] and Edith E. den Hartog [2]

⁂

THE DOMESTIC antimony industry in 1959 was characterized by an increase in smelter output and consumption and a reduction in stocks. Demand was stronger than in 1958, despite strikes in some antimony producing and consuming industries. Prices were steady.

LEGISLATION AND GOVERNMENT PROGRAMS

Antimony remained on the Commodity Credit Corporation's (CCC) list of materials eligible for barter of domestic agricultural commodities. Through CCC barter transactions, 1,228 short tons of antimony metal was received in 1959.

TABLE 1.—Salient antimony statistics

(Short tons)

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Production:						
Primary:						
Mine	1,853	633	590	709	705	668
Smelter [1]	12,146	10,414	11,855	11,400	8,557	8,748
Secondary	22,722	23,702	24,106	22,565	19,515	20,043
Imports (antimony content)	14,078	14,417	13,577	15,265	9,878	13,273
Ore and concentrates	8,464	7,514	6,572	8,198	3,427	6,466
Metal	3,112	3,671	4,693	5,052	4,355	4,395
Oxide	1,284	1,834	1,236	1,571	1,356	1,706
Sulfide	15	32	32	27	95	114
Antimonial lead	1,203	1,366	1,044	417	645	592
Exports of ore, metal, and alloys	110	212	65	68	86	174
Consumption [2]	18,550	15,870	16,006	12,389	11,880	13,317
Average price of antimony at New York (cents per pound)	36.79	32.15	34.97	35.09	31.76	31.30
World: Production	49,000	51,000	54,000	50,000	44,000	52,000

[1] Includes primary content of antimonial lead produced at primary lead smelters.

[2] Includes primary content of antimonial lead produced at primary lead smelters and antimony content of alloys imported.

DOMESTIC PRODUCTION

MINE PRODUCTION

Domestic mine production of antimony in 1959 was 678 tons. The entire output was recovered by Sunshine Mining Co., Shoshone County, Idaho, as a byproduct in refining silver-lead ore. Production was reported in the form of impure cathode metal.

---

[1] Commodity specialist.

[2] Statistical assistant.

SMELTER PRODUCTION

Primary.—Domestic smelter production of primary antimony was 2 percent above the 1958 total. The increase was attributed to a relatively high output of byproduct antimonial lead and antimony oxide in the first half of the year. Antimony ores and concentrates, 80 percent of which came from foreign sources and 8 percent from domestic mines, accounted for 72 percent of the total source materials for smelter output. Intermediate smelter products, derived from both foreign and domestic concentrates, accounted for the remaining 28 percent. The intermediate smelter products were used in the production of byproduct metal, oxide, and antimonial lead. Byproduct antimony that originated in domestic ores totaled 1,032 tons, or 12 percent of the domestic primary smelter output.

TABLE 2.—Production and shipments of antimony (concentrates and metal) in the United States

(Short tons)

Years	Gross weight of antimony-bearing concentrate produced	Contained antimony, percent	Antimony produced	Antimony shipped
1950–54 (average)	5,598	30.3	1,853	[1]
1955	4,011	16.1	633	633
1956	3,714	16.9	590	1,732
1957	3,022	23.5	709	253
1958	4,309	16.4	705	382
1959	4,671	14.5	678	146

[1] Data not available.

Companies that reported primary antimony production in 1959 were American Smelting & Refining Co., Foote Mineral Co., Harshaw Chemical Co., Hummel Chemical Co., McGean Chemical Co., National Lead Co., and Sunshine Mining Co.

Secondary.—Secondary antimony recovered in 1959 totaled 20,043 short tons compared with 19,515 tons in 1958. All secondary antimony was recovered from antimony-bearing lead and tin scrap and was produced as an element of lead and tin alloys, largely by secondary smelters. No secondary metallic antimony was produced in the United States in 1959.

Smelters recovered 11,400 tons of antimony from battery-plate scrap, chiefly in the production of antimonial lead, in 1959. From type-metal scrap 3,300 tons of antimony was recovered, from drosses 2,700 tons, from bearing metals 1,400 tons, and from antimonial-lead scrap 1,000 tons.

In addition to scrap, secondary lead smelters required 2,400 tons of primary metallic antimony in making lead and tin alloys.

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	
1950-54 (average)	2,701	6,056	100	743	2,546	12,146
1955	2,138	5,390	92	762	2,032	10,414
1956	4,291	4,731	129	639	2,065	11,855
1957	4,658	4,210	107	510	[1] 1,915	11,400
1958	2,833	3,825	84	319	1,496	8,557
1959	2,667	4,411	70	430	1,170	8,748

[1] Corrected figure.

TABLE 4.—Secondary antimony produced in the United States

(Short tons, antimony content)

Kind of scrap	1958	1959	Form of recovery	1958	1959
New scrap:					
Lead-base	2,631	2,589	In antimonial lead [1]	11,997	12,343
Tin-base	44	66	In other lead alloys	7,490	7,659
			In tin-base alloys	28	41
Total	2,675	2,655	Total	19,515	20,043
Old scrap:			Value (million)	$12.4	$12.5
Lead-base	16,794	17,358			
Tin-base	46	30			
Total	16,840	17,388			
Grand total	19,515	20,043			

[1] Includes 1,307 tons of antimony recovered in antimonial lead from secondary sources at primary plant in 1958 and 754 tons in 1959.

TABLE 5.—Byproduct antimonial lead produced at primary lead refineries, in the United States

(Short tons)

Year	Antimonial lead produced at primary lead refineries					
	Gross weight	Antimony content				
		From domestic ores [1]	From foreign ores [2]	From scrap	Total	
					Quantity	Percent
1950-54 (average)	61,534	1,822	724	1,728	4,274	7.0
1955	64,044	1,307	725	1,523	3,555	5.6
1956	66,826	1,320	745	1,283	3,348	5.0
1957	67,786	1,300	615	1,149	3,064	4.5
1958	50,246	811	685	1,307	2,803	5.6
1959	37,487	676	494	754	1,924	5.1

[1] Includes primary residues and small amount of antimony ore.
[2] Includes foreign base bullion and small quantities of foreign antimony ore.

CONSUMPTION AND USES

Industrial consumption of primary antimony in the United States was 13,300 tons, an increase of 12 percent over 1958. Antimonial lead, bearing metal and bearings accounted largely for the increased consumption in metal products; flameproofing chemicals, ceramics and glass, pigments, and plastics, for that in nonmetal products.

STOCKS

Total industrial stocks declined 2 percent in 1959, although metal stocks rose 15 percent and stocks of residues 21 percent. The decline was caused by a reduction in stocks of ore and concentrates, oxide, and sulfide.

On December 31, 1959, Government stocks of antimony metal included 620 tons in the CCC inventory, 6,861 tons in the supplemental stockpile, and quantities that may not be disclosed in the strategic stockpile.

TABLE 6.—Industrial consumption of primary antimony in the United States

(Short tons, antimony content)

Year	Class of material consumed						Total
	Ore and concentrates	Metal [1]	Oxide	Sulfide	Residues	Byproduct antimonial lead	
1950-54 (average)	2,143	6,264	6,725	129	743	2,546	18,550
1955	491	5,407	7,051	127	762	2,032	15,870
1956	1,149	5,198	6,843	112	639	2,065	16,006
1957	677	4,055	5,129	103	510	1,915	12,389
1958	515	4,179	5,283	88	319	1,496	11,880
1959	270	5,420	5,948	79	430	1,170	13,317

[1] Includes antimony in imported alloys.

TABLE 7.—Industrial consumption of primary antimony in the United States, by class of material produced

(Short tons, antimony content)

Product	1950–54 (average)	1955	1956	1957	1958	1959
Metal products:						
Ammunition	5	5	14	12	(1)	(1)
Antimonial lead [2]	7,967	5,234	5,494	4,233	3,698	4,141
Bearing metal and bearings	1,152	831	1,077	944	644	886
Cable covering	85	146	190	183	208	157
Castings	87	67	57	106	82	84
Collapsible tubes and foil	36	24	12	20	37	33
Sheet and pipe	192	157	300	258	273	202
Solder	155	131	144	90	100	113
Type metal [2]	1,284	1,281	1,050	607	877	883
Other	101	161	137	153	147	130
Total [2]	11,064	8,037	8,475	6,606	6,066	6,629
Nonmetal products:						
Ammunition primers	21	20	13	14	10	11
Fireworks	27	32	37	37	33	28
Flameproofing chemicals and compounds	1,791	1,218	1,082	760	758	1,033
Ceramics and glass	1,759	2,048	2,188	1,611	1,570	1,727
Matches	29	17	18	26	18	19
Pigments	1,255	1,283	1,471	1,085	1,047	1,167
Plastics	659	767	976	748	841	1,034
Rubber products	51	78	156	284	265	217
Other	1,894	2,370	1,590	1,218	1,272	1,452
Total	7,486	7,833	7,531	5,783	5,814	6,688
Grand total	18,550	15,870	16,006	12,389	11,880	13,317

[1] Included with "Other" to avoid disclosing individual company confidential data.
[2] Includes antimony content of imported antimonial lead consumed.

TABLE 8.—Industry stocks of primary antimony in the United States, at end of year

(Short tons, antimony content)

	1955	1956	1957	1958	1959
Ore and concentrate	3,568	2,474	2,337	3,052	2,884
Metal	1,267	2,236	1,300	1,232	1,422
Oxide	3,234	2,638	2,510	1,889	1,659
Sulfide	94	159	160	143	115
Residues and slags	445	598	746	565	685
Antimonial lead [1]	307	314	329	371	373
Total	8,915	8,419	7,382	7,252	7,138

[1] Inventories from primary sources at primary lead smelters only.

PRICES

The quoted price of RMM brand antimony metal continued unchanged at 29.00 cents per pound, in bulk, f.o.b., Laredo, Tex., and 31.30 cents per pound in cases, New York, N.Y., throughout 1959. Prices of foreign metal changed only slightly, ranging from 24.00 to 25.50 cents, duty-paid delivery in New York. Quoted prices for oxide and ore remained virtually unchanged.

FOREIGN TRADE[3]

Imports.—General imports of contained antimony totaled 13,300 tons compared with 9,900 tons in 1958. Imports of ores and concentrates, which rose 88 percent in 1959, accounted for most of the increase. The Union of South Africa, Mexico, and Bolivia, in the order named, were the major suppliers of ores and concentrates accounting, respectively, for 36, 31, and 19 percent of the total. Yugoslavia (41 percent), the United Kingdom (19 percent), and Belgium-Luxembourg (18 percent) collectively supplied 78 percent of all metallic antimony imports.

Exports.—Exports of antimony in 1959 as in preceding years, were nominal.

Tariff.—Tariff on antimony and antimonial products remained unchanged in 1959. Ores and concentrates were admitted duty free. Metal was dutiable at 2 cents per pound and oxide at 1 cent.

TABLE 9.—Antimony price ranges in 1959

Type of antimony:		*Price*
Domestic metal[1]	cents per pound	29.00–31.30
Foreign metal[2]	do	24.00–25.50
Antimony trioxide[3]	do	24.00–26.00
Antimony ore,[3] 50–55 percent	dollars per short-ton unit	2.25– 2.40
Antimony ore, minimum 60 percent	do	2.50– 2.60
Antimony ore, minimum 65 percent	do	3.10– 3.20

[1] RMM brand, f.o.b., Laredo, Tex.
[2] Duty-paid delivery, New York.
[3] Quoted in E&MJ Metal and Mineral Market.

---

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 10.—Antimony imported into the United States [1]

[Bureau of the Census]

Country	Antimony ore			Needle or liquated antimony		Antimony metal		Antimony oxide	
	Short tons (gross weight)	Antimony content: Short tons	Antimony content: Value (thousands)	Short tons (gross weight)	Value (thousands)	Short tons	Value (thousands)	Short tons (gross weight)	Value (thousands)
1950-54 (average)	19,755	8,464	$2,609	22	$12	3,112	$1,806	1,547	$847
1955	16,307	7,514	1,877	46	19	3,671	1,860	2,210	926
1956	17,424	6,572	1,762	46	23	4,693	2,424	1,489	640
1957	21,374	8,198	1,973	38	17	5,052	2,413	1,893	[2] 790
1958									
North America:									
Guatemala	73	47	11	---	---	---	---	---	---
Mexico	4,870	1,367	205	---	---	335	215	---	---
Total	4,943	1,414	216	---	---	335	215	---	---
South America:									
Bolivia [3]	1,218	781	143	---	---	---	---	---	---
Chile [3]	143	93	26	---	---	---	---	---	---
Peru [3]	106	70	15	---	---	25	10	---	---
Total	1,467	944	184	---	---	25	10	---	---
Europe:									
Belgium-Luxembourg	---	---	---	3	1	796	330	369	151
Czechoslovakia	---	---	---	---	---	17	7	---	---
France	---	---	---	---	---	99	36	---	---
Germany, West	---	---	---	---	---	17	7	131	43
Italy	---	---	---	---	---	119	44	---	---
United Kingdom	---	---	---	133	57	1,522	644	1,134	449
Yugoslavia	---	---	---	---	---	1,425	607	---	---
Total	---	---	---	136	58	3,995	1,675	1,634	643
Africa: Union of South Africa	1,793	1,069	243	---	---	---	---	---	---
Grand total	8,203	3,427	643	136	58	4,355	1,900	1,634	643
1959									
North America:									
Canada	---	---	---	---	---	(4)	4	---	---
Guatemala	143	97	21	---	---	---	---	---	---
Mexico	7,732	2,018	232	---	---	660	436	---	---
Total	7,875	2,115	253	---	---	660	440	---	---
South America:									
Bolivia [3]	1,931	1,221	302	---	---	---	---	---	---
Chile [3]	556	359	63	---	---	---	---	---	---
Peru [3]	---	---	---	---	---	191	70	---	---
Uruguay	336	118	12	---	---	---	---	---	---
Total	2,823	1,698	377	---	---	191	70	---	---
Europe:									
Belgium-Luxembourg	---	---	---	47	20	813	340	356	152
France	---	---	---	---	---	28	11	---	---
Germany, West	---	---	---	---	---	---	---	192	78
Italy	---	---	---	---	---	66	32	---	---
Netherlands	---	---	---	---	---	---	---	55	22
United Kingdom	112	73	4	45	20	815	343	1,453	573
Yugoslavia	---	---	---	71	34	1,822	787	---	---
Total	112	73	4	163	74	3,544	1,513	2,056	825
Asia: Turkey	441	229	38	---	---	---	---	---	---
Africa: Union of South Africa	4,056	2,351	564	---	---	---	---	---	---
Grand total	15,307	6,466	1,236	163	74	4,395	2,023	2,056	825

---

[1] Data are general imports, that is, include antimony imported for immediate consumption, plus material entering the country under bond. Table does not include antimony contained in lead-silver ores.

[2] Data known to be not comparable with other years.

[3] Imports shown from Chile probably were mined in Boliva or Peru and shipped from a port in Chile.

[4] Less than 1 ton.

TABLE 11.—Antimony imported for consumption in the United States[1]

[Bureau of the Census]

Year	Antimony ore			Needle or liquated antimony		Antimony metal		Type metal and antimonial lead[2] (short tons)	Antimony oxide	
	Short tons (gross weight)	Antimony content		Short tons (gross weight)	Value (thousands)	Short tons	Value (thousands)		Short tons (gross weight)	Value (thousands)
		Short tons	Value (thousands)							
1950–54 (average)	19,473	8,387	$2,590	22	$12	3,126	$1,815	1,203	1,547	$847
1955	16,307	7,514	1,877	46	19	3,667	1,860	1,366	2,210	926
1956	17,424	6,572	1,762	46	23	4,321	2,245	1,044	1,479	636
1957	21,374	8,198	1,973	38	17	5,412	2,587	417	1,893	[3] 790
1958	8,203	3,427	643	136	58	4,282	1,871	645	1,634	643
1959	15,307	6,466	1,236	177	79	4,422	2,039	592	2,056	825

[1] Does not include antimony contained in lead-silver ore.

[2] Estimated antimony content; for gross weight and value, see Lead chapter of this volume.

[3] Known to be not comparable with other years.

WORLD REVIEW

Bolivia.—Production of antimony ore and concentrates in 1959 came almost entirely from privately owned mines, as the output reported from nationalized mines was very small. The Compañía Metalurgica Vinto began operating an antimony smelter at Orura in March 1959. About 60 tons of metal of 99.3 percent purity was produced, part of which was used in a barter agreement with Venezuela to obtain fuel oil and other petroleum products for Bolivia.

Canada.—Antimony was recovered as a byproduct of lead refining. All production came from operations of the Consolidated Mining & Smelting Co. at Trail, British Columbia. Production of 800 tons in 1959 almost doubled the output of 1958.

Iran.—The discovery of an apparently rich antimony deposit at Kuk Surkh, about 20 miles west of Turbat-i-Haidari, was reported in 1959. A mine which will produce an estimated 1,000 tons of ore annually began operations. The total reserve is not known, but the deposit now being worked was estimated to contain 10,000 tons of ore.

Mexico.—Production and exports of antimony ores and concentrates in 1959 were essentially unchanged from 1958. Domestic consumption of metal and compounds was relatively small. Most exports of metal, ores, and concentrates were shipped to the United States. Small quantities of antimonial chemicals were imported for use in manufacturing paints, enamels, and glass.

Union of South Africa.—Production of antimony ore by Consolidated Murchison (Transvaal) Goldfields & Development Co., Ltd., South Africa's sole antimony producer, showed a slight gain over 1958. Exploratory development was continued at the Gravelotte and Mulati sections, and explorations were initiated at the United Jack section. The antimony market remained steady throughout the year.

United Kingdom.—The market for imported antimony fluctuated little but was slightly below that in 1958. Imports of antimony metal from Communist China and the U.S.S.R. were restricted by the duty of £40 per ton on imported regulus. Consumption of 4,923 long tons of primary antimony metal and compounds and 4,672 tons of secondary antimony represent an increase over the 1958 totals which were, respectively, 4,740 and 4,468 tons. The increases in consumption of primary metal and oxides were in metal consumed in batteries and oxides used in making white pigments. The increase in consumption of secondary antimony was spread over all uses.

TABLE 12.—World production of antimony (content of ore except as indicated), by countries,[1] in short tons [2]

[Compiled by Augusta W. Jann and Berenice B. Mitchell]

Country [1]	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada [3]	1,247	1,011	1,070	680	430	807
Guatemala (U.S. imports)	---------	---------	---------	13	47	97
Mexico [4]	5,752	4,209	5,022	5,734	3,029	3,621
United States	1,853	633	630	709	705	678
Total	8,852	5,853	6,722	7,136	4,211	5,203
South America:						
Argentina	[5] 45	7	2	7	11	---------
Bolivia (exports)[4]	9,128	5,907	5,635	7,026	5,818	6,065
Peru [4]	970	960	1,068	920	964	902
Total	10,143	6,874	6,705	7,953	6,793	6,967
Europe:						
Austria	503	493	489	430	514	631
Czechoslovakia [5]	1,850	1,800	1,800	1,800	1,800	1,800
France	396	103	258	---------	---------	---------
Greece	408	---------	---------	---------	---------	---------
Italy	604	402	309	138	130	175
Portugal	41	---------	---------	11	7	[5] 7
Spain	214	210	250	220	220	[5] 180
Yugoslavia (metal)	1,617	1,769	1,767	1,950	1,835	2,514
Total [1] [5]	5,600	4,800	4,900	4,500	4,500	5,300
Asia:						
Burma [4]	103	65	90	70	90	240
China [5]	9,300	13,000	14,300	15,400	16,500	16,500
Iran [6]	171	63	44	[5] 110	160	[5] 160
Japan	260	357	619	474	298	390
Thailand	75	28	41	2	---------	10
Turkey	1,613	1,841	1,063	1,232	[7] 1,687	[7] 1,380
Total [5]	11,500	15,400	16,200	17,300	18,700	18,700
Africa:						
Algeria	1,829	1,328	2,641	1,547	1,106	1,135
Morocco:						
Northern zone	295	397	330	360	203	254
Southern zone	703	327	---------	---------	---------	---------
Rhodesia and Nyasaland, Fed. of: Southern Rhodesia	61	223	72	83	151	104
Union of South Africa	9,426	15,640	15,689	11,021	7,904	13,619
Total	12,314	17,915	18,732	13,011	9,364	15,112
Oceania: Australia	272	344	322	543	775	[5] 800
World total (estimate)[1]	49,000	51,000	54,000	50,000	44,000	52,000

---

[1] Antimony is also produced in Hungary and U.S.S.R., but production data are not available. No estimates are included in the total.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Antimony content of smelter products exclusively from mixed ores.

[4] Includes antimony content of smelter products derived from mixed ores.

[5] Estimate.

[6] Year ended March 20 of year following that stated.

[7] Exports.

TECHNOLOGY

Production of superpure antimony for use in manufacturing semiconductors was expanded in the United States in 1959.[4]

Progress was also reported in the U.S.S.R. in the production of indium, aluminum, and gallium antimonide crystals for use in semiconductors, and investigations were conducted on clarifying the role played by impurities.[5]

An investigation was conducted of the uranium-antimony system covering the complete composition range.[6] A method of processing antimony sulfide to improve the purity of the product [7] and the manufacture of an improved antimony oxide-silica pigment [8] were reported. The vacuum extraction of antimony from low-grade sulfide ore was also described.[9]

---

[4] Wallace Miner, Transistor Antimony is New Product of Bunker: Vol. 53, No. 43, Nov. 26, 1959, p. 1. Battelle Technical Review, Purest Crystals from Compounds: Vol. 8, No. 12, December 1959 (inside front cover).

[5] Kolomeyets, B. T. [Investigation of Semiconductor Materials]: Vestnik Akad. Nauk S.S.S.R., Moscow, vol. 29, No. 10, October 1959, pp. 107–108.

[6] Beaudry, B. J., and Daane, A. H., The Antimony-Uranium Alloy System: Trans. Metallurgical Soc. of AIME, vol. 215, No. 2, April 1959, pp. 199–203.

[7] Bundy, W. S. (assigned to Barium & Chemicals, Inc.), Liquation of Antimony Sulfide: U.S. Patent 2,890,102, June 9, 1959.

[8] Dunn, E. J., and Kushner, M. (assigned to National Lead Co.), Composite Antimony Oxide-Silica Pigment and Process of Manufacture: U.S. Patent 2,882,178, Apr. 14, 1959.

[9] Darling, A. S., Low Pressure Metallurgy: Metallurgica, Manchester, vol. 60, No. 360, October 1959, pp. 137–143.

Arsenic

By A. D. McMahon [1] and Gertrude N. Greenspoon [2]

PRODUCTION of white arsenic in the United States in 1959 was the lowest since 1914, principally because of strikes in the copper-producing industry during the last half of the year. However, the drop in domestic output was more than offset by larger imports, so that the domestic supply of arsenic rose 30 percent over 1958.

TABLE 1.—Salient statistics of white arsenic, in short tons

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Production	13,835	10,780	12,201	10,493	11,508	5,189
Shipments	12,753	11,673	18,876	12,785	10,931	7,239
Imports	8,668	7,222	6,422	10,135	9,524	19,386
Producers' stocks at end of year	8,372	11,571	4,827	2,535	3,112	1,058
Apparent consumption [1]	21,421	18,895	25,298	22,920	20,455	26,625
Price [2] cents per pound	6	5½	5½	5½	5½	4–5
World: Production	47,000	[3] 45,000	[3] 48,000	[3] 40,000	[3] 39,000	47,000

[1] Producers' shipments, plus imports, minus exports; no exports were reported by producers, 1950–59.
[2] Refined white arsenic, carlots, as quoted by E&MJ Metal and Mineral Markets.
[3] Revised figure.

DOMESTIC PRODUCTION

Domestic production of white arsenic decreased 6,300 tons in 1959 to the lowest quantity since 1914, owing mainly to strikes at copper plants that began in mid-August. The entire output was a byproduct of smelting complex copper and lead ores by The Anaconda Co., United States Smelting, Refining and Mining Co., and American Smelting and Refining Co. Arsenic metal was not produced in 1959.

TABLE 2.—Production and shipments of white arsenic by United States producers

Year	Crude			Refined			Total		
	Production, short tons [1]	Shipments		Production, short tons	Shipments		Production, short tons	Shipments	
		Short tons	Value		Short tons	Value		Short tons	Value
1950–54 (average)	13,082	11,978	$696,105	753	775	$64,226	13,835	12,753	$760,331
1955	9,968	10,986	501,104	812	687	53,557	10,780	11,673	554,661
1956	11,423	18,048	685,145	778	828	69,524	12,201	18,876	754,669
1957	9,814	11,980	475,629	679	805	54,721	10,493	12,785	530,350
1958	11,121	10,544	421,777	387	387	37,884	11,508	10,931	459,661
1959	4,897	6,922	293,940	292	317	27,315	5,189	7,239	321,255

[1] Excludes crude consumed in making refined.

---

[1] Commodity specialist.
[2] Statistical assistant.

CONSUMPTION AND USES

Most of the output of white arsenic in 1959 was consumed in manufacturing lead and calcium arsenate insecticides. Arsenic compounds were also used in weedkillers, glass manufacture, cattle and sheep dips, dyestuffs, and wood preservatives. Apparent consumption of white arsenic totaled 26,600 tons, a 30-percent increase over 1958 and the largest consumption since 1951.

Owing to increased demand in semiconductor compounds and low-melting glasses, capacity for producing high-purity arsenic was increased.[3] It was stated that the high-purity arsenic contained less than 1 p.p.m. of copper and a total of about 1 p.p.m. of selenium, sulfur, and halogens.

TABLE 3.—Production of arsenical insecticides and consumption of arsenic wood preservatives in the United States, in short tons

Year	Production of insecticides [1]		Consumption of wood preservatives [2]
	Lead arsenate (acid and basic)	Calcium arsenate (70 percent $Ca_3(AsO_4)_2$)	Wolman salts (25 percent sodium arsenate)
1950-54 (average)	10,895	10,390	827
1955	7,388	1,885	1,067
1956	5,878	13,553	1,005
1957	5,960	9,739	1,068
1958	7,469	5,216	1,082
1959	(3)	(3)	[4] 1,272

[1] Bureau of the Census, U.S. Department of Commerce.
[2] Forest Service, U.S. Department of Agriculture.
[3] Data not available.
[4] Preliminary figures.

STOCKS

Producers' stocks of white arsenic totaled 1,100 tons at the end of 1959—66 percent below 1958 and lower than in any year since 1947. Data are not available on stocks of calcium and lead arsenate held by producers.

PRICES

White arsenic was quoted at 5½ cents per pound (powdered, in barrels, carlots, delivered) from the beginning of 1959 until early in May. Thereafter, it was quoted at a range of 4–5 cents, New York, through the end of 1959. According to the Oil, Paint and Drug Reporter, calcium arsenate, in carlots, was quote at 9–9¼ cents throughout 1959. The price for lead arsenate, carlots (3-pound bags), was 26½ cents per pound until late April, when it was advanced to 30½ cents and where it remained through the end of the year.

The London price for white arsenic, per long ton, 98–100 percent, was £40–£45 (equivalent to 5.00–5.63 cents per pound) throughout 1959 and for arsenic metal, per long ton, £400 (50.00 cents per pound).

---

[3] Oil, Paint and Drug Reporter, Arsenic Capacity Increased at American Smelting Labs: Vol. 176. No. 19. Nov. 2. 1959. p. 5.

FOREIGN TRADE [4]

Imports.—White arsenic imported for consumption in 1959 totaled 19,400 tons, more than double the 1958 receipts. Mexico continued to be the principal supplier with 65 percent of the total imports, followed by France with 18 percent and Sweden with 14 percent.

Forty-two tons of arsenic metal was received in 1959, of which 25 tons came from Sweden and 17 tons from the United Kingdom. Belgium-Luxembourg supplied 21 tons of arsenic sulfide, and Australia furnished 58 tons of arsenical sheepdip. Of the 76 tons of sodium arsenate imported in 1959, 60 tons came from the United Kingdom and 16 tons from France.

TABLE 4.—White arsenic (As_2O_3 content) imported for consumption in the United States, by countries

[Bureau of the Census]

Country	1950-54 (average)		1955		1956	
	Short tons	Value	Short tons	Value	Short tons	Value
North America:						
Canada	385	$34,881	683	$43,048	540	$49,387
Mexico	7,280	799,069	6,431	713,911	5,831	691,354
Total	7,665	833,950	7,114	756,959	6,371	740,741
South America: Peru	12	1,294	---	---	---	---
Europe:						
France	524	61,407	75	5,880	12	927
Sweden	202	20,349	33	2,413	33	2,954
Other countries [1]	210	10,091	---	---	6	575
Total	936	91,847	108	8,293	51	4,456
Asia: Japan	55	7,836	---	---	---	---
Grand total	8,668	934,927	7,222	765,252	6,422	745,197

Country	1957		1958		1959	
	Short tons	Value	Short tons	Value	Short tons	Value
North America:						
Canada	1,508	$119,427	800	$63,353	607	$49,116
Mexico	6,851	604,932	6,052	541,795	12,528	962,894
Total	8,359	724,359	6,852	605,148	13,135	1,012,010
South America: Peru	---	---	---	---	---	---
Europe:						
France	981	34,770	1,201	49,532	3,504	153,336
Sweden	779	34,317	1,471	64,932	2,746	176,043
Other countries [1]	16	989	---	---	1	122
Total	1,776	70,076	2,672	114,464	6,251	329,501
Asia: Japan	---	---	---	---	---	---
Grand total	10,135	794,435	9,524	719,612	19,386	1,341,511

[1] Includes Belgium-Luxembourg, Germany, Poland-Danzig, and the United Kingdom.

---

[4] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 5.—Arsenicals imported into and exported from the United States, by classes, in pounds

[Bureau of the Census]

Class	1950–54 (average)	1955	1956	1957	1958	1959
Imports for consumption:						
White arsenic (As_2O_3 content)	17, 336, 159	14, 443, 828	12, 843, 816	20, 270, 069	19, 048, 920	38, 771, 199
Metallic arsenic	135, 396	228, 960	88, 666	136, 745	61, 660	84, 769
Sulfide	63, 074	93, 717	84, 894	42, 094	126, 354	41, 872
Sheepdip	69, 964	40, 960	70, 421	67, 763		116, 785
Lead arsenate	34, 997					
Arsenic acid	1, 520					
Calcium arsenate	403, 391		60, 000			
Sodium arsenate	121, 700	172, 175	229, 616	328, 049	173, 337	152, 769
Paris green	25, 979					
Exports:						
Calcium arsenate	4, 137, 345	1, 885, 582	628, 020	2, 779, 954	1, 274, 000	122, 920
Lead arsenate	586, 867	1, 080, 498	2, 563, 176	1, 216, 158	2, 099, 960	1, 398, 900

Exports.—No direct foreign sales of white arsenic were reported by U.S. producers. Exports of calcium arsenate totaled 61 tons, valued at $12,187, of which 49 tons went to Canada and 12 to Peru.

Exports of lead arsenate totaled 699 tons valued at $276,420. Peru received 631 tons, Canada 22, Costa Rica and Republic of Philippines 14 each, France 8, Nicaragua 5, and three other countries the remainder (in lots of less than 5 tons each).

Tariff.—White arsenic, arsenic sulfide, Paris green, and sheepdip (certain varieties contain arsenic) were free of duty. Arsenic acid was subject to a duty of 3 cents per pound and lead arsenate to a duty of 1.5 cents per pound. The duty on metallic arsenic of 2.5 cents per pound, effective June 30, 1958, continued throughout 1959. Compounds of arsenic not specified in the Tariff Act were subject to a duty of 12½ percent of their foreign market value.

WORLD REVIEW

Canada.—Refined white arsenic has been produced in Canada almost continuously since 1885. The Deloro Smelting & Refining Co., Ltd., the only producer in recent years, recovered white arsenic from smelting silver-cobalt concentrate from the Cobalt and Gowganda areas in northern Ontario. Arsenic occurs in the concentrate as arsenides and sulfarsenides of cobalt, iron, and nickel.[5]

Mexico.—Output of white arsenic in Mexico rose from 3,400 tons in 1958 to 11,500 tons of 1959—higher than in any year since 1951. All exports, totaling 7,100 tons, came to the United States.

Sweden.—The entire output of white arsenic in Sweden was produced by Boliden Mining Co., which continued to be the leading world producer. Exports in 1958 totaled 16,700 tons, of which 6,900 tons went to the United Kingdom, 3,600 tons to the Union of South Africa, 1,900 tons to the United States, and 1,750 tons to Australia. In 1959 exports of white arsenic fell to 12,800 tons; data by country of destination are not available.

---

[5] Ross, J. S., Arsenic Trioxide: Canadian Mineral Industry—1958 (Preliminary), Dept. Mines and Tech. Surveys, Ottawa, Canada, Review 28, April 1959. 5 pp.

TABLE 6.—World production of white arsenic, by countries,[1] in short tons [2]

[Compiled by Augusta W. Jann and Berenice B. Mitchell]

Country [1]	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada	744	786	895	1,849	1,162	944
Mexico	6,403	3,256	2,913	5,075	3,411	11,533
United States	13,835	10,780	12,201	10,493	11,508	5,189
South America:						
Brazil	1,098	1,077	819	188	292	[3] 300
Peru	24	---	28	22	369	[3] 330
Europe:						
Belgium (exports)	1,490	2,281	3,056	2,280	543	[3] 3,090
France	4,734	6,369	9,455	[4] 4,716	[4] 6,339	[3] [4] 9,040
Germany, West (exports)	1,228	635	334	216	205	[3] 175
Greece	53	42	45	11	13	[3] 13
Italy	1,437	1,166	1,173	1,087	736	[3] 550
Portugal	970	1,973	1,109	898	[3] 880	[3] 880
Spain	152	---	---	---	285	---
Sweden	12,989	13,803	13,437	11,130	11,194	12,787
Asia: Japan	1,537	1,910	1,833	1,521	1,429	[3] 1,400
Africa: Rhodesia and Nyasaland, Federation of: Southern Rhodesia	331	508	1,084	883	683	528
Oceania: Australia	89	---	---	---	---	---
World total (estimate) [1] [2]	47,000	45,000	48,000	40,000	39,000	47,000

[1] Arsenic may be produced in Argentina, Austria, China, Czechoslovakia, Finland, East Germany, Hungary, U.S.S.R., and United Kingdom, but there is too little information to estimate production.

[2] This table incorporates a number of revisions. Data do not add to totals because of rounding where estimated figures are included in the detail.

[3] Estimate.

[4] Exports.

TECHNOLOGY

An analytical procedure was described for determining microquantities of arsenic that are found in plant materials after treatment with fungicides or insecticides.[6] The method, which involved wet-ashing the material followed by distillation in a special apparatus, detected 0.02 to 1.2 p.p.m. of arsenic per sample by direct reading from a standard curve.

Although several instruments have been developed for detecting arsine, a hemolytic poison, none would disclose the presence of other arsenic compounds. To overcome this deficiency, a continuous monitor was developed that will detect many arsenic-bearing materials that are dangerous but not as poisonous as arsine.[7] In the operation of the detector, arsenic compounds in the air were reacted with hydrogen in a chamber to produce arsine; the arsine-bearing gas was scrubbed to remove hydrogen sulfide; and the gas was dispersed in a pyridine solution of silver diethyldithiocarbamate, which changes color from pale yellow to various shades of red in the presence of arsine. When the color of the reagent changed, a colorimeter actuated a relay which sounded an alarm bell. As little as 5 micrograms of arsenic arsine was detected.

High-purity arsenic containing 1.1×10^{-9} atomic fraction of sulfur, 2×10^{-8} of selenium, and 2×10^{-8} of tellurium was produced by an improved distillation technique.[8] The procedure consisted of heating

---

[6] Frehse, Helmut, and Tietz, Helmut, Quantitative Determination of Arsenic Residues in Plant Materials: Agric. and Food Chem., vol. 7, No. 8, August 1959, pp. 553–558.

[7] Chemical and Engineering News, Instrument Eyes Arsenic: Vol. 37, No. 6, Feb. 9, 1959, p. 54.

[8] Chemical and Engineering News, Ultrapure Arsenic Made: Vol. 37, No. 44, Nov. 2, 1959, p. 40.

one part by weight of purified arsenic with two parts by weight of lead at 600° C., in an evacuated chamber. The arsenic was vaporized from the one-phase liquid melt and condensed in another part of the apparatus, leaving most of the impurities in the lead. Radioactive tracer studies were used to determine the purity of the arsenic. Ultrapure arsenic is used in producing high-purity gallium arsenide and indium arsenide, which may be useful in transistors.

Another use of arsenic in the semiconductor industry was announced.[9] Arsenic was combined with silver to form an alloy that has a melting point of 1,800° F.—well above the usual 1,200° F. range of alloy junction materials. The alloy, containing 99 percent silver and 1 percent arsenic, was produced in spheres ranging from 0.001 to 0.125 inch in diameter.

---

[9] American Metal Market, Silver-Arsenic for Transistor Junctions: Vol. 67, No. 9, Jan. 14, 1960, p. 6.

Asbestos

By D. O. Kennedy [1] and James M. Foley [2]

❖

THE UNITED STATES consumed 33 percent of the world output of asbestos in 1959 but produced only 6 percent of its requirements. Although the Nation ranked seventh among world producers, its output was only 2 percent of world production. Canada, with its extensive asbestos deposits in Quebec, produced almost 50 percent of the world supply.

TABLE 1.—Salient statistics of the asbestos industry

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Production (sales)...short tons..	50, 004	44. 568	41, 312	43, 653	43, 979	45, 325
Value (thousands)...........	$4, 221	$4, 487	$4, 742	$4, 918	$5, 127	$4, 379
Imports (unmanufactured) short tons..	709, 487	740, 423	689, 910	682, 732	644, 331	713, 047
Value (thousands)...........	$56, 604	$60, 958	$61, 939	$60, 104	$58, 314	$65, 006
Exports (unmanufactured)[1] short tons..	10, 622	2, 787	2, 950	2, 893	3, 026	4, 461
Value (thousands)...........	$2, 260	$268	$375	$350	$424	$793
Apparent consumption short tons..	748, 869	782, 204	728, 272	723, 492	685, 284	753, 911
Exports of asbestos products[1] (thousands)....................	$11, 522	$12, 859	$14, 181	$15, 223	$13, 233	$12, 921
World: Production......short tons..	[2] 1,580, 000	1, 950, 000	1, 980, 000	2, 070, 000	[2] 2,060, 000	2, 270, 000

[1] Includes material that has been imported and later exported without change.
[2] Revised figure.

Invitations for bids were sent to Arizona asbestos producers for 500 tons of domestic low-iron asbestos to be used for the national stockpile.

The Commodity Credit Corporation arranged a barter program for amosite and crocidolite asbestos. Producers of crocidolite in the Union of South Africa and Australia expressed interest in the program.

DOMESTIC PRODUCTION

Asbestos production in the United States increased nearly 3 percent compared with 1958. An estimated 1 million tons of rock was mined, from which 45,000 tons of fiber was recovered.

The Vermont Asbestos Mines Division of Ruberoid Co., at Belvedere Mountain near Hyde Park, Vt., was the one large asbestos producer in the United States. A modern mill recovered fibers carefully classified in strict accordance with Canadian grading standards. The small output of spinning fiber was used in electrolytic cells rather than in textiles.

---

[1] Assistant chief, Branch of Construction and Chemical Materials.
[2] Supervisory statistical assistant.

Jaquays Mining Corp. and Phillips Asbestos Mines were the only producers in Arizona; however, shipments were also made by two other firms, American Fiber Corp. and Metate Asbestos Corp. With the termination of purchases by the Government of crudes 1, 2, and 3 on December 31, 1958, sales of these grades in 1959 decreased to 1 ton of Crude 1, none of Crude 2, and 583 tons of Group 3. The new mills of Jaquays Mining Corp. and Metate Asbestos Corp. began operating and some rejected material from former operations was processed at the Metate mill.

Two firms, the Asbestos Bonding Co. and Ray Sylvester, operated in California. The former produced short chrysotile asbestos from the Phoenix claim, Napa County, and the latter tremolite from the Sylvester asbestos claim, Shasta County.

Amphibole asbestos was produced by the Powhatan Mining Co. from the Kilpatrick claim in North Carolina.

The Bureau of Mines issued a report describing asbestos deposits in northern California.[3] The Clute Corp. of Littleton, Colo., acquired Asbestos Bonding Corp., Napa, Calif., and announced plans to install a 1,000-ton-per-day mill to produce 7-R and fine asbestos.[4] The Jefferson Lake Sulphur Co. purchased the Copperopolis, Calif., property of American Asbestos Mining Corp. after a diamond-drilling program had outlined 15 million tons of ore. The firm announced plans to erect a mill to process 2,000 tons of ore per day. Union Carbide Nuclear Corp. explored an asbestos occurrence 35 miles northwest of Coalinga, Fresno County, and National Mill and Mining Co., Inc., began construction of a mill at Coalinga.

CONSUMPTION AND USES

Consumption of chrysotile asbestos increased from 643,000 tons in 1958 to 711,000 tons in 1959. A general rise in construction accounted for most of the increase; over 96 percent of the chrysotile consumed was short fiber, which is used principally in asbestos-cement and asbestos-asphalt building materials. Increased use of asbestos fibers in plastics,[5] in asbestos-phenolic linings for missiles,[6] and as a mineral filler[7] was indicated.

PRICES

Prices of Canadian chrysotile asbestos were reduced twice during 1959 as follows:

Grade:	*Price per ton*		
	Jan. 1	*Oct. 10*	*Nov. 10*
Crude No. 1	$1,520–$1,900	$1,475–$1,850	$1,410–$1,475
Crude No. 2—and sundry	810– 1,230	790– 1,200	610– 875
No. 3—Spinning fiber	380– 670	370– 650	350– 650
No. 4—Shingle fiber	185– 250	180– 245	180– 245
No. 5—Paper fiber	125– 155	120– 150	120– 150
No. 6—Plaster fiber	89	86	86
No. 7—Shorts	40– 80	40– 80	40– 80

---

[3] Wiebelt, F. J., and Smith, M. Clair, A Reconnaissance of Asbestos Deposits in the Serpentine Belt of Northern California: Bureau of Mines Inf. Circ. 7860, 1959, 52 pp.

[4] Engineering and Mining Journal, Chrysotile Asbestos Plant Will Be Expanded: Vol. 160, No. 12, December 1959, p. 128.

[5] Electronic News, Asbestosized Plastics Held Growing in Parts: Vol. 4, No. 128, Feb. 9, 1959, p. 17.

[6] Missiles and Rockets, Asbestos Availability: Vol. 6, No. 3, Jan. 18, 1960, p. 40.

[7] Dietrich, W. F., Market Trends for Mineral Fillers in Western States: Min. Eng., vol. 11, No. 8, August 1959, pp. 813–817.

British Columbia chrysotile asbestos prices as quoted in E&MJ Metal and Mineral Markets were unchanged as follows: Per short ton f.o.b. Vancouver, British Columbia (Canadian currency effective Oct. 1, 1957), crude No. 1 $1,568, AAA $811, AA $703, A $509, AC $335, and AK $227. The AAA fiber corresponds to Rhodesian C&G 1, AA to C&G 2, A to Canadian 3K, AC to Rhodesian C&G 3, and AK to Canadian 4K.

Prices of Vermont asbestos per short ton, f.o.b. Hyde Park or Morrisville, changed in November as follows:

	Jan. 1, 1959	*Nov. 10, 1959*
Group 3 (spinning and filtering)	$370–$428	$353–$440
Group 4 (shingle)	181– 200	181– 218
Group 5 (paper)	120– 152	120– 142
Group 6 (plaster)	86	86
Group 7 (shorts)	41– 75	41– 75

Prices of Arizona asbestos, published in Asbestos magazine, were based upon monthly figures furnished by Arizona producers. The method of classifying Arizona price quotations of crudes 1, 2, and 3, soft and semisoft, and filter fiber, was changed as follows:

	Per short ton, f.o.b Globe	
Grade:	*May 10, 1959*	*Dec. 10, 1959*
No. 1 crude	$1, 475–$1, 850	$1, 475–$1, 850
No. 2 crude	830– 1, 260	830– 1, 260
Group 3	375– 675	350– 450
Group 4	190– 250	190– 250
Group 5	125– 177	125– 177
Group 7	60	60– 100

Market quotations are not available for African or Australian asbestos, because purchases and sales are negotiated individually. U.S. Department of Commerce reports show the following average values per short ton for imports:

	1958	*1959*
Imports:		
Amosite	$150. 44	$153. 10
Crocidolite:		
Bolivia	70. 00	-------
Australia	213. 57	205. 99
Union of South Africa	192. 45	199. 13

FOREIGN TRADE [8]

Imports of crocidolite increased 3 percent, imports of amosite decreased 2 percent, and imports of chrysotile increased 11 percent compared with 1958, resulting in a net increase of 11 percent in total imports of asbestos in 1959.

Nearly 97 percent of the chrysotile imported was short fiber of less than spinning length. Imports of low-iron chrysotile of spinning length from British Columbia increased from 4,779 tons in 1958 to 5,988 tons in 1959.

---

[8] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

Imports from Australia consisted solely of crocidolite. The Union of South Africa supplied crocidolite and chrysotile and was the only source of amosite. Only chrysotile was imported from other countries.

Exports of unmanufactured asbestos increased slightly. Compared with imports they were insignificant.

TABLE 2.—Asbestos (unmanufactured) imported for consumption in the United States, by countries and classes

[Bureau of the Census]

Country	Crude (including blue fiber)		Mill fibers		Short fibers		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1958								
North America: Canada	707	$277,934	134,190	$24,452,416	450,527	$23,643,514	585,424	$48,373,864
South America:								
Bolivia	11	770	------	------	------	------	11	770
Venezuela	6	824	17	2,160	25	3,870	48	6,854
Europe:								
Finland	7	313	------	------	55	1,500	62	1,813
Italy	------	------	2	2,940	------	------	2	2,940
Portugal	4	560	------	------	14	1,455	18	2,015
Yugoslavia	4,090	196,251	------	------	------	------	4,090	196,251
Asia: Japan	------	------	------	------	6	1,653	6	1,653
Africa:								
British East Africa	------	------	9	706	50	6,266	59	6,972
Rhodesia and Nyasaland Federation of [1] [2]	7,178	1,221,092	660	132,035	294	42,470	8,132	1,395,597
Union of South Africa [3]	38,837	6,760,670	491	86,630	1,074	180,572	40,402	7,027,872
Oceania: Australia	6,077	1,297,860	------	------	------	------	6,077	1,297,860
Total	56,917	9,756,274	135,369	24,676,887	452,045	23,881,300	644,331	58,314,461
1959								
North America: Canada	339	109,269	149,341	28,184,066	504,845	26,681,457	654,525	54,974,792
South America: Venezuela	------	------	90	11,800	26	2,200	116	14,000
Europe:								
Finland	102	3,630	------	------	123	3,000	225	6,630
Italy	------	------	8	9,525	------	------	8	9,525
Portugal	14	1,680	------	------	------	------	14	1,680
U.S.S.R	3	643	------	------	------	------	3	643
Yugoslavia	5,646	212,869	------	------	------	------	5,646	212,869
Africa:								
British East Africa	------	------	------	------	49	6,450	49	6,450
Rhodesia and Nyasaland, Federation of [1]	4,347	897,760	729	143,317	111	24,542	5,187	1,065,619
Union of South Africa [3]	36,446	6,485,909	1,511	322,986	760	141,860	38,717	6,950,755
Oceania: Australia	8,557	1,762,690	------	------	------	------	8,557	1,762,690
Total	55,454	9,474,450	151,679	28,671,694	505,914	26,859,509	713,047	65,005,653

---

[1] All believed to be from Southern Rhodesia.

[2] Includes 2 tons ($787) crysotile crudes, credited by the Bureau of the Census to the United Kingdom, and 4 tons ($589) credited to Mozambique, also 206 tons ($47,167) mill fibers, credited by the Bureau of the Census to the United Kingdom.

[3] Includes 1958: 51 tons ($10,800) blue crocidolite and 39 tons ($5,312) amosite crude credited by the Bureau of the Census to Mozambique; 1 ton ($405) amosite crude credited by the Bureau of the Census to West Germany; 880 tons ($125,723) blue crocidolite and 314 tons ($46,365) amosite crude credited by the Bureau of the Census to the Federation of Rhodesia and Nyasaland; 259 tons ($55,950) short fibers credited by the Bureau of the Census to the United Kingdom; and 42 tons short fibers ($5,475) credited to Mozambique. 1959: 75 tons ($9,066) other chrysotile crude, 2 tons ($787) blue crocidolite, 818 tons ($179,364) spinning fibers, and 446 tons ($92,517) short fibers credited by the Bureau of the Census to the United Kingdom; 8 tons ($6,580) amosite crude credited by the Bureau of the Census to Italy; 294 tons ($53,308) other chrysotile crude, 287 tons ($52,197) blue crocidolite, 73 tons ($10,303) short fibers credited by the Bureau of the Census to Mozambique; and 459 tons ($74,879) blue crocidolite, and 129 tons ($18,002) amosite crude credited by the Bureau of the Census to the Federation of Rhodesia and Nyasaland.

TABLE 3.—Asbestos imported for consumption in the United States, from specified countries, by grades, in short tons

[Bureau of the Census]

Grade	1958			1959		
	Canada	Southern Rhodesia [1]	Union of South Africa	Canada	Southern Rhodesia [1]	Union of South Africa
Chrysotile:						
Crude:						
No. 1	56	[2] 418	20	41	35	----------
No. 2	190	65	----------	30	20	----------
Other	461	[2] 6,695	2,133	268	4,292	[3] 1,826
Spinning or textile	18,915	460	466	20,488	527	[3] 1,173
Shingle	68,890	200	25	72,679	202	300
Paper	46,385	----------	----------	56,174	----------	38
Short fiber	450,527	294	[3] 1,074	504,845	111	[3] 760
Crocidolite (blue)	----------	----------	[3] 19,690	----------	----------	[3] 18,006
Amosite	----------	----------	[3] 16,994	----------	----------	[3] 16,614
Total	585,424	8,132	40,402	654,525	5,187	38,717

[1] Reported by the Bureau of the Census as Federation of Rhodesia and Nyasaland. Believed to be from Southern Rhodesia.

[2] Includes countries adjusted by Bureau of Mines. See table 2, footnote 2, for explanation.

[3] Includes countries adjusted by Bureau of Mines. See table 2, footnote 3, for explanation.

TABLE 4.—Exports (domestic[1] and foreign[2]) of asbestos and asbestos products from the United States, by kinds

[Bureau of the Census]

Products	1958		1959	
	Quantity	Value	Quantity	Value
Domestic:				
Unmanufactured:				
Crude and spinning fibers.........short tons	278	$85,979	1,216	$295,549
Nonspinning fibers.........do	514	88,907	802	200,003
Waste and refuse.........do	2,145	232,143	2,299	267,736
Total unmanufactured.........do	2,937	407,029	4,317	763,288
Products:				
Brake lining and blocks—Molded, semimolded and woven	(3)	4,612,458	(3)	4,673,987
Clutch facing and lining.........number	1,340,622	1,091,636	1,427,059	1,139,154
Construction materials, n.e.c.........short tons	13,961	2,758,785	11,031	2,423,793
Pipe covering and cement.........do	3,054	1,032,879	2,414	1,081,061
Textiles, yarn, and packing.........do	1,166	2,965,097	1,164	2,812,663
Manufactures, n.e.c.	(4)	764,740	(4)	771,660
Total products	----------	13,225,595	----------	12,902,318
Foreign:				
Unmanufactured:				
Crude and spinning fibers.........short tons	----------	----------	53	12,570
Nonspinning fibers.........do	30	6,252	19	3,600
Waste and refuse.........do	59	11,045	72	13,780
Total unmanufactured.........do	89	17,297	144	29,950
Products:				
Brake lining and blocks—Molded, semimolded and woven	(3)	740	(3)	18,519
Construction materials, n.e.c.........short tons	56	7,101	----------	----------
Total products	----------	7,841	----------	18,519

[1] Material of domestic origin, or foreign material that has been milled, blended, or otherwise processed in the United States.

[2] Material that has been imported and later exported without change.

[3] Values have been summarized; quantities not shown.

[4] Quantity not recorded.

WORLD REVIEW

NORTH AMERICA

Canada.—Production from 14 mills—12 in Quebec and 1 each in Ontario and British Columbia—increased about 14 percent. During the year 23.1 million tons of rock was mined and 1.1 million tons of fiber recovered from 14 million tons of ore milled. More than 7,000 men were employed in the Quebec mines.

Expansion of the asbestos producing industry resulted in overproduction, accumulation of large inventories at warehouses, and seasonal shutdowns at mines of Asbestos Corp., Ltd., and Johnson's Co., Ltd.[9]

Programs were started by the Canadian Johns-Mansville Co., Ltd., to give more emphasis to open-pit than underground mining at the Jeffery mine[10] in Quebec and to convert from open-pit to underground mining at the Munro mine in Ontario.

The first year of operations at National Asbestos Mines, Ltd., Thetford Mines, Quebec, was reportedly very successful.[11] Underground mining methods were described at five asbestos mines in Quebec.[12]

Operations of Cassiar Asbestos Corp., Ltd., in British Columbia were expanded; sales commitments in 1958 and 1959 necessitated the installation of mill equipment to increase daily capacity from 1,000 to 1,500 tons of ore.[13]

A test mill at Advocate Mines, Ltd., property in Newfoundland produced more than 200 tons of fiber, which was shipped to plants in the United States and Europe for further testing. Feed for the test mill was provided by underground exploration and development work. It was reported that diamond drilling at the Atomic Mining Corp. property in Quebec outlined 9 million tons of 5.1-percent asbestos ore. Exploration on the Chibougamau asbestos property in northwestern Quebec revealed three asbestos-bearing zones. A pilot mill was placed in operation by Golden Age Mines at its property near Beauceville in Quebec. The Murray Mining Corp. began drilling a large asbestos-bearing belt near Deception Bay in the Ungava region of northern Quebec. Encouraging results were reported.[14] The first plant for manufacturing asbestos-cement pipe in Quebec opened in May at Montreal East.

SOUTH AMERICA

Argentina.—Exploration was begun in Jaque, La Rioja Province, of deposits reportedly containing chrysotile, some anthophyllite, and crocidolite.

---

[9] Northern Miner (Toronto), Asbestos Industry Hits Seasonal Lag Improvement in 1959: Vol. 45, No. 44, Jan. 21, 1960, p. 3.

[10] Asbestos, Change in Jeffery Mine Program: Vol. 41, No. 2, August 1959, pp. 10, 12, 14.

[11] Meschter, Elwood, National Gypsum Co. Jumps into Asbestos Production: Rock Products, vol. 62, No. 7, July 1959, pp. 94–96, 98, 100.

[12] Sinclair, W. E., Underground Mining in Canadian Asbestos Mines: Asbestos, vol. 41, No. 1, July 1959, pp. 2, 4, 6, 8, 10.

[13] Northern Miner (Toronto), Cassiar Asbestos Shows Higher Net Mill Being Enlarged: Vol. 45, No. 41, Dec. 31, 1959, pp. 1, 8.

[14] Northern Miner (Toronto), Mine Chances Good for Murray Mining in Asbestos Field: Vol. 45, No. 24, Sept. 3, 1959, pp. 1, 7.

TABLE 5:—World production of asbestos by countries,[1] in short tons [2]

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country [1]	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada (sales) [3]	922,645	1,063,802	1,014,249	1,046,086	925,331	1,050,429
United States (sold or used by producers)	50,004	44,568	41,312	43,653	43,979	45,325
Total	972,649	1,108,370	1,055,561	1,089,739	969,310	1,095,754
South America:						
Argentina	212	1,380	238	319	285	[4] 275
Bolivia (exports)	377	----------	62	121	----------	168
Brazil	1,599	3,124	3,739	2,654	3,816	[4] 3,300
Chile	170	----------	----------	----------	----------	----------
Venezuela	371	1,757	5,041	8,390	9,152	5,095
Total	2,729	6,261	9,080	11,484	13,253	[4] 8,800
Europe:						
Bulgaria	685	1,323	1,100	1,100	1,100	[4] 1,100
Finland [5]	11,299	18,674	8,282	10,031	7,977	9,420
France	10,048	14,459	9,370	15,731	20,503	26,455
Greece	20	3	6	9	----------	----------
Italy	25,161	35,385	39,446	37,797	39,627	49,594
Portugal	193	56	35	64	98	[4] 110
Spain	60	----------	----------	----------	----------	----------
U.S.S.R.[4]	300,000	450,000	500,000	500,000	550,000	600,000
Yugoslavia	2,646	4,305	4,165	5,025	5,960	4,748
Total [4]	350,000	525,000	560,000	570,000	625,000	690,000
Asia:						
China [4]	8,000	23,000	26,000	33,000	66,000	88,000
Cyprus	16,980	15,306	15,375	15,028	16,494	[6] 15,943
India	604	1,564	1,378	1,910	1,190	1,464
Iran [7]	12	110	[4] 165	[4] 165	[4] 165	[4] 165
Japan	5,501	6,932	9,914	13,192	11,179	13,669
Korea, Republic of	46	66	54	96	22	88
Taiwan	93	403	118	268	47	150
Turkey	82	259	634	99	839	[4] 40
Total [4]	31,000	48,000	54,000	64,000	96,000	120,000
Africa:						
Bechuanaland	425	1,426	1,356	1,582	1,734	1,410
Eritrea	[8] 55	----------	----------	55	28	[4] 30
Egypt	389	----------	----------	22	485	[4] 400
Kenya	290	152	170	109	120	45
Morocco: Southern zone	612	631	379	132	----------	----------
Mozambique	40	301	202	152	284	74
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	80,345	105,261	118,973	132,124	127,115	119,699
Swaziland	32,529	32,613	29,875	30,727	25,261	24,807
Uganda	1	2	2	----------	5,600	6,418
Union of South Africa	106,518	119,699	136,520	157,474	175,644	182,405
Total	221,204	260,085	287,477	322,377	336,271	335,288
Oceania:						
Australia	4,014	5,993	9,709	14,670	15,570	[4] 20,000
New Zealand	344	172	368	230	454	[4] 450
Total	4,358	6,165	10,077	14,900	16,024	[4] 20,450
World total (estimate) [1] [2]	1,580,000	1,950,000	1,980,000	2,070,000	2,060,000	2,270,000

---

[1] Asbestos also is produced in Czechoslovakia, North Korea, and Rumania. No estimates for these countries are included in the total, as production is believed to be negligible.

[2] This table incorporates some revisions. Data do not add to totals shown because of rounding where estimated figures are included in the detail.

[3] Exclusive of sand, gravel, and stone (waste rock only), production of which is reported as follows: 1950–54 (average) 33,796 tons; 1955, 28,582 tons; 1956, 45,427 tons; 1957, 13,652 tons; 1958, 18,450 tons; 1959, 29,532 tons.

[4] Estimate.

[5] Includes asbestos flour.

[6] Exports.

[7] Year ended March 20 of year following that stated.

[8] Average for 1 year only, as 1954 was first year of commercial production.

TABLE 6.—Sales of asbestos in Canada by grades

[Dominion Bureau of Statistics]

Grades	1958			1959		
	Short tons	Value		Short tons	Value	
		Total (thousands)	Average per ton		Total (thousands)	Average per ton
Crude No. 1, 2, and other	605	$617	$1,020	432	$491	$1,137
Milled group:						
3	24,900	10,852	436	30,375	13,338	439
4	215,670	40,717	189	238,185	44,210	186
5	101,992	13,025	128	135,459	17,409	129
6	138,747	11,325	82	166,346	13,838	83
7	427,665	18,208	43	465,052	20,256	44
8	15,752	324	21	14,580	303	21
Total, all grades	925,331	95,068	103	1,050,429	109,845	105
Waste rock	18,450	24	1	29,532	29	1

EUROPE

Finland.—The use of anthophyllite asbestos in Finland was described.[15] Anthophyllite has been used in acid-resistant cement, compounds, and plastics in which acid-resistant fibers of moderate strength can be used. Small quantities of short fiber (approximate value $30 per ton) were exported to the United States in 1958 and 1959.

Greece.—Exploration of the Macedonian asbestos deposit by Kennecott Copper Corp. outlined a large body of fiber suitable for use in the asbestos-cement industry. Plans to develop the property were underway.

Rumania.—New asbestos deposits were reported at Socet, Urdele, and Mutinu in the Paring, Poiana Rusca, and Sebes Mountains.

Yugoslavia.—Most of the asbestos produced in Yugoslavia was very short fiber, and the bulk (approximate value $50 per ton) was exported to the United States. Requirements for longer crude material were met by imports, mainly from U.S.S.R.

ASIA

India.—Asbestos was mined in opencut mines in five States and in an underground mine at Cuddapah, Andhra State. Domestic production supplied less than one-tenth of the demand of the growing asbestos-cement industry. Nearly two-thirds of the imported asbestos in 1958 came from Southern Rhodesia.[16]

Japan.—The Hokkaido deposits of the Yamabe district supplied almost all of the output of chrysotile asbestos. Imported asbestos, primarily from Canada and Union of South Africa, was more than 40,000 tons.[17]

Malaya, Federation of.—The Malayan Nozawa Asbestos Co., Ltd., announced plans to build an asbestos-sheet manufacturing plant.

---

[15] Kosonen, E., Over 50 Years of Asbestos Mining in Finland: Asbestos, vol. 40, No. 12, June 1959, pp. 24, 26, 28.

[16] Gilbert, H. A., India Still Needs Asbestos: Foreign Trade (Ottawa), vol. 112, No. 6, Sept. 12, 1959, pp. 15–16.

[17] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 3, March 1960, pp. 4–5.

Pakistan.—The first asbestos-cement sheet plant in Pakistan opened in August 1959. Domestic cement and imported asbestos were used as raw materials. Imports of asbestos sheets were banned by the Government to encourage and assist the new enterprise.

AFRICA

Nigeria.—An Italo-Anglo-Nigerian company was formed to construct a plant for manufacturing asbestos-cement products in Nigeria. Two English groups agreed to furnish the capital and to use Italian technicians and machinery in the project.

Rhodesia and Nyasaland, Federation of.—The Rhodesian and General Asbestos Corp., Ltd. (Turner and Newall), acquired Rhodesian Asbestos Co., Ltd. (Johns-Manville), and mined asbestos at the Temeraire mine, Meshaba area, Southern Rhodesia. Production of top-grade spinning fibers, corresponding to Canadian groups 1, 2, and 3, was more than 14 percent of the total production of asbestos in Southern Rhodesia, compared with 2.5 percent in Canada. Mines controlled by the Turner and Newall group produced over 75 percent of the total output of Southern Rhodesia.[18]

TABLE 7.—Asbestos produced in Southern Rhodesia

Year	Short tons	Value (thousands)	Year	Short tons	Value (thousands)
1955	105,261	$19,684	1958	127,115	$24,147
1956	118,973	23,832	1959	119,699	20,753
1957	132,124	25,185			

TABLE 8.—Asbestos produced in the Union of South Africa, by varieties and sources, in short tons

Variety and source	1955	1956	1957	1958	1959
Amosite (Transvaal)	50,137	50,097	56,798	69,773	71,720
Chrysotile (Transvaal)	20,535	24,336	25,646	27,403	29,326
Blue (Transvaal)	13,964	14,399	15,303	16,670	13,113
Blue (Cape)	34,878	47,688	59,549	61,520	68,024
Anthophyllite (Transvaal)	185				
Tremolite (Transvaal)			178	278	222
Total	119,699	136,520	157,474	175,644	182,405

TABLE 9.—Asbestos produced in and exported from the Union of South Africa

Year	Production (short tons)			Exports	
	Transvaal	Cape Province	Total	Short tons	Value (thousands)
1955	84,821	34,878	119,699	114,056	$18,625
1956	88,832	47,688	136,520	122,867	20,432
1957	97,925	59,549	157,474	142,799	25,278
1958	114,124	61,520	175,644	145,796	25,420
1959	114,381	68,024	182,405	151,515	25,971

---

[18] Mining Journal (London), Asbestos in Southern Rhodesia: Vol. 252, No. 6451, Apr. 10, 1959, pp. 392–393; vol. 254, No. 6495, Feb. 12, 1960, pp. 178–179.

Union of South Africa.—All operations at the chrysotile mine of Stoltzburg Asbestos Holding, Ltd., were suspended pending a special investigation of ore reserves, mining methods, and a possible increase in milling facilities.[19]

OCEANIA

Australia.—Australian Blue Asbestos, Ltd., reported recovery of 13,313 tons of fiber from 214,505 tons of ore milled. Eighty-six percent of the total Australian asbestos production was crocidolite.

Advancing the industrial economy of Australia was the installation at Regents Park, New South Wales, of the first asbestos-gasket manufacturing plant in the Southern Hemisphere.[20]

TECHNOLOGY

Several noteworthy publications on asbestos were issued. A revision of "A Materials Survey, Asbestos," by the late Oliver Bowles, contained the fundamental data needed by defense personnel responsible for emergency planning.[21] A new edition of a textbook on asbestos included new chapters on primary production and manufacture of asbestos products in North America.[22] The structure of the Canadian industry was outlined, and production and demand trends were discussed.[23] Two books on asbestos and other inorganic fibers discussed the traditional applications of asbestos fibers, the development of new products, and their use in the missile industry.[24] Practically all specifications for asbestos materials for electrical insulation have requirements for maximum amounts of total iron and magnetic iron. The significance of these requirements was discussed in an article summarizing the work of a subcommittee of the American Society for Testing Materials.[25]

Industrial television was installed in the Jeffery mine at Asbestos, Quebec, to improve hoisting efficiency. The skip attendant on the 940 level was able to see the skips in either of two dumping positions.[26]

A new asbestos-milling machine, with an inclined conveyor belt in place of aspiration equipment, was described.[27] Five patents were issued by the U.S. Patent Office on methods of opening and recovering asbestos fibers. A mechanic at the British Canadian mine, Black Lake, Quebec, developed a new sealing ring, which prevented the escape of dust from a cone crusher. Overhaul of the crusher to clean

---

[19] Mining World, Union of South Africa: Vol. 21, No. 2, February 1959, p. 78.

[20] Industrial and Mining Standard (Melbourne), Asbestos in Industry: Vol. 114, No. 2879, May 7, 1959, p. 3.

[21] Bowles, Oliver, Asbestos, A Materials Survey: Bureau of Mines Inf. Circ. 7880, 1959, 94 pp.

[22] Sinclair, W. E., Asbestos, Its Origin, Production, and Utilization: Min. Pub., Ltd., London, 1959, 512 pp.

[23] Bonkoff, E. J., Canadian Asbestos Industry: General Research Associates, Toronto, 1958, 41 pp.

[24] Rosato, D. V., Asbestos, Its Industrial Applications: Reinhold Publishing Corp., 1959, 214 pp.
Carroll-Porczynski, C. Z., Inorganic Fibres: Academic Press, 1959, 350 pp.

[25] Nicodemus, P. O., The Significance of Iron in Asbestos Materials Used for Electrical Insulating Purposes: ASTM Bull. 237, April 1959, pp. 62–67.

[26] Mine and Quarrying Engineering (London), Mine Television: Vol. 25, No. 8, August 1959, p. 376.

[27] Smith, C. V., A New Process for the Separation of Asbestos Fibre from Crushed Rock: Asbestos, vol. 40, No. 9, March 1959, pp. 14–18.

dust-fouled machine parts was reduced from once in 3 months to once in 15 months.

Technical service was reported to have an increasingly important role in the sale of asbestos fiber. Asbestos producers were advised to assist in developing and producing more efficient fiber and in developing new uses. Interpretation of consumer requirements into the most effective fiber production was said to be the primary role of technical service.[28]

The asbestos-cement products committee of the American Society for Testing Materials revised the specifications for asbestos-cement pipe, sheet, shingles, and siding. Four patents were issued for asbestos-cement products and for an apparatus that detaches pipe pneumatically from the mandrel on which it is found.

Numerous patents were issued covering the use of asbestos in special heat insulating applications, electrical insulators, vibration damping materials, filters, paint fillers, part of the porous material for filling acetylene containers, and drilling muds for use under conditions of high temperature.

A new motion picture on asbestos, produced in cooperation with the Johns-Manville Co., was added to the Bureau of Mines film library. The new film shows mining operations and describes the uses of asbestos fibers.

---

[28] Monroe, D. L., The Role of Technical Service in Today's Asbestos Fibre Market: AIME Preprint 59H308, September 1959, 7 pp.

Barite

By Albert E. Schreck[1] and James M. Foley[2]

⁂

PRODUCTION and consumption of barite increased in 1959, thus stemming the decline which began in 1957. Imports also increased substantially over 1958. Kentucky and Utah joined the ranks of barite-producing States.

DOMESTIC PRODUCTION

Output of primary barite from domestic mines gained 78 percent over 1958. Many of the mines that were inactive in 1958 resumed operations, although at a smaller rate than in the peak years of 1956 and 1957.

Arkansas was again the leading State in output and sales, and Missouri ranked second. Nevada and Georgia were in third and fourth places, respectively.

TABLE 1.—Salient statistics of the barite and barium-chemical industries

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Primary barite:						
Mine or plant output short tons	879, 575	1, 114, 117	1, 351, 913	1, 304, 542	486, 287	867, 201
Sold or used by producers:						
Short tons	865, 081	1, 108, 103	1, 299, 888	[1] 1, 145, 791	605, 402	901, 815
Value	$8, 180, 760	$10, 809, 119	$13, 497, 972	[1] $12, 897, 419	$7, 509, 797	$10, 300, 860
Imports for consumption:						
Short tons	174, 187	359, 636	589, 053	832, 626	526, 561	639, 598
Value	$1, 312, 874	$2, 181, 119	$3, 601, 504	$5, 864, 124	$3, 733, 423	$4, 825, 137
Consumption short tons [2]	1, 027, 199	1, 459, 671	2, 035, 389	1, 670. 720	1, 195, 669	1, 395, 774
Ground and crushed sold by producers:						
Short tons	814, 695	1, 232, 176	1, 503, 010	1, 467, 117	1, 026, 865	1, 209, 442
Value	$17, 419, 108	$30, 613, 095	$41, 623, 390	$42, 352, 525	$28, 351, 885	$30, 419, 039
Barium chemicals sold by producers:						
Short tons	85, 368	105, 171	106, 739	89, 757	75, 372	95, 579
Value	$11, 331, 382	$14, 490, 048	$13, 855, 058	$12, 253, 526	$10, 685, 392	$13, 657, 460
Lithopone sold or used by producers:						
Short tons	73, 354	42, 845	38, 434	(3)	(3)	(3)
Value	$9, 785, 716	$6, 002, 832	$5, 630, 991	(3)	(3)	(3)
World: Production short tons	2, 010, 000	2, 700, 000	3, 100, 000	3, 500, 000	2, 600, 000	3, 000, 000

[1] Revised figure.
[2] Includes some witherite.
[3] Figure withheld to avoid disclosing individual company confidential data.

---

[1] Commodity specialist.
[2] Supervisory statistical assistant.

Barite was produced in Kentucky for the first time in more than 30 years. Two firms, J. Willis Crider Fluorspar Co. and Mico Mining & Milling Co., accounted for the entire output.

Utah also became a barite-producing State in 1959. Two companies, one in Carbon County and the other in Juab County, reported some barite production.

Output of crushed and ground barite increased 18 percent but was still 26 percent below the record established in 1956. Production of barium chemicals also increased.

The barite deposits in the Hardin-Pope Counties fluorspar area of southern Illinois were described in a publication.[3] The barite has generally been considered a gangue of fluorspar. It occurs as both vein and bedded replacement deposits but appears to be of commercial importance in only a few areas.

U.S. Glass and Chemical Co. planned to construct a $500,000 barite and gravel mill at Dierks, Ark. Capacity of the plant was estimated at 35,000 tons of barite and 250,000 tons of commercial-grade gravel per year.[4]

TABLE 2.—Domestic barite sold or used by producers in the United States

State	1950–54 (average)		1955		1956	
	Short tons	Value	Short tons	Value	Short tons	Value
Arkansas	386,032	$3,650,389	462,986	$3,755,094	486,254	$4,255,982
Georgia South Carolina Tennessee	80,177	979,757	130,396	1,829,141	174,139	2,946,839
Missouri	288,453	2,785,469	363,692	4,003,842	381,642	4,461,955
Nevada	72,446	435,864	113,694	708,804	178,440	1,066,930
Other States[1]	37,973	329,281	37,335	512,238	79,413	766,266
Total	865,081	8,180,760	1,108,103	10,809,119	1,299,888	13,497,972

State	1957		1958		1959	
	Short tons	Value	Short tons	Value	Short tons	Value
Arkansas	477,327	$4,536,827	182,779	$1,668,039	338,539	$3,096,583
Georgia South Carolina Tennessee	175,072	2,982,195	108,511	2,284,561	89,484	1,809,367
Missouri	317,350	3,938,486	199,268	2,666,496	296,093	3,923,651
Nevada	109,663	720,806	59,407	405,636	91,298	622,973
Other States[1]	[2] 66,379	[2] 719,105	55,437	485,065	86,401	848,286
Total	[2] 1,145,791	[2] 12,897,419	605,402	7,509,797	901,815	10,300,860

[1] Includes Arizona (1950–55), California, Idaho, Kentucky (1959 only), Montana (1951–59), New Mexico, Utah (1959 only), and Washington (1953–55, 1957–59).

[2] Revised figure.

---

[3] Bradbury, J. C., Barite in the Southern Illinois Fluorspar District: Illinois State Geol. Survey Circ. 265, 1959, 14 pp.

[4] Pit and Quarry, $500,000 Barite, Gravel Mill Scheduled for Arkansas: Vol. 52, No. 4, October 1959, p. 32.

TABLE 3.—Ground (and crushed) barite produced and sold by producers in the United States

Year	Plants	Production (short tons)	Sales	
			Short tons	Value (thousands)
1950–54 (average)	26	815,267	814,695	$17,419
1955	29	1,314,810	1,232,176	30,613
1956	30	1,625,879	1,503,010	41,623
1957	33	1,480,585	1,467,117	$42,353
1958	34	1,014,133	1,026,865	28,352
1959	33	1,198,069	1,209,442	30,419

Wells Cargo, Inc., completed preliminary drilling on the Jumbo barite property, owned by Chemical and Pigment Co., Oakland, Calif., in the Ellendale district of Nevada. The company planned to mine and ship 5,000 to 8,000 tons of ore and install a crushing and screening plant to provide material for high-density concrete aggregate. Some crude ore was to be shipped to Chemical and Pigment's Oakland plant for use in paint.[5]

The new barium monohydrate unit of Sherwin-Williams began producing during the year. The $1 million plant was reported to have a capacity of several thousand tons per year.[6]

CONSUMPTION AND USES

The quantity of domestic barite sold or used by producers in 1959 increased 49 percent. The quantity of crude barite, both domestic and imported, used in manufacturing crushed and ground barite, lithopone, and barium chemicals increased 17 percent. These increases reversed the downward trend in sales and consumption which began in 1957.

Of the crude barite consumed, about 88 percent went into the manufacture of crushed and ground barite and the remainder was used in barium chemical and lithopone manufacture.

Sales of crushed and ground barite increased 18 percent, owing primarily to increasing consumption by oil- and gas-well drillers who used 95 percent of all crushed and ground barite sold. However, consumption by this industry was 19 percent below the 1956 peak.

Although the quantity of barite used in the mud at a rig varies with location and depth, an account of the quantity used in one well was published.[7] In sinking Tidewater Oil's Lacassane No. 2, a 16,000-foot gas-condensate well in Cameron Parish, La., approximately $150,000 was spent on mud additives. Of this total, $113,400 was spent for about 2,447 tons of barite. The other additives included bentonite, lime, quebracho, cornstarch, soluble caustic-lignin product,

---

[5] Mining Record, Drilling Completed at Jumbo Barite Property in Nevada: Vol. 70, No. 26, June 25, 1959, p. 5.

[6] Oil, Paint & Drug Reporter, Barium Monohydrate Debuts at S-W Plant: Vol. 175, No. 16, Apr. 13, 1959, p. 5.

[7] Chemical Week, Drilling Mud Makers Dig Deeper for Profits: Vol. 84, No. 18, May 2, 1959, pp. 33–34, 37–38.

sodium lignosulfonate, carboxymethylcellulose, hemlock bark extract, ferrochrome lignosulfonate, and lost circulation materials (shredded cellophane flakes, mica, ground walnut hulls, volcanic ash, and other fibrous materials) and totaled only 194 tons.

Barium titanate transducers were used to drive the welding heads in a new automatic, ultrasonic cold-seam welder.[8]

The glass, rubber, and paint industries purchased about the same quantities of barite as in 1958. Sales of barium chemicals increased 27 percent.

TABLE 4.—Crude barite (domestic and imported) used in the manufacture of ground barite and barium chemicals in the United States, in short tons

Year	In manufacture of—			Total	Year	In manufacture of—			Total
	Ground barite[1]	Litho-pone	Barium chemi-cals[2]			Ground barite[1]	Litho-pone	Barium chemi-cals[2]	
1950–54 (average)	823,324	71,194	132,681	1,027,199	1957	1,501,415	(3)	169,305	1,670,720
1955	1,256,361	45,898	157,412	1,459,671	1958	1,053,297	(3)	142,372	1,195,669
1956	1,839,770	31,065	164,554	2,035,389	1959	1,226,168	(3)	169,606	1,395,774

[1] Includes some crushed barite.
[2] Includes some witherite.
[3] Included with "Barium chemicals" to avoid disclosing individual company confidential data.

TABLE 5.—Ground (and crushed) barite sold by producers, by consuming industries

Industry	1950–54 (average)		1955		1956		1957		1958		1959	
	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total
Well drilling[1]	725,781	89	1,142,309	93	1,421,033	95	1,392,394	95	977,255	95	1,153,560	95
Glass	24,616	3	28,737	2	32,661	2	27,595	2	9,890	1	11,700	1
Paint	25,400	3	25,633	2	20,602	1	16,179	1	14,641	1	17,046	1
Rubber	18,600	2	25,104	2	22,101	2	21,782	1	18,387	2	19,806	2
Undistributed	20,298	3	10,393	1	6,613	(1)	9,167	1	6,692	1	7,330	1
Total	814,695	100	1,232,176	100	1,503,010	100	1,467,117	100	1,026,865	100	1,209,442	100

[1] Less than 1 percent.

---

[8] Ceramic Industry, Ceramics Drive First Automated Ultrasonic Cold Seam Welder: Vol. 72, No. 3, March 1959, p. 92.

TABLE 6.—Barium chemicals produced and used or sold by producers in the United States, in short tons

Chemical	Plants	Produced	Used by producers[1] in other barium chemicals[2]	Sold by producers[3]	
				Short tons	Value
Black ash:[4]					
1950–54 (average)	12	132,009	130,393	750	$51,894
1955	9	135,455	134,202	1,943	165,502
1956	10	131,006	129,969	6,356	524,359
1957	9	112,048	110,900	1,087	79,474
1958	8	93,539	81,861	1,351	126,050
1959	7	104,740	102,040	2,947	289,580
Carbonate (synthetic):					
1950–54 (average)	4	61,371	20,924	40,844	3,490,636
1955	4	78,946	27,273	53,274	5,021,001
1956	5	82,043	31,022	50,524	4,783,453
1957	6	74,160	31,056	42,937	4,335,469
1958	6	[5] 60,534	[5] 26,835	35,307	3,753,712
1959	6	77,043	29,398	47,137	5,099,366
Chloride (100 percent $BaCl_2$):					
1950–54 (average)	4	13,823	2,889	10,878	1,481,797
1955	3	11,852	120	11,601	1,689,252
1956	3	11,746	130	11,174	1,706,683
1957	3	9,715	------------	9,373	1,538,809
1958	4	[5] 8,428	------------	8,122	1,328,413
1959	4	(6)	(6)	(6)	(6)
Hydroxide:					
1950–54 (average)	5	11,648	306	11,006	2,279,248
1955	4	15,540	74	16,150	3,174,167
1956	5	16,957	120	16,762	3,051,368
1957	5	12,698	162	12,551	1,915,700
1958	4	9,892	68	10,093	1,853,900
1959	5	14,293	(6)	13,914	2,320,522
Oxide:					
1950–54 (average)	3	11,418	6,615	4,655	1,124,167
1955	3	16,509	8,102	8,722	2,128,911
1956	3	19,816	8,117	11,222	1,969,817
1957	3	20,452	5,446	14,159	2,585,193
1958	3	(6)	(6)	(6)	(6)
1959	3	(6)	(6)	(6)	(6)
Sulfate (synthetic):					
1950–54 (average)	6	13,596	------------	13,262	1,491,287
1955	5	10,722	367	9,976	1,347,248
1956	6	9,981	192	9,281	1,263,575
1957	4	9,124	------------	8,719	1,281,657
1958	3	6,581	------------	6,628	844,946
1959	4	(6)	(6)	(6)	(6)
Other barium chemicals:[7]					
1950–54 (average)	(8)	6,285	1,915	3,973	1,412,353
1955	(8)	2,396	176	3,505	963,967
1956	(8)	1,808	190	1,420	555,803
1957	(8)	1,252	137	931	517,224
1958	(8)	18,549	3,213	13,871	2,778,377
1959	(8)	43,860	10,893	31,581	5,947,992
Total:[9]					
1950–54 (average)	18	------------	------------	85,368	11,331,382
1955	16	------------	------------	105,171	14,490,048
1956	17	------------	------------	106,739	13,855,058
1957	14	------------	------------	89,757	12,253,526
1958	13	------------	------------	75,372	10,685,392
1959	14	------------	------------	95,579	13,657,460

---

[1] Of any barium chemical.

[2] Includes purchased material.

[3] Exclusive of purchased material and exclusive of sales by one producer to another.

[4] Black-ash data include lithopone plants.

[5] Revised figure.

[6] Included with "Other barium chemicals" to avoid disclosing individual company confidential data.

[7] Includes barium acetate, oxide, chloride, hydroxide (used only), nitrate, peroxide, sulfate, and other unspecified compounds. Specific chemicals may not be revealed by specific years.

[8] Plants included in above figures.

[9] A plant producing more than 1 product is counted but once in arriving at the total.

PRICES

E&MJ Metal & Mineral Markets quoted the following prices on barite in 1959: Georgia, f.o.b. cars: Crude, jig and lump, per short ton, $18; beneficiated, per short ton, in bulk, $21; and in bags, $23.50 to $25. Missouri, per short ton carlots, f.o.b. mine or mill: Water ground and floated, bleached, $45 to $49; crude ore, minimum 94 percent $BaSO_4$, less than 1 percent Fe, $16 to $18. Crude, oil-well grade, minimum 4.3 specific gravity, bulk, per short ton, $18. Some restricted sales, $11.50. Ground, oil-well grade, $26.75. Imported: Crude, oil-well grade, minimum 4.25 specific gravity, bulk, c.i.f. Gulf ports, per short ton, $16 to $18. Canada, f.o.b. shipping point: Crude, in bulk, per long ton, $11; ground, in bags, per short ton, $16.50. The prices have remained unchanged since 1957.

TABLE 7.—Quotations on barium chemicals in 1959

[Oil, Paint and Drug Reporter]

		Jan. 5–Dec. 28
Barium carbonate, precipitated, bags, carlots, works	short tons	$111.50
Smaller lots, works	do	126.50
Barium chlorate, drums, works	pounds	.32–.41
Barium chloride, anhydrous, bags, carlots, works	short tons	176.00
Less carlots, works	do	196.00
Barium chromate, bags, freight equaled	pounds	.38
Barium dioxide (peroxide), drums, freight equaled	do	.20
Barium hydrate, crystals, bags, carlots, ton lots, freight equaled	short tons	208.00
Less carlots, less ton lots, freight equaled	do	218.00
Barium nitrate, barrels, carlots, ton lots, delivered	pounds	.16
Less carlots, less ton lots, delivered	do	.17
Barium oxide, ground, drums, carlots, ton lots, freight equaled	short tons	275.00
Less carlots, less ton lots, freight equaled	do	285.00
Blanc, fixe, direct process, bags, carlots, works	do	145.00
Less carlots, works	do	155.00
New York warehouse	do	195.00
Lithopone, ordinary, bags, carlots, delivered	pounds	[1] .08⅜ E
Less carlots, delivered	do	[1] .09⅛ E
Titanated (high strength), bags, carlots, delivered	do	.11
Less carlots, delivered	do	.12

[1] E=East.

FOREIGN TRADE[9]

Imports of crude barite increased about 100,000 tons over 1958 and came principally from Mexico, Canada, and Peru.

Ground-barite imports continued to increase. Imports from Canada, the principal supplier in 1959, increased 150-fold. West Germany, Algeria, and Italy contributed the remainder.

The United Kingdom supplied all of the crude witherite imported in 1959 and West Germany, the 264 pounds of crushed or ground witherite imported.

Total imports of barium chemicals increased over 1958. Imports of only one compound, barium nitrate, decreased. West Germany supplied about 80 percent of the imports; France, Netherlands, Italy,

---

[9] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

Belgium-Luxembourg, United Kingdom, and Switzerland, in descending order, supplied the remainder.

Exports of lithopone continued to decline. Cuba received about 58 percent of the total shipments; Canada, about 33 percent; and Guatemala, Iceland, Nicaragua, and Mexico, the remainder.

TABLE 8.—Barite imported for consumption in the United States, by countries

[Bureau of the Census]

	1958		1959	
	Short tons	Value	Short tons	Value
Crude barite:				
North America:				
Canada	114,299	$870,862	171,462	$1,457,502
Cuba	7,467	65,467	1,498	11,500
El Salvador	----------	----------	262	418
Mexico	211,250	1,225,815	194,133	1,090,746
Total	333,016	2,162,144	367,355	2,560,166
South America: Peru	74,924	750,557	112,178	1,097,522
Europe:				
Greece	45,569	253,887	92,994	518,144
Italy	19,156	175,724	8,747	81,224
Yugoslavia	53,896	391,111	58,324	568,081
Total	118,621	820,722	160,065	1,167,449
Grand total	526,561	3,733,423	639,598	4,825,137
Ground barite:				
North America:				
Canada	10	658	1,536	51,211
Mexico	743	11,539	----------	----------
Total	753	12,197	1,536	51,211
Europe:				
Germany, West	128	4,326	60	2,595
Italy	107	3,691	22	1,055
Total	235	8,017	82	3,650
Africa: Algeria	22	1,120	25	1,070
Grand total	1,010	21,334	1,643	55,931

TABLE 9.—Barium chemicals imported for consumption in the United States

[Bureau of the Census]

Year	Lithopone		Blanc fixe (precipitated barium sufate)		Barium chloride		Barium hydroxide	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1950–54 (average)	420	$69, 071	378	$27, 129	360	$34, 665	109	$22, 525
1955	30	4, 355	901	91, 341	994	[1] 75, 069	15	2, 431
1956	143	[1] 19,931	1, 026	104, 662	1, 378	[1] 107, 913	22	3, 130
1957	57	8, 124	1, 447	115, 627	1, 407	[1] 120, 080	113	18, 905
1958	69	9, 307	1, 573	103, 865	1, 376	129, 159	161	25, 832
1959	73	8, 752	1, 757	122, 067	1, 510	134, 663	232	35, 104

Year	Barium nitrate		Barium carbonate precipitated		Other barium compounds	
	Short tons	Value	Short tons	Value	Short tons	Value
1950–54 (average)	274	$44, 993	1, 225	$91, 043	401	$85, 938
1955	77	14, 906	1, 638	105, 240	841	[1] 170, 345
1956	591	[1] 91, 177	1, 801	130, 852	138	29, 735
1957	798	120, 075	1, 543	105, 046	61	22, 209
1958	701	107, 724	322	23, 350	38	26, 415
1959	596	89, 822	1, 895	127, 734	55	41, 823

[1] Data known to be not comparable with other years.

TABLE 10.—Lithopone exported from the United States

[Bureau of the Census]

Year	Short tons	Value		Year	Short tons	Value	
		Total	Average			Total	Average
1950–54 (average)	9, 351	$1, 507, 060	$161. 17	1957	991	$177, 891	$179. 51
1955	1, 892	300, 960	159. 07	1958	613	122, 462	199. 77
1956	1, 387	239, 892	172. 96	1959	538	99, 578	185. 09

TABLE 11.—Witherite, crude, unground, imported for consumption in the United States

[Bureau of the Census]

Year	Short tons	Value [1]	Year	Short tons	Value [1]
1950–54 (average)	3, 724	$123, 808	1957 [2]	3, 029	$138, 494
1955	2, 363	77, 867	1958 [2]	2, 240	108, 119
1956 [2]	2, 934	110, 039	1959 [2]	2, 552	113, 229

[1] Valued at port of shipment.

[2] In addition, crushed or ground witherite was imported as follows: 1957, 8 tons ($533); 1958, 202 tons ($15,610); 1959, less than 1 ton ($478). Class established June 1, 1956; no transactions.

TABLE 12—World production of barite, by countries,[1] in short tons [2]

[Compiled by Liela S. Price and Berenice B. Mitchell]

Country [1]	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada	155,988	253,736	320,835	228,048	195,719	255,023
Cuba (exports)	981	----------	----------	22,796	9,407	----------
Mexico (exports)	27,314	117,654	235,792	429,537	217,350	198,579
United States	879,575	1,114,117	1,351,913	1,304,542	486,287	867,201
Total	1,063,858	1,485,507	1,908,540	1,984,923	908,763	1,320,803
South America:						
Argentina	18,090	22,481	19,152	25,264	18,596	[3] 18,700
Brazil	8,898	3,950	16,197	55,349	68,630	[3] 68,000
Chile	2,080	3,466	476	860	[3] 1,100	[3] 1,100
Colombia	5,106	6,614	8,378	6,963	14,330	11,023
Peru	13,644	9,410	11,601	95,388	117,802	105,557
Total	47,818	45,921	55,804	183,824	220,458	[3] 204,400
Europe:						
Austria	6,878	4,365	3,413	3,902	4,709	4,008
France	43,665	70,507	60,627	71,650	85,980	[3] 132,000
Germany:						
East [3]	23,149	27,600	27,600	27,600	27,600	27,600
West (marketable)	362,905	456,710	453,836	448,144	409,105	428,304
Greece	26,627	21,451	28,843	143,549	227,091	[3] 165,000
Ireland	3,897	6,232	7,729	11,231	11,283	[3] 11,000
Italy	73,598	114,635	103,075	124,945	122,976	107,122
Poland	(4)	11,574	12,346	[3] 12,400	[3] 12,400	[3] 12,400
Portugal	470	357	346	853	1,351	[3] 1,300
Spain	14,112	9,833	8,505	20,287	31,408	[3] 27,600
Sweden	66	137	----------	----------	----------	----------
U.S.S.R.[3]	109,129	110,000	110,000	110,000	130,000	130,000
United Kingdom [5]	88,764	92,906	84,670	87,280	78,078	[3] 77,000
Yugoslavia	60,522	109,129	102,870	133,137	103,801	118,267
Total [1] [3]	819,000	1,040,000	1,010,000	1,200,000	1,250,000	1,250,000
Asia:						
India	13,587	8,537	7,072	14,462	15,481	14,718
Japan	17,993	20,374	20,578	27,514	16,510	21,594
Korea, Republic of	550	933	744	8	----------	----------
Philippines	----------	----------	5,045	6,088	64	186
Turkey	----------	----------	----------	2,111	6,035	[3] 3,000
Total [1] [3]	42,900	52,000	61,000	83,000	93,000	95,000
Africa:						
Algeria	20,220	33,720	32,843	37,724	47,415	48,771
Egypt	25	67	88	294	2,282	[3] 3,300
Morocco: Southern Zone	4,547	27,170	32,622	16,276	47,060	40,574
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	190	----------	----------	----------	34	241
Swaziland	454	449	516	351	480	461
Union of South Africa	2,215	1,892	2,713	3,369	2,721	2,355
Total	27,651	63,298	68,782	58,014	99,992	95,702
Oceania: Australia	6,631	7,016	6,730	10,951	7,618	[3] 4,400
World total (estimate)[1] [2]	2,010,000	2,700,000	3,100,000	3,500,000	2,600,000	3,000,000

[1] Barite is produced in China, Czechoslovakia, and North Korea, but data on production are not available. Estimates by author of chapter included in total.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Estimate.

[4] Data not available; no estimate included in the total.

[5] Includes witherite.

WORLD REVIEW

NORTH AMERICA

Canada.—Baroid of Canada, Ltd., a subsidiary of National Lead Co., received an option to purchase the Spillimacheen properties of Giant Mascot Mines, Ltd. Terms permitted Baroid to produce barite from the property with a $2-per-ton royalty and a minimum payment of $20,000 annually. Royalty payments were to be deducted from the $300,000 purchase price, and the option to purchase had to be exercised during the first 3 years of the 10-year contract.[10]

EUROPE

Belgium.—Three firms, the Union Chimique Belge, the Société anonyme des Produits Chimiques de Wilsele, and the Société anonyme Produits Chimiques de Nieuport, manufactured lithopone in Belgium. The last-named firm acquired the Société Chimiques du Hainaut (also a producer of lithopone) in 1958 and transferred part of the lithopone plant of Hainaut to its Nieuport works. A modernization and expansion program at the Nieuport plant was completed.[11]

France.—To increase the number of drilling-mud products the Société Carbonisation et Charbons Actifs (CECA) in association with Société France-Barytes constructed a barite grinding plant at Port-la-Nouvelle.[12]

Yugoslavia.—The foreign trade firm, Metalexport, of Sarajevo, concluded a contract with Polish importers for delivery in 1959 of about 1,500 tons of ground barite.[13] Large tonnages of ground barite were also to be shipped to U.S.S.R., Rumania, Egypt, and Japan. Negotiations were under way for the sale of ground barite to Middle Eastern and Near East markets.

Contracts for the exports of some 75,000 tons of lump barite were also concluded. Lump barite is shipped primarily to the United States, France, West Germany, Great Britain, and Austria.

Two mills, the Kresevo and Tarcin, were the largest barite grinders in Yugoslavia. Ground barite output exceeded 20,000 tons a year; however, production could almost be doubled without major construction.

ASIA

India.—Permission to construct a barium chemical plant was given P. N. Bala Subramanium by the Indian Government.[14] A west German firm was to aid in constructing the plant at Kurichi, near Coimbatore, South India. Annual capacity was reported to be about 3,000 tons of barium sulfate, sulfide, carbonate, chloride, and nitrate.

---

[10] Canadian Mining Journal, Giant Mascot Deal with Baroid of Canada: Vol. 80, No. 10, October 1959, p. 149.

[11] Chemical Trade Journal and Chemical Engineer, Notes from Abroad, Belgian Lithopone: Vol. 145, No. 3777, Oct. 23, 1959, p. 748.

[12] Chemistry and Industry (London), CECA's Expanding Activities: No. 46, Nov. 14, 1959, p. 1444.

[13] Mining Journal (London), Yugoslav Barytes Contracts: Vol. 253, No. 6468, Aug. 7, 1959, p. 127.

[14] Chemical Trade Journal and Chemical Engineer, Notes from Abroad: Vol. 145, No. 3777, Oct. 23, 1959, p. 748.

AFRICA

Morocco.—Of the 47,000 short tons of barite produced in 1958, some 37,000 tons were shipped for export. No domestic consumption was reported. Yearend stocks totaled 21,000 tons. The following three firms (mine names in parentheses), S.M.M.I.C. (Djebel Irhoud), Société Africaine des Mines (Tessaout), and Bureau de Recherches et de Participations Minières (Barit Tnine), accounted for the entire output.[15]

TECHNOLOGY

A flowsheet for treating barite-fluorspar-lead ores was published.[16] Complex ores containing 20 percent lead as carbonates, 36 percent barite, and 37 percent fluorspar in a siliceous gangue were studied.

Ore ground to 100-mesh passes to a conditioner where a reagent to activate and collect the lead is added. The resulting pulp undergoes rougher flotation, and the lead concentrate is cleaned twice. The tailing passes to the barite circuit, where it is thickened and excess reagents are removed. Two-stage conditioning depresses the fluorspar and gangue and activates the barite. The conditioned pulp is subjected to rougher flotation and two-stage cleaning. The tailing from the barite circuit is then treated to recover the fluorspar. This process yields a barite concentrate analyzing 98.3 percent $BaSO_4$ with an 89-percent recovery.

Contamination of barium titanates due to milling and the effect of contamination on the electrical properties of barium titanates were discussed in an article.[17] Contamination introduced by the grinding medium and milling time had a deleterious effect on the dielectric constant. The research indicated that contamination was minimum when porcelain balls were used and grinding time was minimum.

A method for spray drying barium titanate, at the Electronic Division of Onandaga Pottery Co., Syracuse, N.Y., was described.[18] The slurry, barium titanate, with the binder and lubricant necessary for pressing, passes from water-jacketed, heated tanks to the drier, where it is introduced countercurrent to the drying air. Air enters the top of the drier at approximately 610° F., and the dried particles are discharged at 275° F. An exhaust fan removes the particles from the drier to a collector directly below. This process did not affect the electrical properties of the titanate, improved flow characteristics, and reduced manpower and operating costs.

---

[15] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 6, December 1959, p. 37.

[16] Deco Trefoil, Flowsheet Study: Lead-Barite-Fluorspar: Vol. 23, No. 4, August-September-October 1959, pp. 15, 16.

[17] Nelson, Karl E., and Cook, Ralph L., Effect of Contamination Introduced During Wet Milling on the Electrical Properties of Barium Titanate: Bull. Am. Ceram. Soc., vol. 38, No. 10, October 1959, pp. 499–500.

[18] Ceramic Age, Spray Drying Barium Titanate Slurries: Vol. 73, No. 6, June 1959, pp. 40–41.

Bauxite

By Richard C. Wilmot,[1] Arden C. Sullivan,[2] and Mary E. Trought[2]

⁂

WORLD production of bauxite increased 8 percent. U.S. output increased 30 percent, and consumption by this Nation rose 23 percent. Jamaica continued to be the world's leading producer of bauxite, and commercial production was begun in the Dominican Republic.

In the United States about 4.1 million short tons of alumina and aluminum oxide products was produced from bauxite. Production of aluminum accounted for 87 percent of the bauxite consumed.

Almost 1 million tons of new annual alumina capacity, brought into production at three U.S. plants, increased domestic capacity 25 percent. Except for 375,000 tons of capacity planned at Point Comfort, Tex., the scheduled alumina-plant expansion in the United

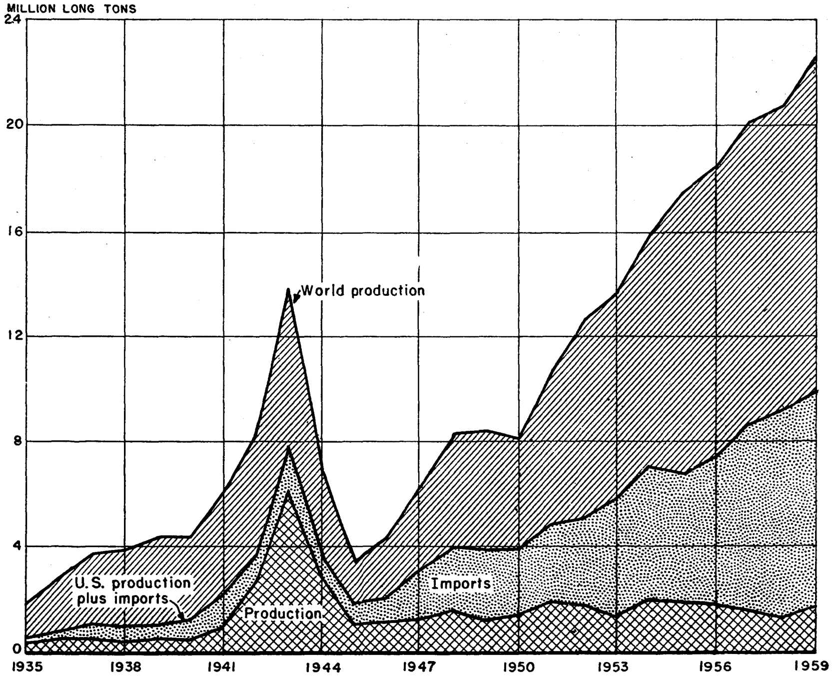

FIGURE 1.—U.S. supply and world production of bauxite, 1935–59.

---

[1] Commodity specialist.
[2] Statistical assistant.

States was complete. (Aluminum is discussed in the Aluminum chapter of this volume.)

TABLE 1.—Salient statistics of the bauxite industry, thousand long tons

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Crude-ore production (dry equivalent)	1,685	1,788	1,744	1,416	1,311	1,700
Value, thousands	$12,158	$14,543	$15,109	$12,868	$11,898	$17,725
Imports [1]	3,603	4,882	5,670	7,098	[2] 7,915	8,107
Exports (as shipped)	44	14	15	61	12	17
Consumption (dry equivalent)	4,711	6,989	7,751	7,633	7,034	8,621
World: Production	12,700	17,500	18,500	20,100	[2] 20,900	22,500

[1] Import figures adjusted to dry equivalent for Jamaican, Haitian, and Dominican Republic bauxite. Other imports are on an as-shipped basis.

[2] Revised figure.

DOMESTIC PRODUCTION

Production of crude bauxite in the United States was 1.7 million long tons, dry equivalent, a 30-percent increase over 1958. On a dry basis, shipments of ore from domestic mines and processing plants to consumers increased 17 percent over 1958. The domestic production was 17 percent of the new supply, compared with 14 percent in 1958.

The American Cyanamid Co. mined bauxite in Georgia; R. E. Wilson Mining Co., D. M. Wilson Bauxite Co., and Harbison-Walker Refractories Co. mined ore in Alabama. These companies produced a total of 69,000 tons, dry equivalent, a 30-percent increase over 1958. Crude ore was processed at the R. E. Wilson Mining Co. drying plant

TABLE 2.—Mine production of bauxite and shipments from mines and processing plants to consumers in the United States, thousand long tons

State and year	Mine production			Shipments from mines and processing plants to consumers		
	Crude	Dried-bauxite equivalent	Value (thousands)[1]	As shipped	Dried-bauxite equivalent	Value (thousands)[1]
Alabama and Georgia:						
1950–54 (average)	53	44	$359	49	47	$489
1955	89	67	516	73	67	714
1956	94	75	665	74	68	728
1957	77	59	554	67	62	672
1958	67	53	504	61	58	630
1959	89	69	677	63	61	678
Arkansas:						
1950–54 (average)	1,942	1,641	11,799	1,787	1,609	13,127
1955	2,050	1,721	14,027	1,939	1,660	14,845
1956	1,967	1,669	14,444	1,817	1,568	14,644
1957	1,625	1,357	12,314	2,004	1,696	16,476
1958	1,517	1,258	11,394	[2] 1,588	[2] 1,348	[2] 13,354
1959	1,940	1,631	17,048	1,827	1,580	17,960
Total United States:						
1950–54 (average)	1,995	1,685	12,158	1,836	1,656	13,616
1955	2,139	1,788	14,543	2,012	1,727	15,559
1956	2,061	1,744	15,109	1,891	1,636	15,372
1957	1,702	1,416	12,868	2,071	1,758	17,148
1958	1,584	1,311	11,898	[2] 1,649	[2] 1,406	[2] 13,984
1959	2,029	1,700	17,725	1,890	1,641	18,638

[1] Computed from selling prices and values assigned by producers and estimates of the Bureau of Mines.

[2] Revised figure.

near Eufaula, Ala., the Harbison-Walker calcining plant in Henry County, Ala., and the American Cyanamid drying plant at Adairsville, Ga. D. M. Wilson Bauxite Co. shipped crude ore.

Arkansas produced 96 percent of the U.S. bauxite output. The two leading producers were Aluminum Company of America (Alcoa) and Reynolds Metals Co.; each shipped ore to its own alumina plant. Three companies mined smaller quantities of bauxite in Arkansas: American Cyanamid Co., Dulin Bauxite Co., and Dickinson McGeorge, Inc. Stauffer Chemical Co. shipped from stocks. Campbell Bauxite Co., Stauffer Chemical Co., and Porocel Corp. operated plants for producing dried, calcined, and activated bauxite. The Norton Co. mine and plant were inactive.

All bauxite operations were terminated by Dulin Bauxite Co., and its bauxite leases and mining properties were sold to Reynolds.

The new 500-foot-deep Wrightman mine was put into production by Reynolds. Ripping-type, continuous-mining machines, similar to those used in coal mines, were operated.

TABLE 3.—Recovery of dried, calcined, and activated bauxite in the United States, in long tons

Year	Crude ore treated	Processed bauxite recovered			
		Dried	Calcined or activated	Total	
				As recovered	Dried-bauxite equivalent
1950–54 (average)	539,347	371,979	56,493	428,472	458,582
1955	199,313	114,863	23,166	138,029	151,333
1956	181,625	114,685	17,914	132,599	145,166
1957	187,921	128,509	13,093	141,602	147,508
1958	[1] 192,921	92,111	[1] 44,394	[1] 136,505	[1] 151,072
1959	215,008	85,833	60,135	145,968	171,187

[1] Revised figure.

CONSUMPTION AND USES

Domestic consumption of bauxite increased 23 percent. Domestic-ore consumption was 19.5 percent of total consumption, about the same as in 1958. Of the foreign ore consumed, 58 percent was Jamaican-type ore (from Jamaica, Haiti, or the Dominican Republic).

Shipments of domestic ore containing less than 8 percent silica were 13 percent of the total, a slight decrease from the 14 percent shipped in 1958. The proportion of ore containing 8 to 15 percent silica decreased from 57 percent in 1958 to 54 percent, and the proportion of ore containing more than 15 percent silica increased to 33 percent. Owing to the marked increase in total shipments, however, there was an increase in the tonnage of each class of ore shipped.

The eight domestic alumina plants operated by the aluminum companies produced 4,008,000 short tons of calcined alumina and aluminum oxide products calculated on the basis of the calcined equivalent. This represented a 25-percent increase over 1958. The gross weight of the calcined alumina and aluminum oxide produced was 4,074,000

TABLE 4.—Bauxite consumed in the United States, by industries, in long tons

(Dried-bauxite equivalent)

Industry	Domestic	Percent	Foreign	Percent	Total	Percent
1958						
Alumina	1,184,420	87.8	5,326,115	93.7	6,510,535	92.6
Abrasive [1]	323	----------	185,171	3.2	185,494	2.6
Chemical	96,876	7.2	122,848	2.2	219,724	3.1
Refractory	14,317	1.1	46,043	.8	60,360	.9
Other	52,952	3.9	4,833	.1	57,785	.8
Total [1]	1,348,888	100.0	5,685,010	100.0	7,033,898	100.0
Percent	19.2	----------	80.8	----------	100.0	----------
1959						
Alumina	1,513,824	90.2	6,513,168	93.8	8,026,992	93.1
Abrasive [1]	913	.1	216,504	3.1	217,417	2.5
Chemical	97,291	5.8	140,200	2.0	237,491	2.8
Refractory	15,175	.9	68,220	1.0	83,395	1.0
Other	50,828	3.0	4,510	.1	55,338	.6
Total [1]	1,678,031	100.0	6,942,602	100.0	8,620,633	100.0
Percent	19.5	----------	80.5	----------	100.0	----------

[1] Includes consumption by Canadian abrasives industry.

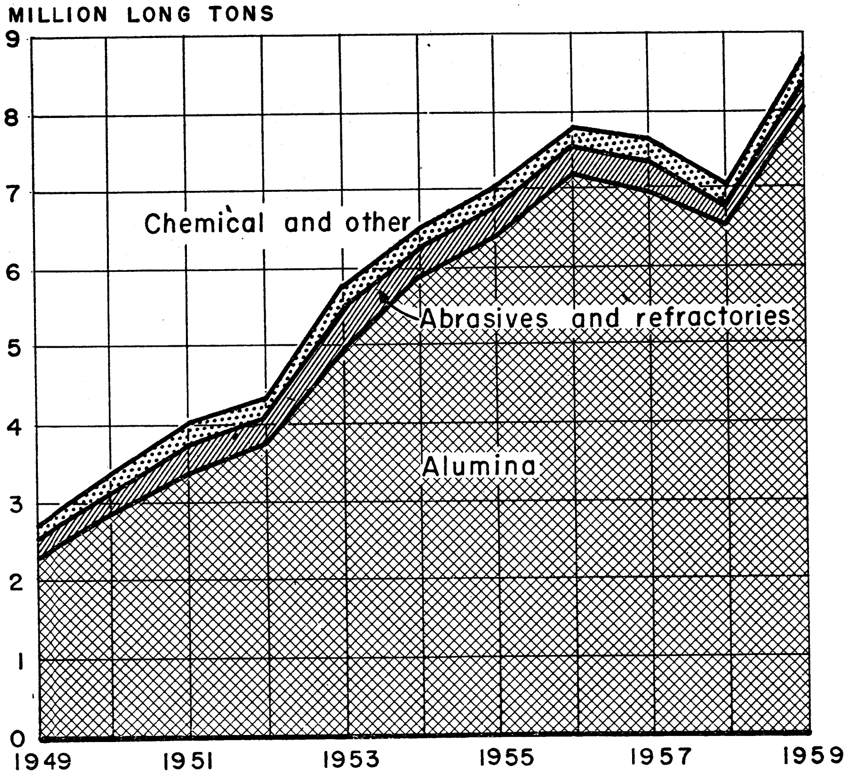

FIGURE 2.—Domestic consumption of bauxite, by uses, 1949–59.

TABLE 5.—Bauxite consumed in the United States in 1959, by grades, in long tons

(Dried-bauxite equivalent)

Grade	Domestic origin	Foreign origin	Total	Percent
Crude	1,527,020	6,422	1,533,442	17.8
Dried	72,956	6,668,988	6,741,944	78.2
Calcined	66,810	267,192	334,002	3.9
Activated	11,245	----------	11,245	.1
Total	1,678,031	6,942,602	8,620,633	100.0
Percent	19.5	80.5	100.0	----------

tons. Of this total, 3,840,000 tons was calcined alumina, 183,000 tons was trihydrate alumina, and the remainder was activated or tabular alumina. Shipments of alumina and aluminum oxide products totaled 4,016,000 tons, of which 3,765,000 tons went to the aluminum industry. The remaining 251,000 tons, valued at $23.5 million, was shipped as commercial trihydrate or as activated, calcined, or tabular alumina for use primarily by the chemical, abrasive, ceramic, and refractory industries.

The annual rated alumina-plant capacity increased 25 percent to 4,865,500 short tons per year. Two new alumina plants and a new unit at a third plant were placed in production. At the end of 1959 the expansion of alumina-plant capacity scheduled for construction by the aluminum companies was completed, with one exception.

Reynolds Metals Co. began operation of the fourth 182,500-ton unit at the Sherwin plant, La Quinta, Tex., bringing the capacity of that plant to 730,000 tons of alumina per year. The ore used at the plant was mined in Jamaica and Haiti. Kaiser Aluminum & Chemical Corp. commenced treating Jamaican ore at the 430,000-ton-per-

TABLE 6.—Capacities of domestic alumina plants in operation and under construction

Company and plant	Capacity (short tons per year) as of Dec. 31, 1959	
	Operating plants	Plants under construction
Aluminum Company of America:		
Mobile, Ala	985,500	------------
Bauxite, Ark	420,000	------------
Point Comfort, Tex	375,000	375,000
Total	1,780,500	375,000
Reynolds Metal Co.:		
Hurricane Creek, Ark	730,000	------------
La Quinta, Tex	730,000	------------
Total	1,460,000	------------
Kaiser Aluminum & Chemical Corp.:		
Baton Rouge, La	850,000	------------
Gramercy, La	430,000	------------
Total	1,280,000	------------
Ormet Corp.: Burnside, La	345,000	------------
Grand total	4,865,500	375,000

year plant at Gramercy, La. The plant site was planned to permit expansion to four times the present capacity.

At Point Comfort, Tex., the Aluminum Company of America completed and placed in operation two 187,500-ton units of a scheduled four-unit plant with a planned total capacity of 750,000 tons. Bauxite from the Dominican Republic and Surinam was to be used. The ore was to be unloaded from ocean-going steamers outside Matogorda Bay and placed on barges for the 78-mile trip to the plant site. Initial funds for dredging a deepwater channel were appropriated by Congress. To increase transportation capacity, a new 34,000-ton ore carrier was launched to join the Alcoa fleet in 1960.

Mexico Refractories Co. of Mexico, Mo., merged with Kaiser Aluminum & Chemical Corp. Mexico Refractories produced acid refractories, including high-alumina firebrick used in high-temperature applications where resistance to spalling and erosion are important. As Kaiser already produced basic refractories, the merger added a complementary line of products.

Calcined alumina consumed at the 22 aluminum reduction plants in the United States totaled 3,736,000 short tons, an increase of 24 percent over 1958 An average of 2.003 long dry tons of bauxite was required to produce 1 short ton of alumina, and an average of 1.913 short tons of alumina was required to produce 1 short ton of aluminum metal. The overall ratio was 3.832 long dry tons of bauxite to 1 short ton of aluminum.

TABLE 7.—Production and shipments of selected aluminum salts in the United States, 1958

Type of salt	Production (short tons)	Number of plants producing	Shipments and interplant transfers	
			Quantity (short tons)	Value f.o.b. plant (thousands)
Aluminum sulfate:				
General:				
Commercial (17 percent Al_2O_3)	824,498	48	812,503	$30,476
Municipal (17 percent Al_2O_3)	6,326	6		
Iron-free (17 percent Al_2O_3)	43,516	15	23,744	1,617
Sodium aluminate (62.2 percent Al_2O_3)	(1)	4	(1)	(1)
Aluminum chloride:				
Liquid (32° Be′)	20,225	11	12,287	894
Crystal (32° Be′)				
Anhydrous (100 percent $AlCl_3$)	30,042	9	24,165	7,157
Aluminum fluoride, technical	36,214	4	36,090	10,269
Aluminum trihydrate (100 percent $Al_2O_3.3H_2O$)	134,971	10	120,830	8,300
Other aluminum salts				[2] 11,247
Total				69,960

[1] Included with "Other aluminum salts."

[2] Includes cryolite, sodium-aluminum sulfate, sodium-aluminate, potassium-aluminum sulfate, ammonium-aluminum sulfate, aluminum hydroxide (light or litho), and other aluminum compounds.

SOURCE: Data are based upon report form MA-28E.1, Annual Report on Shipments and Production of Inorganic Chemicals and Gases, Bureau of the Census.

STOCKS

Bauxite stocks in the United States declined 133,000 long dry tons from stocks at the end of 1958. On a dry basis, consumers' inventories declined 8 percent; those at mines and processing plants increased

14 percent. No withdrawals were made from the Government-held nonstrategic stockpile.

Jamaican, Surinam, and refractory grades of bauxite remained on the Group I list of strategic materials for the national stockpile. Abrasive-grade bauxite was removed from the Group II listing. There was no Government inventory of this material. The stockpile of fused aluminum oxide was believed adequate for emergency needs.

During the year 690,000 tons of Jamaican-type ore and 570,000 tons of Surinam-type ore were acquired by purchase or barter. This brought the supplementary and Defense Production Act inventories to 3,870,000 tons.

TABLE 8.—Stocks of bauxite in the United States, in long tons [1]

Year	Producers and processors		Consumers		Government	Total	
	Crude	Processed [2]	Crude	Processed [2]	Crude	Crude and processed [2]	Dried-bauxite equivalent
1955	1,042,832	4,979	637,508	1,705,694	2,204,674	5,595,687	5,011,270
1956	1,143,392	5,812	483,173	1,605,262	2,204,674	5,442,313	4,898,229
1957	739,836	6,313	488,564	2,364,206	2,204,671	5,803,593	5,329,014
1958	[3] 644,051	[3] 6,806	606,643	2,163,120	2,204,674	[3] 5,625,294	[3] 5,146,918
1959	741,228	7,341	543,074	1,998,475	2,204,674	5,494,792	5,013,995

[1] Excludes strategic stockpile.
[2] Dried, calcined, and activated.
[3] Revised figure.

PRICES

No open-market price was in effect for bauxite mined in the United States, as the output was consumed mainly by the producing companies.

The average value of bauxite shipped and delivered to domestic alumina plants was estimated at $17.30 per long ton, dry equivalent, for imported ore.

Prices in the E&MJ Metal and Mineral Markets for December 3, 1959, were quoted for imported ore only. Abrasive-grade, crushed and calcined, 86 percent minimum Al_2O_3 f.o.b. port, British Guiana, was quoted at $20.45 per long ton, an increase of $0.50 over quotations of December 4, 1958. Imported Refractory-grade bauxite was quoted at $26.60, the same price as in 1958.

TABLE 9.—Average value of domestic bauxite in the United States [1]

Type	Shipments f.o.b. mines or plants (per long ton)		Type	Shipments f.o.b. mines or plants (per long ton)	
	1958	1959		1958	1959
Crude (undried)	$7.66	$8.98	Calcined	(2)	(2)
Dried	10.88	11.17	Activated	[3] $68.30	$63.31

[1] Calculated from reports to the Bureau of Mines by bauxite producers.
[2] Figure withheld to avoid disclosing individual company confidential data.
[3] Revised figure.

The average value of calcined alumina, as determined from producer reports, was $0.0334 per pound. The value of imported calcined alumina at the port of shipment was comparable.

TABLE 10.—Average value of bauxite imported into and exported from the United States, in long tons

[Bureau of the Census]

Type and country	Average value, port of shipment		Type and country	Average value, port of shipment	
	1958	1959		1958	1959
Crude and dried:			Calcined:[3]		
British Guiana	$6.99	$6.99	British Guiana	$24.30	[4] $24.06
Dominican Republic[1]	-	12.73	Surinam	19.62	[4] 25.00
Haiti[1]	[2] 8.71	8.72	Average	24.30	[4] 24.06
Jamaica[1]	9.44	9.51			
Surinam	7.85	8.04	Bauxite and bauxite concentrate exported	81.57	104.86
Average	8.86	9.03			

[1] Dry equivalent tons used for computation.
[2] Revised figure.
[3] For refractory use.
[4] Estimated by Bureau of Mines.

TABLE 11.—Market quotations on alumina and aluminum compounds

[Oil, Paint and Drug Reporter]

Compound	Dec. 29, 1958	Dec. 28, 1959
Alumina, calcined, bags, carlots, works, pound	$0.05	$0.05
Aluminum hydrate, heavy, bags, carlots, freight equalized, do	.035	.035
Aluminum sulfate, commercial ground bulk, carlots, works, freight equalized, ton	40.00	40.00
Aluminum sulfate, iron free, bags, carlots, works, freight equalized, 100 pounds	3.80	3.80

FOREIGN TRADE[3]

U.S. imports increased only slightly. Imports from Jamaica decreased 15 percent and supplied 51 percent of all imports on a dry equivalent basis. Imports from Surinam increased 27 percent and supplied 38 percent of total imports. The Dominican Republic commenced commercial shipments of bauxite and, on a dry equivalent basis, supplied 5 percent of all imports. British Guiana and Haiti supplied the remaining 6 percent. Imports include bauxite acquired by the U.S. Government.

On a dry basis, 37 percent of the imports entered through the New Orleans, La., customs district; 32 percent through the Galveston, Tex., district; 29 percent through the Mobile, Ala., district; and 2 percent through the other districts. On an as-shipped basis, with no correction for moisture content, bauxite imports were 8,898,000 long tons.

Imports of calcined alumina for producing aluminum were 127,000 short tons; 99 percent came from Japan. Other aluminum com-

---

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 12.—Bauxite (crude and dried) imported for consumption in the United States[1]

(Thousand long tons and thousand dollars)
[Bureau of the Census]

Country	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Dominican Republic (dry equivalent)[2]	(3)					384
Haiti (dry equivalent)[2]				318	[4] 317	308
Jamaica (dry equivalent)[2]	592	2,178	2,573	3,622	[4] 4,950	4,189
Trinidad and Tobago	8					
Other North America	(3)					
Total	600	2,178	2,573	3,940	[4] 5,267	4,881
South America:						
British Guiana	135	242	269	391	[4] 223	155
Surinam	2,699	2,462	2,798	2,767	2,425	3,071
Other South America	1					
Total	2,835	2,704	3,067	3,158	[4] 2,648	3,226
Europe	2				(3)	
Asia	166					
Africa			30			
Grand total[2]	3,603	4,882	5,670	7,098	[4] 7,915	8,107
Value	$24,518	$36,656	$44,414	$60,933	[4] $70,107	$73,203

[1] Only small quantities of undried bauxite were imported. Includes bauxite imported for Government account.
[2] Bureau of the Census import figures adjusted by Bureau of Mines to dry equivalent.
[3] Less than 1,000 tons.
[4] Revised figure.

pounds imported into the United States totaled 9,053 short tons; about one-third came from Canada and the balance from Western Europe.

The duties on crude bauxite, calcined bauxite, and alumina imported for making aluminum were suspended in 1958 until July 16, 1960. Duties on aluminum hydroxide and alumina not used for aluminum production were 0.25 cent per pound.

Exports of bauxite and bauxite concentrate increased nearly 50 percent. Canada received 77 percent of the total.

Of the 14,487 short tons of aluminum sulfate exported, about two-thirds was shipped to Canada and Venezuela. Of the 32,049 short

TABLE 13.—Bauxite (including bauxite concentrate[1]**) exported from the United States, in long tons**

[Bureau of the Census]

Country	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada	42,942	13,115	13,337	58,654	9,548	13,377
Other North America	820	606	800	1,015	1,341	1,706
Total	43,762	13,721	14,137	59,669	10,889	15,083
South America	36	70	80	121	37	346
Europe	195	326	378	403	601	[2] 1,082
Asia	144		295	764	309	835
Africa	16		31	36	32	57
Grand total as exported	44,153	14,117	14,921	60,993	11,868	[2] 17,403
Dried bauxite equivalent[3]	68,447	21,881	23,128	94,539	18,395	26,975
Total value (thousands)	$1,154	$528	$834	$4,847	$968	[2] $1,825

[1] Classified as "Aluminum ores and concentrates" by the Bureau of the Census.
[2] Adjusted by Bureau of Mines.
[3] Calculated by Bureau of Mines.

tons of other aluminum compounds exported, 73 percent was shipped to Norway.

Table 14 shows the international flow of bauxite in 1957. Total exports (12.8 million long tons) increased 13 percent over 1956. Jamaica increased its exports by more than 1 million tons and became the world's largest exporter of bauxite. Haiti began shipments on a commercial scale. A gain in exports of more than 100,000 tons from Greece was offset by a decline in the exports from Surinam of about the same quantity.

In 1957 six countries received 97 percent of the world's exports: United States and Canada received 74 percent; West Germany, Japan, and the United Kingdom, 16 percent; and the U.S.S.R. 7 percent.

TABLE 14.—Production and trade of bauxite in 1957, by major countries, in thousand long tons

[Compiled by Corra A. Barry and Berenice B. Mitchell]

Exports, by countries of origin	Production	Exports	Exports, by countries of destination									
			North America		Europe						Asia	All other countries
			Canada	United States	Germany, West	Italy	Norway	U.S.S.R.	United Kingdom	Other Europe	Japan	
Jamaica	4,643	3,641	(1)	3,641	------	------	------	------	------	------	------	------
Surinam	3,324	3,324	316	2,981	[2] 16	------	------	------	------	11	------	------
British Guiana	2,202	2,021	1,470	451	10	3	(1)	------	22	27	24	14
Greece	820	769	------	------	269	------	34	394	42	19	------	11
Yugoslavia	874	689	------	------	461	223	------	------	1	4	------	------
Hungary	903	460	------	------	------	------	------	[3] 460	------	------	------	------
French West Africa	360	370	273	------	96	------	------	------	------	1	------	------
Malaya	326	341	------	------	------	------	------	------	------	1	307	[4] 33
France	1,657	320	------	------	172	[2] 6	------	------	127	------	------	15
Haiti	263	318	------	[2] 318	------	------	------	------	------	------	------	------
Indonesia	238	254	------	------	[2] 117	------	------	------	------	------	[2] 134	3
Ghana	[5] 185	185	------	------	22	------	------	------	163	------	------	------
United States	1,416	61	59	------	(1)	(1)	------	------	(1)	(1)	(1)	2
Other	2,889	23	------	------	6	------	------	------	3	------	4	10
Total	[6] 20,100	12,776	2,118	7,391	1,169	232	34	854	358	63	469	88

[1] Less than 500 tons.
[2] Imports.
[3] U.S.S.R. and other Communist nations of East Europe.
[4] Taiwan received 33,000 long tons.
[5] Exports.
[6] Estimate.

WORLD REVIEW

World production of bauxite increased 8 percent. Jamaica continued to be the world's largest producer of bauxite and furnished 23 percent of the world's total. A new bauxite producer, the Dominican Republic, began commercial shipments to the United States.

Geologists of British Aluminum Co., Ltd., described the world's bauxite deposits in a paper presented at a Brisbane symposium of the Australian Institute of Mining and Metallurgy. Their estimate of total world bauxite resources, which included a large quantity of inferred material, was 10 billion tons.

Table 15 includes information on capacity, location, and ownership of plants producing alumina throughout the world. Most of the data were based on company reports, consular dispatches, newspaper and journal articles, and private communications.

TABLE 15.—World producers of alumina

(Short tons)

A. FREE WORLD

Country, company, and plant locations	Capacity, end of 1959	Participants
North America: Canada: Aluminum Company of Canada, Ltd.: Arvida.	1,250,000	Subsidiary of Aluminium, Ltd. (Canadian).
Caribbean: Jamacia:		
Alumina Jamaica, Ltd.: Kirkvine	540,000	Do.
Ewarton	28,000	
Total	568,000	
United States, total [1]	4,865,500	
Total, North America	6,683,500	
South America: Brazil:		
Aluminio Minas Gerais: Ouro Preto	16,500	Do.
Cie. Brasileira Aluminio: Sorocaba	33,000	Industrias Votorantim S.A. 80 percent, and other Brazilian interests, 20 percent.
Total	49,500	
Europe:		
France:		
Pechiney, Cie. de Produits Chimiques et Electrometallurgiques:		Privately owned (French).
Gardanne	354,000	
St. Auban	110,700	
Salindres	44,300	
Soc. d'Electro-Chimie, d'Electro-Metallurgie et des Acieries Electriques d'Ugine: La Barasse.	110,000	Do.
Soc. Francaise pour l'Industrie de l'Aluminium: St. Louis les Aygelades.	66,000	Affiliate of Aluminium-Industrie, A.G. (AIAG) (Swiss).
Total	685,000	
Germany, West:		
Aluminium G.m.b.H.: Martinswerke	154,000	Subsidiary of Swiss AIAG.
Vereinigte Aluminiumwerke A.G.:		
Lippewerk	143,000	Government owned.
Innwerk	121,000	
Gebruider Giulini, G.m.b.H.: Ludwigshafen	132,000	Privately owned (German).
Total	550,000	
Italy:		
Industria Nazionale Allumino: Porto Marghera.	95,000	Montecatini group, 100 percent.
Soc. Alluminio Veneto Anonima (SAVA): Porto Maghera.	110,000	Subsidiary of Swiss AIAG.
Total	205,000	
Norway: Norsk Aluminium A/S: Hoyanger	18,700	Privately owned (Norwegian), 50 percent, and Aluminium, Ltd. (Canadian), 50 percent.
Sweden: A/S Svenska Aluminiumkompaniet: Kubikenborg.	8,800	Privately owned (Swedish), 50 percent, and Aluminium, Ltd. (Canadian), 50 percent.
United Kingdom: British Aluminium Co. Ltd.:		Tube Investments Ltd. (British), 47 percent, Reynolds Metals Co. (American), 45 percent, Reynolds Tube Investments Ltd., 4 percent, and miscellaneous shareholders, 4 percent.
Burntisland	67,200	
Newport	50,400	
Total	117,600	
Yugoslavia: State concerns:		Government owned.
Strnisce	8,800	
Moste	8,800	
Kidricevo	55,000	
Total	72,600	
Total, Europe	1,657,700	

[1] For company and plant breakdown see table 6, this chapter.

TABLE 15.—World producers of alumina—Continued

(Short tons)

A. FREE WORLD—Continued

Country, company, and plant locations	Capacity, end of 1959	Participants
Asia:		
Formosa (Taiwan): Taiwan Aluminium Corp.: Takao.	32,000	Government owned.
India:		
Indian Aluminium Co., Ltd.: Muri	19,800	Indian owned, 35 percent, Aluminium, Ltd. (Canadian), 65 percent.
Aluminium Corp. of India, Ltd.: Jaykaynagar.	5,500	Privately owned (Indian).
Total	25,300	
Japan:		
Showa Denko K.K. (Showa Electro-Chemical Industry Co., Ltd.): Yokohama.	88,000	Privately owned (Japanese).
Nippon Keikinzoku K.K. (Japan Light Metals Co.): Shimizu.	180,000	Aluminium, Ltd. (Canadian), 50 percent, and privately owned (Japanese), 50 percent.
Sumitomo Kagaku K.K. (Sumitomo Chemical Co. Ltd.): Kikumoto.	130,000	Privately owned (Japanese).
Total	398,000	
Total, Asia	455,300	
Oceania: Australia: Australian Aluminium Production Commission: Bell Bay.	38,500	Government owned.
Total, free world	8,884,500	

SOVIET BLOC [2]

Country, company, and plant locations	Capacity, end of 1959	Participants
U.S.S.R.: State concerns:		
Boksitogorsk	165,000	Government owned.
Kamensk-Uralskiy	385,000	
Krasnotourinsk	385,000	
Volkhov	88,000	
Zaporozhye	220,000	
Total	[3] 1,243,000	
Germany, East: Vereinigte Aluminiumwerk A.G.: Lauta	100,000	Do.
Hungary:		
Bonautaler Alaunerde: Alamasfuzito	126,700	Do.
Ungarrische Bauxit Gruben A.G.: Ajaka	66,000	Do.
Bauxit Industrie A.G.: Magyarovar	38,500	Do.
Total	231,200	
China (Manchuria): State concerns:		
Fushun	24,200	Do.
Nanting	44,000	
Total	68,200	
North Korea	(4)	
Total, Soviet bloc	1,642,400	
Total, world	10,526,900	

---

[2] In many instances it has been impossible to confirm data on Soviet bloc plants.

[3] Does not include the Pikalevo plant, which began operations of the first section of the plant in September 1959. Capacity is unknown.

[4] Data not available; capacity in 1943 was given as 75,500 tons.

TABLE 16.—Relationship of world production of bauxite and aluminum, in million long tons

Commodity	1950–54 (average)	1955	1956	1957	1958	1959
Bauxite	12.7	17.5	18.5	20.1	[1] 20.9	22.5
Aluminum	2.1	3.1	3.3	3.3	3.5	4.0
Ratio of bauxite to aluminum production	6.0	5.6	5.6	6.1	[1] 6.0	5.6

[1] Revised figure.

NORTH AMERICA

Dominican Republic.—Alcoa Exploration Co. began mining operations at its Cabo Rojo properties in January and by the end of the year had produced 922,600 long tons of ore containing 17 to 18 per-

TABLE 17.—World production of bauxite, by countries, in thousand long tons [1]

[Compiled by Pearl J. Thompson and Berenice B. Mitchell]

Country	1950–54 (average)	1955	1956	1957	1958	1959
North America (dried equivalent of crude ore):						
Dominican Republic	------	------	------	------	------	759
Haiti	------	------	------	263	280	255
Jamaica	[2] 1,179	2,645	3,141	4,643	5,722	5,125
United States	1,685	1,788	1,744	1,416	1,311	1,700
Total	2,864	4,433	4,885	6,322	7,313	7,839
South America:						
Brazil	19	44	69	63	69	[3] 70
British Guiana	2,112	2,435	2,481	2,202	1,586	1,674
Surinam	2,882	3,074	3,430	3,324	2,941	3,376
Total	5,013	5,553	5,980	5,589	4,596	5,120
Europe:						
Austria	12	19	22	22	23	24
France	1,086	1,470	1,439	1,657	1,788	1,717
Germany, West	6	4	5	5	4	[3] 4
Greece	238	492	687	820	843	886
Hungary	1,022	1,221	879	903	1,036	942
Italy	228	322	271	257	294	287
Rumania [3]	10	16	16	16	20	20
Spain	9	6	7	8	8	[3] 8
U.S.S.R. [3]	990	2,030	2,190	2,410	2,710	2,950
Yugoslavia	489	779	868	874	721	802
Total [3]	4,090	6,359	6,384	6,972	7,447	7,640
Asia:						
China (diasporic) [3]	------	------	------	------	150	295
India	68	81	91	97	115	124
Indonesia	273	260	299	238	338	[3] 375
Malaya, Federation of	68	222	264	326	262	382
Pakistan	------	1	3	3	2	2
Sarawak	------	------	------	------	136	207
Taiwan (Quemoy)	2	------	------	------	------	------
Total	411	564	657	664	1,003	1,385
Africa:						
Ghana (exports)	119	116	138	185	207	148
Guinea, Republic of	173	485	444	360	325	297
Mozambique	3	3	4	5	5	4
Total	295	604	586	550	537	449
Oceania: Australia	5	8	10	8	7	[3] 7
World total (estimate)	12,700	17,500	18,500	20,100	20,900	22,500

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[2] Average for 1952–54.

[3] Estimate.

cent moisture. Exports, all to the United States, totaled 420,000-long tons.

Haiti.—A barter agreement to ship 400,000 long tons of bauxite to U.S. Government stocks in 1960 will enable Reynolds Haitian mines to operate at an increased rate.

Jamaica.—Alcoa acquired a joint interest with Caribex, Ltd., a subsidiary of American Metal Climax, Inc., to prospect for bauxite in the Mocho area of Clarendon Parish. The company planned to spend $200,000 by May 1960 for exploration of the lease held by Caribex, Ltd.[4]

Alumina Jamaica, Ltd., began operating its Ewarton alumina plant at the end of 1959 and was to operate at full capacity of 270,000 tons by the second half of 1961.

During the year 4,884,000 long tons (4,197,000 dried basis) of bauxite was exported, a decrease of 13 percent from 1958. Most of the ore was shipped to the United States, and a small quantity went to Canada. In addition, 928,486 (dried basis) tons was produced by Alumina Jamaica, Ltd., for use in local alumina plants. Alumina exports in 1959 totaled 447,100 short tons.

Mexico.—The Mexican Government announced the finding of bauxite under recently discovered gypsum deposits midway between the cities of San Luis Potosi and Tampico, and declared the area a national reserve.

SOUTH AMERICA

British Guiana.—The Demerara Bauxite Co. again operated at 65 percent of capacity and shipped 1,074,000 long tons of dried bauxite and 274,000 tons of calcined bauxite. Of the calcined ore shipped, 129,000 tons was Abrasive grade and 145,000 tons was Refractory grade. Work continued on construction of the alumina plant at MacKenzie.

It was reported that very large deposits of low-grade bauxite were found in the Pakaraima Mountains near the Brazilian border, about 150 miles southwest of Georgetown.

French Guiana.—Société Guyanaise de Bauxite was formed by the

TABLE 18.—**Bauxite exported from British Guiana, in long tons**

Country of destination	1958		1959	
	Dried ore	Calcined ore	Dried ore	Calcined ore
Canada	922,170	66,740	938,770	80,620
France	-----	21,952	3,700	14,861
Germany, West	665	9,495	(1)	22,240
Italy	-----	4,900	-----	15,275
Japan	1,200	8,180	(1)	10,540
United Kingdom	6,605	15,220	7,920	19,855
United States	232,786	48,305	288,953	83,607
Other countries	5,211	20,857	3,038	25,307
Total	1,168,637	195,649	1,242,381	272,305
Value, BWI$ [2]	13,392,778	7,169,410	14,671,463	10,117,781

[1] Breakdown not available; probably included in other countries.
[2] 1 BWI$=US$0.58.

---

[4] Mining World, Alcoa Allocates $200,000 to Explore Jamaica Bauxite: Vol. 21, No. 12, November 1959, p. 78.

Bureau Minier Guyanais and Kaiser Aluminum & Chemical Corp. to explore and possibly exploit bauxite deposits in the Kaw mountains. The deposits consist of discontinuous pockets stretching from Roura, near Cayene, toward Kaw and Guisambourg, and were estimated to contain 69 million long tons of bauxite. Kaiser holds an option on the deposits until the end of 1960.

Surinam.—The Billiton Co. and Surinam Aluminum Co. (Suralco) increased shipments of bauxite in order to fulfill contracts to supply ore to the U.S. Government for stockpiling. Suralco operated under a 1958 contract to ship 600,000 long tons, and an additional contract to ship 136,700 tons was made in 1959. The Billiton Co. also received a contract to supply 147,600 tons to the U.S. Government.

Shipments of bauxite during 1959 totaled 3,330,400 long tons, an increase of 18 percent over 1958. Of this amount 3,147,500 tons was Metal-grade ore, 107,000 calcined ore, and 75,900 Chemical-grade ore.

EUROPE

Hungary.—A new deposit of bauxite was found in the Nyirad basin in western Hungary, near deposits now being worked.

Poland.—An alumina plant under construction at Gorka was expected to be completed by mid-1960. A process (Bretsznajder) was developed that uses, as a raw material, bauxitic clay overlying a lignite deposit at Turoszov.

U.S.S.R.—The first section of the Pikalevo alumina plant in Leningrad began operating in September. The capacity of this section was not announced, but total capacity was to be 550,000 short tons. The plant reportedly processes nepheline concentrate, a byproduct from a plant producing phosphates from apatite in the Kola Peninsula.

It was reported that difficulty was encountered in changing the Soviet's largest bauxite deposit in the northern Urals from opencast to underground mining because of flooding in the lower levels.

The only major operating bauxite mine outside the Urals was at Boksitogorsk, near Leningrad, and the only bauxite mining project under development was the Arkalyk mine near Turgai.[5]

Yugoslavia.—A new discovery of bauxite, reported near Vlasenica in in southeastern Serbia, was being exploited. The deposit was said to contain 10.4 million tons of 50-percent ore.

ASIA

Malaya, Federation of.—Bauxite output in Malaya reached a new peak (46 percent more than in 1958) owing to increased demand from Japanese aluminum producers. Of the 363,800 long tons of bauxite exported, 345,200 went to Japan and 18,600 to Australia.

A second and improved washing plant was completed to facilitate rewashing lower grade ore from the Ramunia field.

India.—Kaiser Aluminum & Chemical Corp. had a 27-percent interest in a new company, Hindustan Aluminium Corp., Ltd. The company plans to mine bauxite at Amarkantak, Madhya Pradesh, and transport the ore to a new alumina plant and smelter to be built near the Rihand Dam.

---

[5] Shabad, Theodore, Ivan and the Seven-Year Plan: 2½ Times More Aluminum: Am. Metal Market, vol. 67, No. 19, Jan. 28, 1960, pp. 1, 15.

The Indian Aluminium Co., Ltd., completed part of the expansion of its Muri alumina plant in Bihar State and the related bauxite mines at Lohardaga. When planned expansion is completed, the Muri plant will have a capacity of 60,000 short tons of alumina per year.

AFRICA

Belgian Congo.—A large deposit of bauxite was reported at Sumi in the Mayumbe region, 60 kilometers north of Inga. The area was prospected by Forminiere, Bamoco Syndicate, and Foraky, a subsidiary of Union Minière du Haut Katanga. Société de Recherches et d'Explorations des Bauxites du Congo (Bauxicongo) was formed by Forminiere, Bamoco, and Cobeal (Compagnie Belge de l'Industrie de l'Aluminium) to prospect the area.

Cameroon.—The discovery of the large Minim-Martap bauxite deposit reported in 1958 was confirmed by the Government in the latter part of 1959. The deposit is on the Adamaoua Plateau, about 80 kilometers southwest of Ngaoundere, and was estimated to contain at least 500 million tons and possibly 2 billion tons of bauxite containing about 40-percent alumina. However, the absence of water and transportation facilities precludes exploitation in the near future.

The Fongo-Tongo deposits were investigated by a syndicate formed by the Bureau Minier and Pechiney and Ugine. These deposits were estimated to contain 45 million tons of recoverable ore averaging 45 percent alumina and 2 percent silica. The Bangam deposits were also investigated by the syndicate and were found to contain a lower grade ore than those of Fongo-Tongo.

Guinea, Republic of.—The entire output of bauxite was exported except a small quantity used in tests at the Fria alumina plant. Commercial production of alumina at Fria was expected to begin by the end of the first quarter of 1960.

Bauxite reserves were estimated at 1 billion tons—Iles de Los (Loos), 4 to 5 million; Boké, 700 million; and Fria, 300 million.

Several articles on the mineral wealth of Guinea were devoted to the bauxite and aluminum industry.[6]

Soudan.—Société Africaine de Recherches et d'Etudes pour l'Aluminium (SAREPA) was prospecting for bauxite. The Service of Geology and Mining Prospection continued its search for bauxite and reported outcroppings in the Falea-Dar Salam region and a deposit in the Fantofa Plateau. The ore was reported to contain 45 percent alumina and a relatively high silica content.

OCEANIA

Australia.—A paper presented at the symposium on Aluminium in Australia held in Brisbane on July 16 and 17, described the exploration of the deposits at the Cape York Peninsula discovered in 1955 by H. J. Evans, geologist of the Commonwealth Aluminium Corporation Pty., Ltd. Preliminary drilling was done on 4,000-foot centers along lines 4,000 to 8,000 feet apart in the laterite area. Evaluation drilling was done on 2,000-foot centers. The Tertiary laterites cover

---

[6] Moyal, Maurice, The Bauxite Ore Wealth of Guinea: Min. Jour. (London), vol. 252, No. 6448, Mar. 20, 1959, pp. 312–313; Exploiting Guinea's Aluminium Potential: Vol. 252, No. 6449, Mar. 27, 1959, p. 342.

an area of 500 square miles, of which about 200 square miles is considered to be bauxite that is potentially economic. The ultimate reserves of the area could exceed 1 billion tons.[7]

Reynolds Pacific Mines Pty., Ltd., surveyed a 45-mile area in south Gippsland, Victoria.

Western Mining Corp., Ltd., North Broken Hill, Ltd., and Broken Hill South, Ltd., were prospecting for bauxite in the Darling Ranges in Western Australia. A trial shipment of 7,500 long tons of bauxite mined by Western Aluminium N.L. in the Darling Ranges was shipped to the Bell Bay smelter for tests.

Dominion Pty., Ltd., a newly formed company, was surveying for bauxite over a 3,520-square-mile area in the northern part of Queensland.

Following favorable test on a 9,000-ton trial shipment of Indian bauxite, the Aluminium Production Commission was negotiating for a continuous supply of bauxite from India to augment shipments from Indonesia and the Federation of Malaya.

TECHNOLOGY

The Bureau of Mines published a bulletin describing the operation of a demonstration alumina plant at Laramie, Wyo.[8] Anorthosite was treated by the lime-soda sinter process to produce about 800 tons of alumina. Anorthosite, limestone, and soda ash were first sintered in a rotary kiln. The sinter was then ground, leached, and filtered to recover the soluble sodium aluminate. The leach solutions were desilicated with lime, and the alumina was precipitated with carbon dioxide. The plant was successfully operated as a unit for 30 days. The problem of gelation of the leach residues was overcome by proper control of the sintering and leaching operations.

The Department of Mines and Technical Surveys, Ottawa, Canada, described a sulfate process for extracting alumina from eastern Canadian shale deposits containing 23 percent Al_2O_3.[9] The rock was baked with sulfuric acid and then leached with hot water, the alumina was precipitated as potassium alum. After the product was recrystallized, the impurities were reported to be low enough to meet requirements for metallurgical alumina. As an alternative to recrystallization, it was possible to use liquid-liquid extraction involving selective extraction of the iron in a kerosene solution of a primary amine.

The North American Coal Corporation of Cleveland, Ohio, in cooperation with the Strategic Materials Corporation of Buffalo, N.Y., was building a $500,000 pilot-plant at Buffalo to test a sulfuric acid process for extracting alumina and aluminum sulfate from coal-mine rejects.[10]

The Sherwin alumina plant at La Quinta, Tex., of Reynolds Metals Co., which treats 4,000 tons per day of Jamaica-type ore, was de-

---

[7] Evans, H. J., Geology and Exploration of the Cape York Peninsula Bauxite Deposits: Chem. Eng. Min. Rev., Melbourne, vol. 51, No. 11, Aug. 15, 1959, pp. 48–57.

[8] St. Clair, H. W., and others, Operation of Experimental Plant for Producing Alumina from Anorthosite: Bureau of Mines Bull. 577, 1959, 127 pp.

[9] Thomas, G., and Ingraham, T. R., The Alum-Amine Process for the Recovery of Alumina From Shale, Department of Mines and Technical Surveys, Ottawa, Mines Branch Research Rept. R 45, Apr. 3, 1959, 25 pp.

[10] Mining Journal, $500,000 Alumina Pilot Plant: Vol. 253, No. 6478, Oct. 16, 1959, p. 368.

scribed.[11] Because the bauxite contains bohemite in addition to gibbsite, higher temperatures and pressures are necessary to extract the alumina than when an ore containing only gibbsite is treated. The bauxite is ground in spent liquor fortified with caustic, then it is passed to the digesters which operate at temperatures of about 400° F. and pressures of 200 p.s.i. Retention time in the digesters is 30 minutes or less. The slurry is then pumped to a series of tray settlers, thickeners, and pressure filters. The red mud underflow is sent to waste, and the overflow is pumped to Pachuca tanks for precipitation of alumina trihydrate. The alumina is then filtered and calcined to yield a final product containing 99.1 percent alumina.

The genesis of the Pocos de Caldas bauxite deposits of Brazil was discussed in relation to the composition of the original rocks and the effect of climatic factors.[12] The bauxite was derived from a series of nepheline-bearing phonolites, syenites, and gneisses. The drainage and the pH of the weathering solutions determined whether bauxite or kaolin formed.

A symposium of 26 papers describing the geology of many bauxite deposits of the Soviet Union and discussing their mineralogy, geochemistry, and problems of genesis was reviewed in detail. Soviet bauxite deposits range in age from late Proterozoic to late Tertiary. They occur in a wide variety of conditions, although many of the largest are associated with a karst topography in limestone. Soviet geologists favored the theory of a sedimentary chemical origin of bauxite. Only a few believed that residual weathering and mechanical transportation were important.[13]

As high-quality bauxite reserves in the U.S.S.R. are limited, several alternative sources of alumina have been studied. The costs of producing alumina from different materials was compared under conditions assumed to be similar to those in the northern Urals. The Bayer process, used on high-grade Urals ore containing 50 to 55 percent Al_2O_3 and 4 percent silica, yielded alumina at a cost of 588 rubles per metric ton of product. The combination process, applied to Turgay bauxites with about 45 percent Al_2O_3 and 12 percent silica, was estimated to cost 594 rubles per ton of alumina. The estimate of the cost of producing alumina from high-silica Tikvin bauxites by the lime-soda sinter process was 748 rubles per ton. The Siberian Krasnoyarsk nepheline syenites, when treated by the lime-soda sinter process, were estimated to produce alumina at a cost of 1,297 rubles per ton. If 310 rubles was allowed as credits for using the residue as cement and recovering soda from the nepheline syenites, the cost was reduced to 987 rubles per ton of alumina. Estimates of producing alumina from the Zaglik alunites containing 23 percent Al_2O_3 were 855 rubles per ton using an acid process. A credit of 120 rubles, allowed for the SO_2 byproduct, reduced the cost of the alumina to 735 rubles per ton. Data on material balances, energy consumption, and capital costs were included.[14]

---

[11] Engineering and Mining Journal, Reynolds Expands Alumina Production: Vol. 160, No. 5, May 1959, pp. 98–101.

[12] Webber, Benjamin N., Bauxitization in the Pocos de Caldas District, Brazil: Min. Eng., vol. 11, No. 8, August 1959, pp. 805–809.

[13] Zans, V. A. (Ed. by Strachov, N. M., and Bushinsky, G. I.), A Review of Bauxites, Their Mineralogy and Genesis: Econ. Geol., vol. 54, 1959, pp. 957–974.

[14] Kuznetsov, G. D. [Appraisement of the Effectiveness of the Utilization of Several Types of Alumina-Bearing Raw Materials in the U.S.S.R. Industry]: Ixvestiya Vysshisk Uchebnykh Zavendenii, Tsvetnaya Metallurgiya, No. 3, 1958, pp. 142–148.

Beryllium

By Donald E. Eilertsen[1]

◆

SEARCH for domestic beryllium ore deposits continued in 1959, and intensified research was directed toward solving complex problems that impeded greater use of the metal in aircraft, missiles, and nuclear reactors.

LEGISLATION AND GOVERNMENT PROGRAMS

General Services Administration (GSA) bought 343 short tons of domestically produced beryl for the Government through its program encouraging domestic production, making a cumulative total of 2,487 tons purchased since the program began in 1952. Only shipments consisting of clean crystals of beryl cobbed free of waste and containing at least 8 percent beryllium oxide (BeO) were accepted. This program terminates June 30, 1962, or when 4,500 tons has been delivered, whichever occurs first.

TABLE 1.—Salient statistics of beryllium, in short tons

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Beryl, approximately 10–12 percent BeO:						
Domestic mine shipments	596	500	445	521	463	328
Value	$244,800	$267,927	$231,126	$275,855	$238,017	$170,523
Imports	5,794	6,037	12,371	7,290	4,599	8,038
Consumption	2,896	3,860	4,341	4,309	6,002	8,173
Approximate price per unit BeO, domestic[1]	$41	$49	$47	$48	$47	$47
Approximate price per unit BeO, imported (10 percent BeO)	$40	$37	$36	$35	$34	$29
World: Beryl production, 10–12 percent BeO	7,500	8,900	12,900	[2] 11,300	[2] 7,400	7,300

[1] 10 percent BeO, 1950–54, and 11 percent BeO, 1955–59.
[2] Revised figure.

DOMESTIC PRODUCTION

Mine Production.—Beryl production was the smallest since 1948. Based on shipments, 328 tons of beryl was produced by 100 operations in seven States. Individual shipments of beryl varied from a few pounds to 92 tons. Boomer Lode mine in Park County, Colo., was the

---

[1] Commodity specialist.

leading single producer of handsorted beryl; some low-grade beryl also was sold.

South Dakota produced 48 percent of the domestic beryl; Colorado, 38 percent; and five other States 14 percent.

Refinery Production.—The Beryllium Corp. plants at Reading and Hazelton, Pa., and The Brush Beryllium Co. plant at Elmore, Ohio, were the only plants in the United States that processed beryl to beryllium metal, various alloys, and compounds. More beryllium metal was produced than in any previous year. Data on production were not available for publication. The second year elapsed of the 5-year contracts awarded to the two domestic producers by the Atomic Energy Commission (AEC) for annual delivery of 37,500 pounds of nuclear-grade beryllium.

TABLE 2.—Beryl shipped from mines in the United States, by States, in short tons [1]

State	1950–54 (average)	1955	1956	1957	1958	1959
Colorado	76	46	163	182	134	124
New Hampshire	(2)	20	(2)	4	14	20
New Mexico	(2)	106	31	29	27	11
South Dakota	259	294	195	268	240	156
Other States [3]	261	34	56	38	48	17
Total:						
Short tons	596	500	445	521	463	328
Value	$244, 800	$267, 927	$231, 126	$275, 855	$238, 017	$170, 523

[1] Estimated 10–12 percent BeO.

[2] Included with "Other States" to avoid disclosing individual-company confidential data.

[3] Arizona 1950–51, 1953–58; Connecticut 1953–59; Georgia 1952–57; Idaho 1953–54, 1957; Maine 1950–59; Maryland 1954, 1957; New York 1954; North Carolina 1951, 1953–1958; Virginia 1954–56; Wyoming 1956–59.

CONSUMPTION AND USES

Domestic consumption of beryl in 1959, 8,173 tons, was the greatest recorded, and almost all was processed into beryllium metal and its alloys.

Net sales of The Beryllium Corp. were $21.2 million, compared with $14.8 million in 1958. The Brush Beryllium Co. sales were $18.1 million, compared with $12.7 million in 1958.

Five other consumers of beryl were: Beryl Ores Co., Arvada, Colo., which produced specialized beryl materials for the ceramic industry; Glass Coating Materials Division, A. O. Smith Corp., Milwaukee, Wis., which produced ground-coat frit (glass) for ceramics; Lapp Insulator Co., LeRoy, N.Y., which used ground beryl in making high-voltage electrical porcelain; the Ceramic Division, Champion Spark Plug Co., Detroit, Mich., which used beryl as a minor constituent in special ceramic compositions (primarily for spark plugs); and Delta Star Electric Division, H. K. Porter Co. (Delaware), Lisbon, Ohio, which used beryl in other ceramic products.

A substantial quantity of beryllium was produced for AEC, for special use in aircraft and missiles, and for research seeking new applications in these fields. Among the uses for beryllium metal were windows in X-ray tubes, nuclear-reactor parts, cans for nuclear-reactor fuels, inertial-guidance gyroscope parts, and heat-sink material such as, for the proposed man-in-orbit space vehicles, and airplane brake disks. Use of high-purity beryllium and beryllium oxide in special nuclear applications, as well as use of high-purity beryllium oxide in electronics and aircraft gained in interest. Beryllium oxide was used for crucibles and as a wash material for graphite crucibles. Beryllium-copper was used in aircraft, business machines, electronics, radios, electrical appliances, and automotive parts. Beryllium-aluminum was used in dies. Beryllium was reported to have been used as a new aluminum alloy to rocket engines.[2]

STOCKS

Consumer stocks of beryl at the end of the year totaled 3,871 tons. Stocks of beryllium metal and alloys were larger than in 1958.

No imported beryl or domestically produced beryllium-copper was added to the national strategic stockpile. Some domestically produced beryllium-copper containing imported raw materials was acquired as a result of the U.S. Department of Agriculture barter program, in which the Commodity Credit Corp. (CCC) exchanges surplus commodities for strategic materials.

PRICES AND SPECIFICATIONS

Domestically produced beryl containing 10–12 percent BeO was quoted at \$46–\$48 per short-ton unit of BeO, f.o.b. mine. The price of imported beryl per short-ton unit of BeO, based on 10–12 percent BeO, c.i.f. U.S. ports, and on short-term contracts, was \$31–\$32.25 until July 23, \$31.50–\$33 until September 3, and \$34–\$34.50 for the remainder of the year. Spot prices for imported beryl ranged from \$28 to \$32.50 per short-ton unit of BeO.[3] GSA bought domestic beryl at Franklin, N.H.; Spruce Pine, N.C.; and Custer, S. Dak. depots. Purchases were made by short-ton units (20 pounds) of contained BeO; prices per unit were as follows: 8–8.9 percent BeO, \$40; 9–9.9 percent BeO, \$45; and 10 percent BeO and over, \$50.

Beryllium metal, 97 percent, lump or beads, f.o.b. Cleveland, Ohio, and Reading, Pa., was \$71.50 per pound. Beryllium-copper master alloy, f.o.b. Reading, Pa., Elmore, Ohio, and Detroit, Mich. was \$43 per pound of contained beryllium plus market price of copper on date of shipment. Beryllium-aluminum, f.o.b. Reading, Pa., Elmore, Ohio, and Detroit, Mich., was \$74.75 per pound of contained beryllium plus market price of the aluminum. Prices per pound of beryllium-copper strip ranged from \$1.885 to \$1.975, beryllium-copper rod, bar, and wire ranged from \$1.865 to \$1.955.[4]

FOREIGN TRADE[5]

Imports.—In addition to the handsorted beryl imports shown in table 3 were imports of beryllium oxide or carbonate (not specifically

---

[2] American Metal Market, New Aluminum Rocket Engine Alloy Contains Beryllium: Vol. 66, No. 217, Nov. 7, 1959, p. 11.

[3] E&MJ Metal and Mineral Markets, vol. 30, No. 1–53, January–December 1959.

[4] American Metal Market, vol. 66, No. 1–252, January–December 1959.

[5] Import and Export figures compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

provided for): 904 pounds, valued at $2,928, from France; and 2 pounds, valued at $306, from United Kingdom.

TABLE 3.—Berryllium ore (beryl concentrate) imported for consumption in the United States, by countries, in short tons

[Bureau of the Census]

Country	1956	1957	1958	1959
South America:				
Argentina	2,330	1,545	772	2,480
Brazil	2,607	2,165	888	2,833
Total	4,937	3,710	1,660	5,313
Europe:				
Norway			3	4
Portugal	242	33		77
Sweden				41
Total	242	33	3	122
Asia:				
Hong Kong	1			
India	3,360	1,256	600	
Pakistan	15	69		
Total	3,376	1,325	600	
Africa:				
Belgian Congo	992	222	1,188	395
British East Africa (principally Uganda)	264	56	30	15
British Somaliland	29			
British West Africa, n.e.c.	22			
Madagascar	212	43		329
Morocco	26			
Mozambique	1,110	965	284	1,382
Rhodesia and Nyasaland, Federation of	559	266	135	151
Union of South Africa (includes South-West Africa)	602	670	699	331
Total	3,816	2,222	2,336	2,603
Grand total: Short tons	12,371	7,290	4,599	8,038
Value	$4,459,387	$2,526,068	$1,547,466	$2,345,285

Exports.—Exports included 200 pounds of beryllium ore, valued at $220, to United Kingdom. Exports of beryllium and beryllium-alloy powder (except beryllium copper) were 3,113 pounds, valued at $4,417, to Canada, and 2,406 pounds, valued at $182,867, to the United Kingdom. Exports of beryllium metal and alloys in crude form and scrap (except beryllium copper) were 22,435 pounds, valued at $51,886, to Canada; 8,782 pounds, valued at $31,841, to Norway; 34,222 pounds, valued at $598,628, to United Kingdom; 110 pounds, valued at $524, to Netherlands; 79,806 pounds, valued at $172,807, to West Germany; 663 pounds, valued at $2,388, to Switzerland; 3,333 pounds, valued at $77,164, to Italy; and 4,077 pounds, valued at $17,880, to Japan. Exports of beryllium and beryllium alloys in semifabricated forms, not elsewhere classified, were 157 pounds, valued at $27,403, to Canada; 13 pounds, valued at $1,266, to Sweden; 2,204 pounds, valued at $7,987, to Norway; 910 pounds, valued at $161,829, to United Kingdom; 2,017 pounds, valued at $187,309, to Belgium and Luxembourg; 3 pounds, valued at $1,735, to West Germany; and 9 pounds, valued at $2,085 to Taiwan.

WORLD REVIEW

World production of beryl was the least since 1951.

France.—A new beryllium plant of the Pechiney Company began production at Calypso.[6]

Japan.—According to Japan Metal Bulletin, the Nippon Gaishi (Japan Insulator) Co. had capacity to produce 6 tons of beryllium a month, and Yokozawa Chemical Co. had a capacity of 10 tons a month. Both firms planned to expand facilities.

The following shipments of beryllium copper alloy also were reported in the Japan Metal Bulletin.

TABLE 4.—World production of beryl, by countries,[1] in short tons[2]

[Compiled by Augusta W. Jann and Berenice B. Mitchell]

Country [1]	1950–54 (average)	1955	1956	1957	1958	1959
North America: United States (mine shipments)	596	500	445	521	463	328
South America:						
Argentina	452	1,488	1,722	1,571	1,004	[3] 660
Brazil	2,245	1,954	2,321	1,452	1,295	[3] 2,200
Total	2,697	3,442	4,043	3,023	2,299	[3] 2,680
Europe:						
Norway [4]	------	------	------	------	3	4
Portugal	211	337	244	191	52	19
Sweden	------	------	------	------	28	[3] 28
Total [1 2 3]	300	440	340	300	200	150
Asia:						
Afghanistan	10	33	30	15	------	------
India [4]	247	845	3,360	1,256	600	------
Korea, Republic of	2	[4] 6	------	(5)	------	------
Total	259	884	3,390	1,271	600	------
Africa:						
Belgian Congo (including Ruanda-Urundi)	[6] 29	362	1,905	1,771	1,113	467
British Somaliland	------	19	17	------	------	------
Kenya	[7] 1	------	------	6	4	2
Madagascar	545	316	169	299	180	463
Morocco: Southern zone	69	2	------	------	------	------
Mozambique	410	960	944	1,871	1,134	1,548
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	6	21	13	5	13	2
Southern Rhodesia	1,216	963	606	572	332	440
South-West Africa	660	472	454	385	246	170
Uganda	43	110	98	78	86	234
Union of South Africa	547	137	133	711	464	214
Total	3,526	3,362	4,339	5,696	3,572	3,540
Oceania: Australia	111	230	356	442	278	[3] 400
World total (estimate) [1 2]	7,500	8,900	12,900	11,300	7,400	7,300

[1] Beryl also produced in U.S.S.R. but production data are not available; estimate included in total.

[2] This table incorporates some revisions. Data do not add to totals shown, because of rounding where estimated figures are included.

[3] Estimate.

[4] United States imports.

[5] Less than 0.5 ton.

[6] Average for 1953–54.

[7] Average for 1952–54.

---

[6] Chemical Trade Journal and Chemical Engineer (London), Pechiney Exports Rise: Vol. 145, No. 3761, July 3, 1959, p. 1439.

Company	Designation	Quantity	Value
Nippon Gaishi	United Kingdom	2 tons	$5,500
Do	Germany, West	5 do	15,000
Yokozawa Chemical	United Kingdom	½ do	1,600

Nippon Gaishi Co. contracted to import 70 tons of beryllium ore from Argentina.

Pakistan.—Large deposits of beryl reportedly were found at high altitudes by a Pakistan-German firm.[7]

Uganda.—A total of 507 short tons of beryl, 11–12 percent BeO, was produced in 1953–58 by opencast methods. Operational survey of the Bulema Mine to August 1957 indicated that 35,000 cubic yards of rock had been broken and that the yield was 10.2 pounds of beryl and 2.7 ounces of microlite-tantalite per cubic yard of rock. The United Kingdom Atomic Energy Authority (AEA) planned to assess resources and study economics of mining beryl in Uganda.[8]

United Kingdom.—A research production unit, whose first annual production was about 7 tons of wrought beryllium metal, was operated by Imperial Chemical Industries, Ltd., at its Witton works, near Middlesbrough, England. This was the first plant in Europe designed for processing large quantities of beryllium raw material to wrought beryllium metal. Beryllium production will be used by AEA for fuel cans in their experimental gas-cooled nuclear-reactor program.[9]

Consolidated Beryllium, Ltd., was established. The new firm is owned equally by the Beryllium Corporation, Reading, Pa., and Imperial Smelting Corp. Ltd., London, a wholly owned subsidiary of Consolidated Zinc Corp., Ltd. Nuclear-grade beryllium and beryllium-copper master alloy are to be produced.

TECHNOLOGY

The Federal Bureau of Mines continued its stepped-up search for adequate and dependable long-range supplies of domestic beryllium ore, research for recovering disseminated beryl from pegmatite deposits, and research for developing methods to extract and purify beryllium. Deposits in Alaska, Colorado, Idaho, Montana, Nevada, New Mexico, North Dakota, South Dakota, Utah, Wyoming, and some New England States were studied; and the Badger Flats area in Park County, Colo., was selected for further examination. Bureau engineers at Spokane, Wash., developed a mobile spectrographic laboratory for rapidly testing in the field large numbers of rock samples for beryllium and other uncommon metals. Bureau engineers at Denver, Colo., planned to use a nuclear device for detecting beryllium. The Bureau continued its research to develop flotation methods for recovery of disseminated beryllium ore from various deposits. Late in 1959 a beryl flotation test-plant was erected to test the feasibility of recovering disseminated beryl from pegmatite in the spodumene belt, Kings Mountain, N.C. Feed material for the plant consisted of tailings from a commercial spodumene mill. Development of processes to recover

---

[7] Mining Journal (London), Mining Miscellany: Vol. 253, No. 6484, Nov. 27, 1959, p. 541.

[8] Bureau of Mines, Mineral Trade Notes, Beryllium: Vol. 49, No. 2, August 1959, p. 7.

[9] Chemical and Process Engineering, Metals for the New Age: Vol. 41, No. 1, January 1960, pp. 32–33.

beryllium salts from various grades and types of beryl concentrate continued. Bench-scale research continued, developing ways to process low-grade beryl concentrates by means of sintering, fusion, and leaching, and by chlorination, fluorination, or solvent extraction. Experiments were made for producing high-purity beryllium metal both by using the method of reducing beryllium chloride or beryllium oxide with various metals and by fused-salt electrorefining. One objective of this work was to devise a technique for producing ductile beryllium. The Bureau continued its work developing field tests for beryllium,[10] and started research to develop a rapid method for petrographic grain counting of beryl in ores and concentrates.

Additional research on beryllium, sponsored by the Government, included rolling sheet metal, ductility, casting, forging, extrusion, joining, alloys, fabrication, applications, and safe handling.[11]

Several companies explored for beryllium ore in various parts of the United States, and studies were conducted to develop beneficiation and extraction processes.

In the search for an alloy or improved beryllium that could be rolled, extruded, and subsequently fabricated into aircraft and missile components more readily than commercial metal, beryllium produced from subsieve-size powder containing 2.1 to 2.5 percent beryllium oxide was found to have superior tensile properties. Preliminary evaluation also indicated that certain quantities of nickel or silver might improve the mechanical properties of beryllium.[12]

After a year's study for methods of producing high-purity beryllium, the halide reduction process appeared to have the greatest promise.[13]

Cold compacting, followed by upsetting, was the most economical of five processes examined for obtaining optimum properties and good surface finish of beryllium.[14]

A topical search of progress reports and journal references on beryllium, emphasizing 1947–57, was made, and a report published.[15]

Limited success was reported on direct-welding beryllium by tungsten-arc, pressure, and electron beam processes.[16]

Use of carbide tools for drilling, milling, and turning beryllium at speeds up to 100, 150, and 250 surface feet per minute, respectively was described.[17]

---

[10] Dressel, W. M., and Ritchey, R. A., Field Test for Beryllium: Bureau of Mines Inf. Circ. 7946, 1960, 5 pp.

[11] Battelle Memorial Institute, Beryllium Research and Development Review—1958: Defense Metals Inf. Center, Columbus, Ohio (DMIC), Report S2, Jan. 16, 1959, app. pp. A–1 to A–8.

[12] Klein, John G., Perelman, Leslie M., and Beaver, Wallace W. (The Brush Beryllium Co.), Development of Wrought Beryllium Alloys of Improved Properties: Wright Air Development Center, Tech. Rept. 58–478, pt. 1, PB 151711, Office of Tech. Services, U.S. Dept. of Commerce, Washington 25, D.C., February 1959, 139 pp.

[13] Lukesh, Joseph L., Schetky, Lawrence McD., Spacil, Henry S., and Basche, Malcolm (Alloyd Research Corp.), Research on Techniques for the Production of Ultra-Pure Beryllium: Wright Air Development Center, Tech. Rept. 58–457, pt. 1, PB 151878, Office of Tech. Services, U.S. Dept. of Commerce, Washington 25, D.C., February 1959, 38 pp.

[14] Muvdi, B. B. (The Martin Co.), Structural Evaluation of Beryllium Produced by Several Processes: Wright Air Development Center, Tech. Rept. 58–162, PB 151263, Office of Tech. Services, U.S. Dept. of Commerce, Washington 25, D.C., June 1958, 66 pp.

[15] Bradshaw, Wanda G. (Lockheed Aircraft Corp.), Beryllium, A Search of the Unclassified Literature: Performed under U.S. Navy Contract NOrd 17017, PB 161012, Office of Tech. Services, U.S. Dept. of Commerce, Washington 25, D.C., undated, 54 pp.

[16] Weare, N. E., and Monroe, R. E., Joining of Beryllium: Defense Metals Inf. Center (DMIC) Memo. 13, Battelle Memorial Institute, Columbus, Ohio, PB 161163, Office of Tech. Services, U.S. Dept. of Commerce, Washington 25, D.C., March 1959, 28 pp.

[17] Olofson, C. T., The Machining of Beryllium: Defense Metals Inf. Center (DMIC) Memo. 21, Battelle Memorial Institute, Columbus, Ohio, PB 161171, Office of Tech. Services, U.S. Dept. of Commerce, Washington 25, D.C., June 1959, 16 pp.

Beryllium is high on the list of suitable materials for heat sinks in thermal protection systems. The heat capacity of beryllium and the effect of impurities on heat capacity were discussed.[18]

Numerous discussions on beryllium disease were published.[19]

Many domestic occurrences of beryllium in nonpegmatitic deposits were described.[20]

A report describing the occurrence of beryl in the Beecher No. 3-Black Diamond Pegmatite, Custer County, S. Dak. was published.[21]

The market situation for beryl was discussed.[22]

---

[18] Holladay, J. W., Heat Capacity of Beryllium: Defense Metals Inf. Center (DMIC) Memo. 36, Battelle Memorial Institute, Columbus, Ohio, PB 161186, Office of Tech. Services, U.S. Dept. of Commerce, Washington 25, D.C., October 1959, 9 pp.

[19] American Medical Association Archives of Industrial Health, Conference on Beryllium Disease and Its Control, held at Massachusetts Inst. of Technol., Sept. 30–Oct. 1, 1958: vol. 19, No. 2, February 1959, pp. 91–267.

[20] Warner, Lawrence A., Holser, William T., Wilmarth, Verl R., and Cameron, Eugene N., Occurrence of Nonpegmatite Beryllium in the United States: Geol. Survey Prof. Paper 318, 1959, 198 pp.

[21] Redden, Jack A., Beryl Deposits of the Beecher No. 3–Black Diamond Pegmatite, Custer County, South Dakota: Geol. Survey Bull. 1072–I, 1959, pp. 537–559.

[22] Hershberger, David H., Beryllium Ore, Present and Future Market Situation: Mines Mag., vol. 49, No. 3, March 1959, pp. 35–37.

Bismuth

By G. Richards Gwinn [1] and Edith E. den Hartog [2]

⁂

THE BISMUTH industry in 1959 was characterized by an increase in industrial consumption, a decline in imports and consumer inventories, and a continuation of the 1958 level of domestic production. Shipments for the national stockpile that had been a factor in the bismuth market in 1958 were discontinued. No purchases were made for the strategic stockpile, and no barter contracts were executed by Commodity Credit Corporation.

DOMESTIC PRODUCTION

Domestic output of bismuth was essentially the same as in 1958. Production of refined bismuth derived from foreign and domestic ores came almost exclusively from metallurgical byproducts of lead refining. Companies reporting production were American Smelting and Refining Co., The Anaconda Co., the United States Smelting Lead Refinery, Inc. (a subsidiary of United States Smelting, Refining and Mining Co.), and United Refining & Smelting Co., which was reported as a producer for the first time in 1959. Bismuth recovered from alloy scrap and reclaimed in alloy products increased substantially over 1958.

TABLE 1.—Salient statistics of bismuth metal, in pounds

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Consumption	[1] 1,629,800	1,548,000	1,513,000	1,615,200	1,242,700	1,480,700
Imports	657,926	595,566	918,152	847,868	637,309	457,163
Exports	171,183	203,667	287,092	158,393	316,318	179,744
Price per pound, New York, ton lots	$2.25	$2.25	$2.25	$2.25	$2.25	$2.25
Consumers' and dealers' stocks, Dec. 31	[1] 206,600	234,300	229,000	375,300	546,100	472,600
World: Production	4,100,000	[2] 4,200,000	[2] 5,300,000	[2] 5,000,000	[2] 4,600,000	5,200,000

[1] Data not available for 1950.
[2] Revised figure.

CONSUMPTION AND USES

Domestic consumption of refined bismuth metal was 1.5 million pounds—19 percent more than in 1958. In addition, an unknown quantity of bismuth contained in bismuth-lead bars was used in fabricating alloys.

---

[1] Commodity specialist.
[2] Statistical assistant.

The quantities of bismuth consumed in both alloys and pharmaceuticals have remained fairly constant for years. The largest single use under "Other alloys" (table 2) was to improve the machinability of iron. Substantial quantities also were used in bismuth-cadmium and bismuth-aluminum alloys. The increase in experimental uses is attributed largely to work on nuclear and thermoelectric projects. Industrial and laboratory chemical products have formed an increasingly large part of the pharmaceutical uses.

STOCKS

Stocks of metallic bismuth held by consumers and dealers declined to 472,600 pounds as a result of increased consumption and reduced imports. Stocks at domestic refineries, however, increased 25 percent, reversing the trend of 1958. The increase was attributed partly to the addition of another domestic producer in 1959.

TABLE 2.—Bismuth metal consumed in the United States, by uses, in pounds

Uses	1958	1959	Uses	1958	1959
Fusible alloys	488,368	478,542	Experimental uses	87,018	161,040
Other alloys	208,423	300,911	Other uses	36,256	56,692
Pharmaceuticals [1]	422,647	483,554	Total	1,242,712	1,480,739

[1] Includes industrial and laboratory chemicals.

PRICES

In 1959 the E&MJ Metal and Mineral Markets continued to quote the New York price for refined bismuth metal at $2.25 per pound, in ton lots—a price that has remained unchanged since September 1950. The Metal Bulletin (London) quotation also remained unchanged at $2.24 per pound. Bismuth ore, also listed in the Metal Bulletin, was quoted at $1.10 per pound of contained bismuth in concentrate having a minimum of 65 percent bismuth. Bismuth concentrate of lower grade commanded proportionally lower prices. Prices of bismuth chemicals and compounds, as listed in Oil, Paint and Drug Reporter, were recorded in the 1955 Minerals Yearbook chapter on bismuth and remained unchanged through 1959.

FOREIGN TRADE

Imports of refined metal declined 28 percent in 1959, reflecting accelerated industrial demand in Europe and a relatively small increase in U.S. demand. Metal imports, however, were augmented by receipts of bismuth-enriched intermediate smelter products, bismuth-lead bars, and concentrate. The economically recoverable bismuth contents of the smelter products and concentrate entered the market as domestically refined bismuth. Most of the bismuth-lead bars, however, were consumed directly in alloy fabrication. Statistics in this chapter exclude this category of imported bismuth, which was estimated at 221,000 pounds in 1959.

TABLE 3.—Metallic bismuth imports[1] into the United States, in pounds

[Bureau of the Census]

Country	1958	1959	Country	1958	1959
North America:			Europe:		
Canada	2,839	2,948	Netherlands	1,529	-----
Mexico	130,111	155,156	United Kingdom	-----	3,000
Total	132,950	158,104	Yugoslavia	42,088	46,295
South America: Peru	460,742	249,764	Total	43,617	49,295
			Grand total	637,309	457,163

[1] Data are "general" imports; that is, they include bismuth imported for immediate consumption plus material entering the country under bond.

TABLE 4.—Bismuth metal and alloys exported from the United States

[Bureau of the Census]

Year	Gross weight (pounds)	Value	Year	Gross weight (pounds)	Value
1950–54 (average)	171,183	$377,154	1957	158,393	$213,313
1955	203,667	363,186	1958	316,318	389,078
1956	287,092	558,601	1959	179,744	261,367

Exports of bismuth metal and alloys (gross weight) totaled 179,700 pounds in 1959—a 43-percent decrease from the 316,300 pounds exported in 1958. Bismuth-metal exports were 44,200 pounds and represented 25 percent of the total exports, compared with 64,000 pounds and 20 percent in 1958.

WORLD REVIEW

Argentina.—Bismuth production in Argentina came from ores in which bismuth occurs as a metallic constituent and some native bismuth is present, in contrast to many other countries where bismuth is recovered as a byproduct in the refining of other metals. Production came largely from the Los Condores mine in San Luco Province, where bismuth carbonate (bismutite) and native bismuth are associated with wolframite.

Bolivia.—The bulk of the output of bismuth concentrate came from the Tasna tin mine. Small amounts were recovered from the Chorolque and Caracoles mines, which are tin and tin-tungsten mines, respectively. Domestic consumption of bismuth was negligible, and most of the output of concentrate and bullion was exported to the United Kingdom.

Canada.—The growth in production of bismuth metal and concentrates continued through 1959, and Canada was the third largest world producer. Output, in order of importance, was reported from Quebec, British Columbia, and Ontario. In 1959, as in 1958, the entire output of refined metal was produced by Consolidated Mining & Smelting Co. of Canada, Ltd., at Trail, British Columbia.

Mexico.—Reported production of refined and semirefined bismuth metal increased over 1958. Metalurgica Penoles, S.A., a subsidiary of American Metal Climax, Inc., was the only producer of refined bismuth. Refined bismuth bars were shipped to the United States, England, Netherlands, and West Germany. All semifinished bismuth bars were shipped to the United Kingdom.

Uganda.—Bismuth concentrate was recovered at the Itama Mines, Ltd., the Nyahashunze, and the Marambi mines in the extreme southwest section of Uganda. Bismuth concentrate was a major product at the Itama mines, but was a byproduct of the processing of tin ores at the other two mines. There was no domestic consumption of bismuth, and most of the output was exported to the United Kingdom.

TABLE 5.—World production of bismuth, by countries,[1] in pounds[2]

[Compiled by Augusta W. Jann and Berenice B. Mitchell]

Country [1]	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada (metal) [3]	192,063	265,896	285,861	319,941	412,792	415,909
Mexico [3]	706,572	773,800	1,391,100	780,200	417,700	524,695
South America:						
Argentina:						
Metal	[4] 220	16,300	---	---	---	---
In ore [4]	2,520	20,700	20,000	47,800	59,300	134,500
Bolivia [5]	95,999	113,000	74,800	90,600	244,700	480,600
Peru [3]	623,527	734,714	634,757	804,800	851,560	775,323
Europe:						
France (in ore)	148,590	69,500	112,400	119,000	[4] 110,000	[4] 110,000
Spain (metal)	34,901	48,234	71,650	190,500	116,229	[6] 81,000
Sweden [4]	74,956	145,500	88,000	120,000	110,000	110,000
Yugoslavia (metal)	198,806	229,516	245,039	219,805	169,670	200,026
Asia:						
China (in ore)	[4] 97,000	(7)	(7)	(7)	(7)	(7)
Japan (metal)	98,063	142,364	156,859	144,800	168,751	[4] 176,000
Korea, Republic of (in ore)	215,389	287,000	396,000	240,000	198,000	227,000
Africa:						
Belgian Congo (in ore)	999	70	---	---	---	---
Mozambique	4,861	4,145	785	6,975	2,167	[4] 2,200
South-West Africa (in ore)	3,739	2,360	310	670	680	[4] 500
Uganda	4,096	3,100	660	2,700	15,030	[4] 13,000
Union of South Africa (in ore)	5,990	228	360	145	2,023	[4] 600
Oceania: Australia (in ore)	1,993	3,000	5,150	1,340	2,352	[4] 1,000
World total (estimate) [1] [2]	4,100,000	4,200,000	5,300,000	5,000,000	4,600,000	5,200,000

---

[1] U.S. production included in total; Bureau of Mines not at liberty to publish separately. Bismuth is believed to be produced in Brazil, Germany, and U.S.S.R. Production figures are not available for these countries, but estimates are included in the world total.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Refined metal plus bismuth content of bullion exported.

[4] Estimate.

[5] Content in ore and bullion exported, excluding that in tin concentrates.

[6] Estimated recoverable content of ore produced.

[7] Data not available; estimate included in total.

Yugoslavia.—Bismuth was recovered as a byproduct in lead-zinc ores at the Trepca smelter. The bismuth-containing concentrate came from the Trepca and several other mines in the Trepca area. A new mine, containing recoverable quantities of gold, silver, pyrite, and bismuth, was opened during the year near Pristina in southern Serbia. Relatively large quantities of the bismuth output were exported to the United States and European markets.

TECHNOLOGY

The development of high-purity bismuth and bismuth alloys for use in semiconductors continued in 1959. Bismuth telluride was produced for use in semiconductors of both n- and p-types.[3]

The separation of bismuth, polonium, lead, and radium by anion exchange [4] and a redetermination of the volume changes on the solidification and fusion of lead-bismuth alloys near eutectic composition [5] were reported. Data were given on the possible use of bismuth oxide as a cathode material in the manufacturing commercial dry-cell batteries,[6] and molten bismuth pentafluoride was found to be a powerful fluorinating agent. The reaction of bismuth pentafluoride with the fluorides of alkali metals suggested the possibility of developing a new series of fluorinating agents.[7]

---

[3] Electronic News, U.K. Firm Developing Metals of High Purity: Vol. 4, No. 179, Dec. 21, 1959, p. 27.

[4] Hyde, E. K., and Roby, B. A. (assigned to the United States of America as represented by the Chairman of the Atomic Energy Commission), Separation of Bismuth, Polonium, Lead, and Radium by Anion Exchange: U.S. Patent 2,873,170, Feb. 10, 1959.

[5] Preston, C. T., and Bromfield, G. H., A Redetermination of the Volume Changes on Solidification and Fusion of Lead-Bismuth Alloys Near Eutectic Composition: Inst. of Metals Jour., vol. 87, pt. 7, March 1959, p. 240.

[6] Morehouse, C. K., and Glickman, R., Magnesium-Bismuth Oxide Dry Cells: Jour. Electrochem. Soc., vol. 106, No. 1, January 1959, pp. 61–63.

[7] Chemical and Engineering News, Fluorinating Agent Made: Vol. 37, No. 15, Apr. 13, 1959, pp. 44–45.

Boron

By Henry E. Stipp[1] and James M. Foley[2]

⁂

SALES of boron minerals and compounds increased approximately 17 percent in 1959. U.S. exports of boric acid, borates, and boron compounds increased about 8 percent.

TABLE 1.—Salient statistics of boron minerals and compounds in the United States

	1950–54 (average)	1955	1956	1957	1958	1959
Sold or used by producers:						
Short tons:						
Gross weight [1]	720,007	[2] 521,887	[2] 544,677	541,124	528,209	619,946
B_2O_3	208,980	246,226	267,864	[2] 269,251	265,613	314,286
Value	$18,881,000	[2] $30,728,000	[2] $32,812,000	$38,041,000	$38,310,000	$46,150,000
Imports for consumption:						
Short tons	3	11	[3] 74	[3] 5,078	24	41
Value	$10,200	$2,400	[3] $174,000	[3] $284,000	$133,000	$144,200
Exports:						
Short tons	160,850	222,588	243,725	214,497	235,584	253,674
Value	$10,045,000	$14,533,000	$16,596,000	$15,975,000	$18,292,000	$21,047,000
Apparent consumption:						
Short tons	559,160	299,310	301,026	331,705	292,649	366,313

[1] Gross weight reported for 1950–54 included a higher proportion of crude ore to finished products than in 1955–59.
[2] Revised figure.
[3] Imports for 1956 and 1957 include a higher proportion of crude ore to refined products.

DOMESTIC PRODUCTION

Boron minerals and compounds were produced from the brine of Searles Lake by American Potash & Chemical Corp. at Trona, Calif., and West End Chemical Division of Stauffer Chemical Co. at Westend, Calif. Pacific Coast Borax Division of U.S. Borax & Chemical Corp. mined borax and kernite from a bedded deposit in the Kramer district near Boron, Calif., colemanite at Death Valley Junction, and ulexite from a deposit near Shoshone, Calif.

U.S. Borax & Chemical Corp. leased land containing boron minerals in Harney County, Oreg., from the State Land Board. American Potash & Chemical Corp. was building an $800,000 boric oxide plant at Trona, Calif. Kern County Land Co. was reported to be developing borate deposits on its land in the Mojave Desert of southern California. Sunray Oil Co. began exploratory drilling in the Mojave Desert for boron minerals. The Carborundum Co. scheduled

---

[1] Commodity specialist.
[2] Supervisory statistical assistant.

the erection of a $750,000 pilot plant at Niagara Falls, N.Y., to produce boron nitride and boron carbide. Metal Hydrides, Inc., signed a 15-year research agreement with Australian Paper Mfg., Melbourne, Australia, to study the use of hydrides in preparing pulp and paper.

Phelps Dodge Corp. drilled part of the Detrital Valley Saline Project of Goldfield Consolidated Mines Co., near Lake Mead, Ariz., exploring for boron minerals. The Dow Chemical Co. and U.S. Borax Research Corp. signed an agreement for a joint venture to perfect an economic process for manufacturing boron trichloride. Stauffer Chemical Co. stopped producing boron trichloride at its plant in Niagara Falls, N.Y.

CONSUMPTION AND USES

Large quantities of boron compounds were consumed by the glass and ceramics industries. It was estimated that glass consumed 28 percent of the borate output and porcelain enamel, 14 percent. The consumption of borax for these uses was expected to increase at rates above normal, owing to expanding use in construction for glass beams, fibers, and porcelain curtain walls. Agricultural consumption of borax was estimated to be 14 percent, distributed between herbicides (10 percent) and fertilizers (4 percent). Borax used in soaps, organic boron compounds, and antifreeze accounted for 3 percent each of sales. Starch, adhesives, and insulation materials each consumed 2 percent of borax output, and 1 percent was used at smelters, in drugs and cosmetics, in iron and steel, and in electrolytic condensers. Increasing sales of electronic equipment improved the outlook for consumption of boron materials in electrolytic condensers. Consumption of organic boron compounds was reported to be growing.[3]

The use of organoboron compounds as fungicides, insecticides, and nematocides for crop protection was reported to be developing.[4] Borax and boric acid were said to be very effective as a timber preservative.[5] The use of sodium borohydride as a blowing agent in foamed plastics and as a chemical reducing agent seemed to have possibilities. Barium borate was used in paint to decrease chalking and as a fungicide. Boron nitride was used for making electronic parts.[6] Steel containing 1 percent boron was used in the floor of an atomic reactor in the Enrico Fermi powerplant near Monroe, Mich. Phenylboronic acid, p-tolyboronic acid, p-bromophenylboronic acid, m-nitrophenylboronic acid, and m-aminophenylboronic acid were used for cancer research.

Developments were numerous on potential use of high-energy boron fuels. The U.S. Air Force awarded Stauffer-Aerojet Chemical Co. a $2 million contract for a plant to obtain design data on a boron-

---

[3] Oil, Paint and Drug Reporter, Borax's Big Three Prophesy A Twofold Consumption Rise In Ten Years, Barring "Ifs": Vol. 175, No. 2, Jan. 12, 1959, pp. 3, 36, 38.

[4] Chemical Trade Journal and Chemical Engineer (London), Boron Products Outlook: Vol. 144, No. 3742, Feb. 20, 1959, pp. 423–424.

[5] Chemical Age (London), Boron is Effective as Timber Preservative, Says Carr of Borax: Vol. 82, No. 2094, Aug. 29, 1959, p. 220.

[6] The Carborundum Company, Advanced Materials Technology, Boron Nitride: A New Design Material for Electronic Prototypes: Vol. 2, No. 2, September 1959, p. 4.

fuel production process.[7] The U.S. Government canceled a $13.5 million contract with Metal Hydrides, Inc., for making sodium borohydride, an intermediate chemical used in producing high-energy boron fuels.[8] The U.S. Department of Defense canceled plans to produce boron fuels at plants near Model City, N.Y., and Muskogee, Okla.[9] Later, the Department of Defense decided to close and dismantle the boron fuel plant at Model City, N.Y., and place the plant at Muskogee, Okla., on a hot standby basis until June 1960. According to reports of a joint working group of Congress, total requirements for boron fuels could increase from 180,000 pounds a year to a maximum of 5 million pounds in 5 years. However, if the use of boron fuels in rocket propellants proves impractical all requirements for boron fuels could virtually cease.[10]

PRICES

The price of most grades of borax and boric acid increased in June 1959. The following prices were quoted by Oil, Paint and Drug Reporter:

	January–June	*July–December*
Borax, tech., anhydrous, 99.5 percent, bags, carlots, works, ton	$87.50	$92.00
Ton lots, bags, exwarehouse, New York or Chicago, 100 pounds	7.19	7.42
Bulk, carlots, works, ton	78.50	83.00
Granular, decahydrate, 99.5 percent, bags, carlots, works, ton	47.50	50.00
Ton lots, bags, exwarehouse, New York or Chicago, 100 pounds	5.19	5.32
Granular, pentahydrate, 99.5 percent, bags, carlots, works, ton	63.00	64.50
Ton lots, bags, exwarehouse, New York or Chicago, 100 pounds	5.97	6.05
Bulk, carlots, works, ton	56.50	58.00
Powder, 99.5 percent, bags, carlots, works, ton	52.50	54.00
Ton lots, bags, exwarehouse, New York or Chicago, 100 pounds	6.34	6.45
U.S.P. borax, $15 per ton higher than technical.		
Boric acid, tech., anhydrous, 99.9 percent, bags, carlots, works, ton	335.00	335.00
Ton lots, bags, exwarehouse, New York or Chicago, 100 pounds	19.50	19.62
Crystals, 99.9 percent, bags, carlots, works, ton	160.00	163.50
Ton lots, bags, exwarehouse, New York or Chicago, 100 pounds	10.87	11.05
Granular, 99.9 percent, bags, carlots, works, ton	108.50	112.00
Ton lots, bags, exwarehouse, New York or Chicago, 100 pounds	8.29	8.47
Powder, 99.9 percent, bags, carlots, ton lots, bags, exwarehouse, New York or Chicago, 100 pounds	8.67	8.85

U.S.P. boric acid, $25 per ton higher than technical.

---

[7] Chemical Engineering, View Clears Slightly on High-Energy Fuel Picture: Vol. 66, No. 6, Mar. 23, 1959, p. 94.

[8] Chemical and Engineering News, Fuels Program Shuffled: Vol. 37, No. 27, July 6, 1959, p. 23.

[9] Chemical and Engineering News, Concentrates: Vol. 37, No. 33, Aug. 17, 1959, p. 19.

[10] Oil, Paint and Drug Reporter, Boron Fuel Has Found a Friend; House's Space Committee Wants Integrated National HEF Plan: Vol. 176, No. 17, Oct. 19, 1959, pp. 3, 61.

The price of sodium borohydride was reduced to $19.90 per pound for one shipment, 5,000-pound lots, 98-percent-pure dry material, packed in 55-gallon drums.[11]

FOREIGN TRADE [12]

Boron carbide imports totaled 81,000 pounds valued at $144,000 compared with 47,000 pounds valued at $133,000 in 1958.

WORLD REVIEW

The United States produced most of the world supply of boron minerals; however, production in Turkey increased substantially.

SOUTH AMERICA

Argentina.—Production of boron minerals (crude) totaled 11,737 tons in 1958 compared with 22,898 tons in 1957.[13] A paper was published that described the topography, structure, igneous activity, and mineral deposits of several provinces in northwestern Argentina.[14]

Chile.—Ulexite production totaled 6,345 tons compared with 9,292 tons in 1958.[15] Anglo-Lautaro Co. was building a plant to produce 4,000 tons of boric acid a year.[16]

EUROPE

Belgium.—A plant was built at the Jemeppe-sur-Sambre works of Société Solvay et Cie. to manufacture sodium perborate.[17]

France.—Borax Francais, S. A., embarked on a $10-million program. Modernization of factory services and expansion of boric acid production were planned.[18]

Germany, West.—Production of boron and boron compounds totaled 49,549 tons in 1958 compared with 50,400 tons in 1957. A process for making boron trialkyls from aluminum trialkyls was developed at the Max Planck Institute for Coal Research, Muelheim, Germany.[19]

Italy.—Boric acid production totaled 3,814 tons in 1958 compared with 4,000 tons in 1957.[20]

United Kingdom.—Vitreous enamel and glass industries petitioned the Board of Trade to reduce import duty on borax.[21] Two papers described deficiency of boron in soils, characteristics of crops suffering from boron deficiency, and application of boron materials to soils.[22]

---

[11] Chemical Week, Market Newsletter: Vol. 85, No. 15, Oct. 10, 1959, p. 96.

[12] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

[13] U.S. Embassy, Buenos Aires, Argentina, State Department Dispatch 1445: Apr. 6, 1960, p. 2.

[14] Economic Geology, Structural Belts and Mineral Deposits of Northwestern Argentina: Vol. 54, No. 5, August 1959, pp. 903–912.

[15] U.S. Embassy, Santiago, Chile, State Department Dispatch 812: May 6, 1960, p. 2.

[16] Chemical Trade Journal and Chemical Engineer (London), Anglo-Lautaro to Make Boric Acid: Vol. 145, No. 3763, July 17, 1959, p. 1508.

[17] Chemical Trade Journal and Chemical Engineer (London), Notes From Abroad: Vol. 144, No. 3755, May 22, 1959, p. 1174.

[18] Oil, Paint and Drug Reporter, Borax Concern Planning to Modernize in France: Vol. 176, No. 7, Aug. 17, 1959, p. 5.

[19] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 2, August 1959, p. 39.

[20] U.S. Embassy, Rome, Italy, State Department Dispatch 1277: Apr. 28, 1959, p. 1.

[21] Chemical Age (London), Borax Duty Petition: Vol. 82, No. 2090, Aug. 1, 1959, p. 84.

[22] Fertilizers and Feeding Stuffs Journal (London), Boron Deficiency: Vol. 51, No. 10, Dec. 16, 1959, p. 475.

TABLE 2.—Boric acid, borates, and compounds[1] exported from the United States, by countries of destination

[Bureau of the Census]

Country	1958		1959	
	Short tons	Value	Short tons	Value
North America:				
Canada	14,056	$1,524,517	13,361	$1,537,248
Costa Rica	295	32,201	289	24,170
Cuba	521	43,578	655	66,239
Dominican Republic	12	1,155	96	10,788
Mexico	4,348	415,177	5,235	484,753
Nicaragua	12	4,305	26	7,715
Trinidad and Tobago	18	1,453	28	2,342
Other North America	58	9,458	31	9,404
Total	19,320	2,031,844	19,721	2,142,659
South America:				
Brazil	5,171	430,204	4,559	378,780
Colombia	424	46,072	354	32,571
Peru	473	34,256	533	39,773
Uruguay	80	8,868	352	42,384
Venezuela	235	24,792	185	22,154
Other South America	57	12,054	82	15,552
Total	6,440	556,246	6,065	531,214
Europe:				
Austria	3,277	160,724	3,445	172,368
Belgium-Luxembourg	2,944	253,068	3,914	373,977
Denmark	927	107,990	707	95,185
Finland	590	41,643	1,262	92,127
France	29,191	2,153,625	28,899	2,091,397
Germany, West	48,427	3,180,397	50,501	3,723,584
Greece	579	30,496	181	11,518
Ireland	1,128	69,441	361	28,073
Italy	10,338	675,557	9,458	692,995
Netherlands	11,358	994,803	14,039	1,384,784
Norway	3,585	329,382	2,497	191,224
Poland	1,968	114,719	2,756	146,703
Portugal	1,522	116,547	946	76,582
Spain	1,239	61,544	5	712
Sweden	2,935	207,681	3,551	314,527
Switzerland	4,989	380,038	2,855	220,049
United Kingdom	44,431	3,338,888	51,826	3,812,334
Yugoslavia	1,103	100,044	826	80,262
Other Europe	28	2,145	----------	----------
Total	170,559	12,318,732	178,029	13,508,401
Asia:				
Ceylon	125	$7,605	177	$13,892
Hong Kong	4,137	346,772	4,320	368,409
India	4,507	328,964	6,284	499,685
Indonesia	877	52,456	342	22,550
Iran	276	17,965	223	19,874
Israel	485	36,209	527	50,464
Japan	14,505	1,150,356	21,128	1,873,734
Korea, Republic of	192	21,264	281	24,650
Lebanon	57	3,459	47	3,975
Malaya, Federation of	20	1,673	74	7,686
Pakistan	599	44,857	788	58,763
Philippines	596	63,645	709	75,520
Singapore, Colony of	75	5,531	114	8,334
Taiwan	844	55,439	401	29,154
Thailand	467	36,278	340	29,627
United Arab Republic (Syria Region)	55	5,298	22	1,316
Viet Nam	----------	----------	106	7,211
Other Asia	121	7,745	4	1,014
Total	27,938	2,185,516	35,887	3,095,858
Africa:				
Rhodesia and Nyasaland, Federation of	151	13,891	437	32,669
Union of South Africa	1,437	149,366	2,026	232,565
United Arab Republic (Egypt Region)	216	20,335	256	28,082
Other Africa	180	20,279	93	11,221
Total	1,984	203,871	2,812	304,537
Oceania:				
Australia	6,530	684,249	8,588	1,186,311
New Zealand	2,813	311,625	2,572	278,082
Total	9,343	995,874	11,160	1,464,393
Grand total	235,584	18,292,083	253,674	21,047,062

---

[1] Classified by the Bureau of the Census as boric acid and borates, crude, refined, and compounds (including borate esters and other boron compounds) n.e.c.

ASIA

China.—Extraction of borax from deposits recently found in northwestern Tsinghai was scheduled to begin in 1958. Output was expected to reach about 33,000 tons.[23]

India.—Deposits of borax were found in the Pugga Valley, 100 miles southeast of the city of Leh. Plans were made to extract borax from the deposits.[24]

Japan.—Plans were made to extract boron by ion exchange from underground waters in the gasfields of Niigata Prefecture.[25]

Turkey.—Production of boron minerals continued to rise in 1958 to a new peak of 76,502 tons (revised figure) compared with 30,179 tons in 1957. Exports of boron minerals from Turkey in 1958 increased to 56,506 tons valued at $2 million, compared with 24,244 tons valued at $1 million in 1957. Turkey exported 24,158 tons of boron minerals to the United States in 1958.[26]

TECHNOLOGY

An authoritative technical publication reported that the relation of Tertiary Playa lake sediments to basalt flows could be a useful guide in selecting areas to explore for boron minerals.[27] Gravity data were considered helpful in outlining potential basins and associated faults. Also, magnetic mapping could furnish information on volcanic flows, which were considered indicative of potential zones of borate mineralization.

The use of boron materials in concrete for shielding against atomic radiation has been questioned, owing to their cost and harmful effects on setting time and strength of the concrete. However, boron-concrete mixes were found to be practical and economical for many reactor shields. Three boron materials suitable for use in concrete were colemanite, borocalcite, and boron frit.[28]

Removal of boric acid from primary-loop water of atomic reactors with a strong-base anion exchanger was studied. Data indicated that boric acid was reduced to the low levels required for reactor operation. Ion-exchange resins could also be used to remove impurities from a boric acid solution.[29]

A study of the effect of carbon dioxide on boron carbide, elemental boron, and several boron compounds yielded information that could be useful in the field of atomic energy. Most boron compounds oxidized rapidly to form boron oxide, which reacted to give a volatile boron compound.[30]

---

[23] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 1, July 1959, p. 29.

[24] U.S. Embassy, New Delhi, India, State Department Dispatch 1038: Mar. 11, 1959, p. 1.

[25] Mining Journal (London), Mining Miscellany: Vol. 252, No. 6460, June 12, 1959, p. 650.

[26] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 5, November 1959, pp. 34–35.

[27] Griswold, William T., Colemanite as an Important Source of Borates: AIME Soc. of Min. Eng., Preprint No. 59H20, Feb. 15, 1959, p. 1.

[28] Journal of the American Concrete Institute, Properties of Nuclear Shielding Concrete: Vol. 31, No. 1, July 1959, pp. 37–46.

[29] Thompson, Joseph, and Reents, A. C., Ion Exchange Processes: Ind. Eng. Chem., vol. 51, No. 10, October 1959, pp. 1259–1261.

[30] Davies, M. W., and Phennah, P. J., Reactions of Boron Carbide and Other Boron Compounds With Carbon Dioxide: Jour. Appl. Chem. (London), vol. 9, pt. 4, April 1959, pp. 213–219.

Boric acid and boric acid anhydride were produced in the absence of added free acid by moistening an alkaline earth borate material with water and heating it from 300° to 2,000° F. while in contact with water vapor.[31]

A new process for manufacturing boron trichloride was patented. Liquified petroleum asphalt was applied to a boron compound heated in a rotary kiln. The dehydrated boron and carbonized asphalt were chlorinated to obtain boron trichloride.[32]

A promising process was discovered for hydrating hydrocarbon compounds containing double bonds. The technique could be used to rearrange and isomerize an unsaturated molecule. Chemists reacted a terminal olefin with diborane and hydrogen peroxide at room temperature, obtaining a primary alcohol. Mixed alcohols were derived by treating an internal olefin. A primary alcohol was produced from an olefin containing a double bond by heating it with diborane at 160° C. for 1 hour, then oxidizing it.[33]

Investigations were reported on the use of sodium tetraborate as a corrosion inhibitor for hydraulic brake fluids.[34]

The possibility of preparing hydrolytically and thermally stable polymers of exceptional solvent resistance by using boron was investigated. Some uses for these polymers could be as elastomers, plastics for structural applications, hydraulic fluids, and heat transfer media.[35]

Very pure boron nitride was found to have high insulation resistance at 500° C. Conductance of boron nitride increased when baked in an oxygen atmosphere at about 800° C. Boron nitride was converted to boron oxide by atomic irradiation at 400° C.[36]

Studies of boron-nitrogen bonds revealed that adding diethylamine dropwise to boron trichloride in methylene chloride led to the isolation of insoluble diethylammonium tetrachloroborate and diethylaminoboron dichloride.[37]

A general and simple method of preparing chlorides of organoboron compounds was reported. Esters of organoboron acids, reacted with phosphorus pentachloride, exchanged alkoxyl groups for chlorine atoms. The reaction of organoboron chlorides with water, alcohols, organic acids and their anhydrides, ammonia, and amines were investigated.[38]

Compounds of boron and phosphorus were unusually resistant to attack by heat, water, and oxidation. Dicyclohexylphosphinoborine trimer had the highest resistance to oxidation (484° C.) of any phos-

---

[31] Harman, Cameron G. (assigned to Horizons, Inc.), Production of Boric Acid: U.S. Patent 2,898,192, Aug. 4, 1959.

[32] Montgomery, Charles W., and Pardee, William A. (assigned to Gulf Research and Development Co. Pittsburgh, Pa.), Process for the Manufacture of Boron Trichloride: U. S. Patent 2,876,076, Mar. 3, 1959.

[33] Chemical and Engineering News, Diborane Ousts Double Bonds: Vol. 37, No. 3, Jan. 19, 1959, pp. 36–37.

[34] Jordan, Charles B., Review of the Use of Sodium Tetraborate as a Corrosion Inhibitor for Hydraulic Brake Fluids: Coating and Chem. Lab., Aberdeen Proving Ground, Md., May 6, 1959, p. 7.

[35] Kupchik, E. J., Literature Survey on the Preparation and Properties of Inorganic Polymers Based on Boron, Phosphorus, or Germanium: Materials Lab., Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, July 1952, 10 pp.

[36] Monk, Gaines W., Ultrathermic Capacitors: American Machine and Foundry Co., Alexandria, Va., Wright Air Development Center Tech. Rept. 57–599, August 1958, 75 pp.

[37] Gerrard, W., Hudson, H. R., and Mooney, E. F., Interaction of Secondary Amines and Boron Trichloride: Chem. and Ind. (London), No. 13, Mar. 28, 1959, p. 432.

[38] Izvestiya Akademii Nauk, U.S.S.R., Otdeleniye Khimicheskikh Nauk (Moscow), [Synthesis and Transformation of Chlorides of Organoboron Compounds]: No. 11. November 1958, pp. 1399–1401.

phinoborine compound. Preparation of linear dimethylphosphinoborine polymer was said to be a major breakthrough in this field. Possible uses for boron-phosphorus compounds are as elastomers, adhesives, or fluids.[39]

Boric esters, boron-nitrogen systems, borazole systems, and boron-phosphorus polymers were reviewed at the Oil and Colour Chemists Association conference, Edinburgh, Scotland. A study of certain linkages which might lead to the development of thermally stable polymers was described.[40]

Boron phosphide, a refractory material harder than silicon carbide, could make transistors usable at 1,000° C. The boron compound had a very high energy gap (5.9 electron volts) compared with gallium phosphide (about 2.4 electron volts), its closest competitor. Four chemical reactions were reported that yield crystalline material of semiconductor grade.[41]

Methods of treating hardwoods with boron compounds for protection against insects were developed in Australia 25 years ago. Timber was treated by pressure or diffusion impregnation. The treated timber retained its natural color.[42]

A technique was patented for adding alkaline earth compounds to boron nitride to give it a superior resistance to attack by water.[43]

An instrument that contained a radium-beryllium neutron source was used to measure boron continuously in flowing liquid streams.[44]

A lightweight synthetic rubber compound containing powdered boron was developed for shielding personnel from neutrons in nuclear-powered aircraft and ships.[45]

Vinyl foams were made by a new process that used sodium borohydride as the blowing agent.[46]

The reduction of wood pulp with borohydride gave a product similar to cotton cellulose. This material was not economic, but it could compete with cotton for certain uses if the price of borohydride could be reduced.[47]

A triorganoborane $(CH_3)_3SiC_2H_4)_3B$ was obtained by reacting sodium borohydride and aluminum chloride with trimethylvinylsilane. The boron compound has potential use as an oxygen scavenger in silicone fluids.[48]

A borosilicate glass panel coated with an electrically conductive film intercepted and grounded radio interference from fluorescent lamps.[49]

---

[39] Chemical and Engineering News, Seek Polymers Stable at 1,000° F.: Vol. 37, No. 24, June 15, 1959, p. 40.

[40] Chemical Age (London), O.C.C.A. Polymer Conference—2: Vol. 81, No. 2079, May 16, 1959, p. 827.

[41] Chemical and Engineering News, High Temperature Transistors: Vol. 37, No. 16, Apr. 20, 1959, p. 60.

[42] Chemical Trade Journal and Chemical Engineer (London), Wood Preservation With Boron Compounds: Vol. 145, No. 3761, July 3, 1959, pp. 1447–1448.

[43] Taylor, Kenneth M. (assigned to Carborundum Co., Niagara Falls, N.Y.), Boron Nitride Shapes and Method of Making: U.S. Patent 2,855,316, Oct. 7, 1958.

[44] Chemical and Engineering News, Analyzer Monitors Boron: Vol. 37, No. 23, June 8, 1959, pp. 52, 54, 57.

[45] Chemical and Engineering News, Rubber Stops Neutrons: Vol. 37, No. 25, June 22, 1959, p. 40.

[46] Chemical Engineering, Sodium Borohydride Is Key to New Vinyl Foam Process: Vol. 66, No. 16, Aug. 10, 1959, p. 33.

[47] Chemical and Engineering News, Cotton Quality From Wood Pulp: Vol. 37, No. 21, May 25, 1959, pp. 44, 46.

[48] Chemical and Engineering News, New Organometallics, New Uses: Vol. 37, No. 16, Apr. 20, 1959, p. 42.

[49] Chemical and Engineering News, Glass Lighting Panel To Eliminate Radio Interference: Vol. 37, No. 35, Aug. 31, 1959, p. 52.

Borosilicate glass was used in a shield designed to protect personnel working in areas of intense heat.[50]

A patent was issued for manufacturing of refractory bodies composed of boron nitride and a metal boride. The boron compound has potential use in rocket nozzles.[51]

Recently developed ceramic coatings for aircraft and missiles consisted of a high-temperature-resistant refractory base coating and a boron nitride coating bonded with lithium compounds such as lithium borosilicate.[52]

A method was patented for coating the surface of metal, glass, and ceramic materials with a cermet consisting of 60 to 70 parts by weight of aluminum and aluminum-base alloys and 30 to 40 parts of Gerstley borate and lithia, and a suspension agent fired at a temperature of 1,230° F. The coating could be used for protecting aircraft and missile surfaces.[53]

The dielectric properties of borate glasses were superior to those of other types of glasses. Substitution of lead oxide with barium oxide, aluminum oxide, or silicon dioxide increased the sag point of lead borate glasses and improved their dielectric properties.[54]

An electrical resistor containing boron material was said to have excellent stability and high power dissipation. It was composed essentially of 15 to 65 percent (by weight) molybdenum disilicide, up to 20 percent aluminum oxide and zirconium oxide, up to 10 percent molybdenum oxide, and 25 to 85 percent borosilicate glass frit.[55]

Aluminum plate was treated with a solution of sodium borate, potassium borate, and waterglass before enameling with borosilicate frit. Good results were obtained when the enameled plate was tested by bending. Mixtures of lithium borate and waterglass and sodium borate and waterglass also gave good results.[56]

Boron crystals were made by a new floating-zone technique. Boron powder was coated with boric acid by boiling it to dryness. Pressed bars of coated boron were heated under vacuum to decompose boric acid to boron oxide, which bonded the boron granules together. The boron oxide binder sublimed when the bar was melted, yielding crystalline boron.[57]

Alloys of boron and lead were made by mixing boron powder with molten lead, yielding a material stronger than lead. The boron-lead alloys could be used as a versatile shielding material against gamma rays and neutrons.[58]

---

[50] Chemical Engineering, New Equipment: Vol. 66, No. 12, June 15, 1959, p. 238.

[51] Taylor, Kenneth M. (assigned to Carborundum Co., Niagara Falls, N.Y.), Refractory Bodies Containing Boron Nitride and a Boride and the Manufacture Thereof: U.S. Patent 2,872,327, Feb. 3, 1959.

[52] Ceramic Industry, What's New in Refractory Ceramic Coatings for Supermetal Alloys: Vol. 70, No. 3, 1958, pp. 62–64.

[53] Lang, John V., and Furth, John V. (assigned to Solar Aircraft Co., San Diego, Calif.), Protective Cermet Coating Method and Materials: U.S. Patent 2,898,236, Aug. 4, 1959.

[54] Hirayama, Chikara, and Rutter, Mildred M., Dielectric Studies of Some Borate and Phosphate Glasses: Jour. Am. Ceram. Soc., vol. 42, No. 8, August 1959, pp. 367–373.

[55] Fenity, Robert D., and Harman, Cameron G. (assigned to Globe Union, Inc.), Fired Electrical Resistor Comprising Molybdenum Disilicide and Borosilicate Glass Frit: U.S. Patent 2,891,914, June 23, 1959.

[56] Journal of the American Ceramic Society, Enamels and Refractory Coatings for Metals: Vol. 42, No. 6, June 1959, p. 150.

[57] Chemical Week, Technology Newsletter: Vol. 85, No. 19, Nov. 7, 1959, p. 70.

[58] Chemical and Engineering News, Metal Powders Give Lead Strength: Vol. 37, No. 32, Aug. 10, 1959, pp. 50–51.

A process was patented that gave promise of removing magnesium from elemental boron. After leaching to remove soluble magnesium, the contaminated boron was heated in the presence of a reagent containing fluorine compounds to transform nonleachable magnesium to soluble form. The boron was leached again in hot aqueous acid solution to remove converted magnesium.[59]

Research has disclosed that boron can form delta bonds in which three atoms share an electron pair.[60]

Boron dispersed in paraffin was used as shielding material in a nuclear reactor. Paraffin slabs were lighter, cost less, and were easier to handle than lead or concrete shielding.[61]

Several types of steel with a relatively high boron content were introduced for shielding and control rods in atomic reactors.[62]

In England, steel containing 3 percent boron was produced. A research team discovered that steel containing 4.75 percent boron could be forged if residual aluminum was maintained at a specified level.[63]

Boron vapor plating of steel was accomplished at 800° to 850° C. in 4 to 5 hours, with a diborane to hydrogen ratio of 1 to 75 flowing at 75 to 100 liters per hour. A very hard boronized case, 200 microns thick, was obtained on carbon steel.[64]

The mechanism by which traces of boron and zirconium improved the creep properties of a complex nickel-base alloy was described. Additions of 0.0002 to 0.0088 percent boron had a pronounced stabilizing effect on the grain boundaries, prolonged the life to fracture point of the alloy, and permitted greater deformation before fracture.[65]

Research and development work on high-energy boron fuels was reported to be continuing despite plans to abandon quantity production of the fuel.[66]

One section of the $45 million high-energy boron fuel plant at Model City, N.Y., was retained to make research quantities of boron trichloride. A pilot plant at Lewiston, N.Y., would continue to produce boron fuels for research purposes.[67]

---

[59] Kroll, Wilhelm J., Nies, Nelson P., and Fajans, Edgar W. (assigned to U.S. Borax & Chemical Corp.), Production of Elemental Boron: U.S. Patent 2,893,842, July 7, 1959.

[60] Chemical Engineering, Chementator: Vol. 66, No. 7, Apr. 6, 1959, p. 74.

[61] Chemical Engineering, Boron Paraffin Shields Training Nuclear Reactor: Vol. 66, No. 14, July 13, 1959, p. 78.

[62] Chemical Engineering, More Nuclear Steels Available: Vol. 66, No. 12, June 15, 1959, p. 212.

[63] Steel Review, The British Iron and Steel Federation Quarterly, January 1959, pp. 10–12.

[64] Zhigach, A. F., and others [Surface Impregnation of Steel With Boron]: Metallov (Russia), vol. 4, No. 4572, April 1959, pp. 45–47.

[65] Decker, R. F., and Freeman, J. W., Mechanism of Beneficial Effects of Boron and Zirconium On Creep Rupture Properties of a Complex Heat-Resistant Alloy: NASA, Washington 25, D.C., August 1958, p. 54.

[66] Missiles and Rockets, Pentagon Calls Halt to HE Boron Fuels Program: Vol. 5, No. 34, Aug. 17, 1959, p. 48.

[67] Chemical Engineering, Bad News for High-Energy-Fuel Engineers: Vol. 66, No. 21, Oct. 19, 1959, p. 95.

Bromine

By Henry E. Stipp[1] and James M. Foley[2]

◆

SALES of bromine and bromine compounds increased in 1959 and exceeded in value the previous peak recorded in 1956. Exports of bromine materials decreased for the second consecutive year. Future consumption of ethylene dibromide in automobile gasoline was expected to increase; however, consumption of this bromine compound in aviation gasoline was expected to decrease.

DOMESTIC PRODUCTION

Total sales of bromine in 1959 increased 11 percent over 1958. Larger consumption of ethylene dibromide was chiefly responsible for the increase. Bromine was extracted from sea water, well brines, and saline-lake brines. The Ethyl-Dow Chemical Co. recovered bromine from sea water at Freeport, Tex., and Westvaco Chemical Division of Food Machinery & Chemical Corp. extracted bromine from sea-water bittern at Newark, Calif. The Dow Chemical Co. plants at Midland and Ludington, Great Lakes Chemical Corp. at Manistee, Michigan Chemical Corp. at East Lake and St. Louis, and Morton Salt Co. at Manistee recovered bromine from well brines in Michigan. The Westvaco Chemical Division recovered bromine from well brines at South Charleston, W. Va. Michigan Chemical Corp. recovered bromine from oil-well brines at El Dorado, Ark. American Potash & Chemical Corp. extracted bromine from the brine of Searles Lake at Trona, Calif.

Michigan Chemical Corp. announced it would increase productive capacity of its plant at El Dorado, Ark., to 10 million pounds of bromine a year. Food Machinery & Chemical Corp. introduced reagent-grade 48-percent hydrobromic acid in 1959. Halocarbon Products Corp., introduced a bromotrifluoroethylene polymer for use with flotation fluid.

TABLE 1.—Total sales of bromine and bromine compounds (bromine content) by primary producers in the United States

(Thousand pounds and thousand dollars)

Year	Quantity	Value	Year	Quantity	Value
1950-54 (average)	147,162	$30,460	1957	191,971	$48,038
1955	184,454	39,856	1958	176,397	46,689
1956	196,730	47,434	1959	195,483	51,508

---

[1] Commodity specialist.
[2] Supervisory statistical assistant.

TABLE 2.—Bromine and bromine compounds sold by primary producers in the United States

(Thousand pounds and thousand dollars)

	Quantity		Value
	Gross weight	Bromine content[1]	
1958			
Elemental bromine	14,404	14,404	$3,346
Other, including ethylene dibromide, sodium bromide, ammonium bromide, and potassium bromide	194,606	161,993	43,343
Total	209,010	176,397	46,689
1959			
Elemental bromine	12,537	12,537	2,785
Other, including ethylene dibromide, sodium bromide, ammonium bromide, and potassium bromide	218,901	182,946	48,723
Total	231,438	195,483	51,508

[1] Calculated as theoretical bromine content present in compound.

CONSUMPTION AND USES

Ethylene dibromide, used chiefly as an additive to tetraethyl lead antiknock fluid, consumed about 94 percent of the bromine output. Ethylene dibromide and methyl bromide were used in fumigation mixtures for controlling insects and other pests in seeds and soil. A small quantity of ethylene dibromide was used as an intermediate in the synthesis of dyes and pharmaceuticals; as a solvent for celluloid, resins, gums, and waxes; and as an anaesthetic, sedative, and antispasmodic agent.

Elemental bromine (6 percent of consumption) was used in many organic and inorganic compounds. It was also used as a laboratory reagent, as a bleaching and disinfecting agent, in brominated dyes, in lachrymators, and in shrink-proof wool.

The alkali bromides, sodium, potassium, and ammonium bromide, were used in sedatives in the pharmaceutical industry, in photographic plates, in films and emulsions, and as process and laboratory reagents. Potassium bromate was used as a flour additive. Both sodium and potassium bromates are powerful oxidizing agents and were used for manufacturing and laboratory reactions.

Bromine was consumed in fire-extinguishing compounds, such as monobromotrifluoromethane and bromochloromethane. Dibromopropyl phosphates and tribromoaniline were also used as flameproofing compounds.

Bromine compounds were consumed in many other uses, such as catalysts, dehumidifying agents, atomic energy shields and viewing solutions, hydraulic liquids, flotation mediums for mineral recovery, lithographic chemicals, and effervescent mineral waters.

One company official estimated that about 137 million pounds of ethylene dibromide was used in 1959 in tetraethyl lead antiknock fluid for automobile gasoline. The demand for ethylene dibromide in aviation gasoline was expected to drop from 33.3 million pounds in 1958 to approximately 24.8 million pounds in 1960.[3]

Argonne National Laboratory used bromine trifluoride as a reagent to fluorinate fuel elements for reprocessing.[4]

PRICES

According to the Oil, Paint and Drug Reporter, prices for most bromine and bromine compounds were firm throughout 1959. Prices were quoted as follows: Bromine, purified, cases, carlots, delivered east of the Rocky Mountains, 32 cents a pound; cases, less than carlots, same basis, 34 to 39 cents a pound; drums, lead-lined, carlots, delivered east of the Rocky Mountains, 31 cents a pound; drums, lead-lined, less than carlots, same basis, 31 to 34 cents a pound; ammonium bromide, N.F., granular, barrels, 45 cents a pound; ethylene dibromide, drums, carlots, freight equaled, 30½ cents a pound; drums, less than carlots, freight equaled, 31½ cents a pound; tanks, freight equaled, 28½ cents a pound; potassium bromide, U.S.P., granular, barrels, kegs, 39 to 40 cents a pound; potassium bromate, drums, 1,000-pound lots or more, 50 cents a pound; drums smaller lots, works, 52 to 62 cents a pound; and sodium bromide, U.S.P., granular, drums, works, 40 cents a pound.

FOREIGN TRADE [5]

Exports of bromine, bromides, and bromates decreased for the second consecutive year. In 1959 exports totaled 9.2 million pounds valued at about $2.6 million compared with 10 million pounds valued at $3 million in 1958. Canada and Brazil received the largest shipments; however, 38 other countries imported substantial quantities.

U.S. imports of bromine and bromine compounds (n.s.p.f.) in 1959 totaled 2,200 pounds valued at $12,500 compared with 10,400 pounds valued at $37,000 in 1958. Imports of sodium bromide in 1959 totaled 24,000 pounds valued at $9,400 compared with 1,400 pounds valued at $1,200 in 1958.

WORLD REVIEW

Germany, West.—Production of bromine and bromine compounds in 1958 totaled 3.8 million pounds compared with 3.5 million pounds in 1957.[6]

Israel.—The Israeli Government and Baker Perkins, Ltd., of England, reached an agreement for the manufacture, application, and marketing of tetrabromethane. A pilot plant with an annual output of 276 short tons will be built at Sodom, Israel. A demonstration unit to produce 1 ton of ore per hour using tetrabromethane in the separation process will be built by Baker Perkins, Ltd. The company will

---

[3] Chemical Engineering News, Additives Are Big Business: Vol. 37, No. 22, June 1959, pp. 22–23.

[4] Chemical Engineering, Fluorination Recovers Spent Uranium: Vol. 66, No. 2, Jan. 26, 1959, p. 40.

[5] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

[6] Bureau of Mines, Mineral Trade Notes: Bromine and Bromine Compounds; Vol. 49, No. 2, August 1959, p. 39.

undertake to design, build, develop, and sell special equipment for a tetrabromethane dressing process.[7] The production of bromine in Israel has reached the rated capacity of the Dead Sea Bromine Co., Ltd. plant—2,000 tons a year.[8]

Italy.—In 1958 production of elemental bromine totaled 100,000 pounds.[9]

Japan.—Production of elemental bromine totaled 3.3 million pounds in 1958 compared with 2.5 million pounds in 1957. Potassium bromate production was 628,000 pounds in 1958 and 683,000 pounds in 1957.[10]

Pakistan.—Large deposits of brine were discovered at Dhariala in the Jhelum district of Pakistan. The brine occurs under high pressure and can flow at 60,000 gallons per hour. Indications were that the brine contained bromine.[11]

United Kingdom.—Bromine was recovered from sea water at two plants. Most of the production was converted to ethylene dibromide for use in gasoline antiknock compound. Over 80 percent of this compound is exported.[12]

TECHNOLOGY

The Alberta Research Council of Canada was studying commercial aspects of recovering bromine and magnesium from waste-oil waters of the Redwater and Wizard Lake oilfields. The Redwater field was said to yield about 700,000 barrels of water a month containing 1,400 mg. per liter of bromine or about 0.49 pound a barrel.[13]

A special committee convened by the Surgeon General of the Public Health Service reported that the tetraethyl lead fluid (contains 17.9 percent ethylene dibromide) content of gasoline could be raised from 3 cc. to 4 cc. per gallon without significant harm to public health.[14]

The consumption of tetraethyl lead-ethylene dibromide antiknock fluid could be increased by the introduction of a new gasoline additive. The additive (tert-butyl acetate) should cut costs to consumers, as this method of increasing octane ratings is less costly than upgrading gasoline by refinery methods.[15]

The consumption of ethylene dibromide could be increased by the introduction of another new antiknock mixture composed of tetraethyl lead fluid and methylcyclopentadienyl manganese tricarbonyl.[16]

Brominated butyl rubber was used in a tire liner, as an adhesive for retreading, or blended with natural and synthetic rubber.[17] The brominated butyl vulcanized faster than butyl rubber; thus, it could reduce processing costs.[18]

---

[7] Work cited in footnote 6, pp. 39–40.

[8] Chemical Trade Journal and Chemical Engineer (London), Israeli Bromine: Vol. 145, No. 3777, Oct. 23, 1959, p. 748.

[9] U.S. Embassy, Rome, Italy, State Department Dispatch 1277, Apr. 28, 1959, p. 1.

[10] Bureau of Mines, Mineral Trade Notes: Bromine; Vol. 49, No. 1, July 1959, p. 29.

[11] Canadian Mining Journal (Quebec), Outside Canada: Vol. 80, No. 8, August 1959, p. 127.

[12] Chemical Trade Journal and Chemical Engineer (London), Heavy Chemicals in England and Wales: Vol. 144, No. 3757, June 5, 1959, pp. 1257–1258.

[13] Chemical Week, New Oil Dividend: Vol. 85, No. 24, Dec. 12, 1959, p. 76.

[14] U.S. Department of Health, Education, and Welfare, Public Health Service, Public Health Aspects of Increasing Tetraethyl Lead Content in Motor Fuel: Public Health Service Pub. 712, Washington, 1959, pp. 1–49.

[15] Chemical Engineering Progress, Scope: Vol. 55, No. 4, April 1959, p. 16.

[16] Chemical Engineering News, Chemicals: Vol. 37, No. 46, Nov. 16, 1959, p. 58.

[17] Chemical Engineering, Halogens Boost Butyl Rubber's Stock: Vol. 66, No. 4, Feb. 23, 1959, pp. 57, 60.

[18] Chemical Engineering Progress, Industrial News: Vol. 55, No. 4, April 1959, p. 92.

Bromomethyl alkylated phenol-formaldehyde resin reduced the curing time of butyl rubber and improved heat-resistance and compression-set properties.[19]

Bromine in the form of iodine monobromide was used to halogenate butyl rubber. The modified butyl gave better covulcanization with natural rubber, greater resistance to ozone, and increased adhesion to natural rubber and metals.[20]

Monobromotrifluoromethane was said to be twice as effective as any other extinguishing agent used for fuel and electrical fires. The army has adopted it for use at all installations.[21]

A phosphorus-bromine mixture was effective in reducing the fire hazard created by oil-type preservatives in railroad ties. Pentachlorophenol and 2-, 4-, 6-tribromoamline appeared to be suitable as halogen carriers for this application.[22]

Polymers prepared by ammonium salts of mono- and bis- (dibromopropyl) phosphoric acid and trimethylolmelamine were formed on cotton fabric and gave excellent flame and glow resistance properties to the cloth.[23]

A patent was granted for production of an organic phosphonyl halide by reacting a lower alkoxydihalophosphine and a hydrocarbon compound containing bromine, chlorine, or iodine.[24]

A potential market was reported for about 250,000 pounds a year of bromine for treating water in swimming pools. Advantages of using bromine include less eye and mucous membrane irritation, no odor, and aesthetic appeal (bromine gives water a deep-blue color).[25]

A two-furnace technique to determine bromine and chlorine content of polymers, gas, oils, and heavy residual oils was reported.[26]

A flux for joining and coating metals, comprising ammonium bromide, ammonium chloride or urea, and an amine hydrohalide, was patented.[27]

---

[19] Chemical Engineering, Curing Agent: Vol. 66, No. 11, June 1, 1959, pp. 72, 74.

[20] Morrissey, R. T., Halogenation of Butyl Rubber with Iodine Monochloride and Iodine Monobromide: Rubber World, Vol. 138, No. 5, August 1958, pp. 725–732, 742.

[21] Chemical Engineering News, Monobromotrifluoromethane: Vol. 37, No. 43, Oct. 26, 1959, p. 90.

[22] Chemical Engineering, Flames Die Just After Birth in P–BR–T Treated Wood: Vol. 66, No. 17, Aug. 24, 1959, p. 84.

[23] Reid, David J., and others, Investigation of Silicon Compounds and Dibromopropyl Phosphates as Flame Retardants for Cotton: U.S. Army, Textile, Clothing, and Footwear Division, Quartermaster Research and Engineering Center, Natick, Mass., July 1957, 30 pp.

[24] Kwiatek, J., and Copenhaver, J. W., Production of Organic Phosphonyl Halides: U.S. Patent 2,882,313, Apr. 14, 1959.

[25] Chemical Week, Bromine Splash: Vol. 85, No. 24, Dec. 12, 1959, p. 90.

[26] Chemical Engineering News, Halogens Pinpointed: Vol. 37, No. 5, Feb. 2, 1959, pp. 42–43.

[27] Jordan, Elfred A., and Lederer, F. B. (Lederer, F. B., assigned to Jordan, Elfred A.), Flux Composition and Processes for Soldering and Metal Coating: U.S. Patent 2,880,125, Mar. 31, 1959, p. 1312.

Cadmium

By Arnold M. Lansche [1]

◆

APPARENT consumption of cadmium in the United States in 1959 rose 40 percent to 11.5 million pounds. This high consumption, coupled with decreased supply, caused cadmium stocks to drop nearly 40 percent from 1958. Quotas on imports of zinc ores and concentrates, which contain cadmium, and strikes at domestic zinc smelters and cadmium refineries contributed to the lower cadmium supply.

TABLE 1.—Salient statistics of cadmium, in thousand pounds of contained cadmium

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Primary production	9,078	[1] 9,754	[2] 10,614	[2] 10,549	[2] 9,673	[2] 8,602
Metal imported for consumption	831	927	3,116	1,586	1,002	1,638
Exports	506	1,394	1,284	693	580	900
Apparent consumption	8,559	10,684	12,711	[2] 10,999	[2] 8,177	[2] 11,474
Price (average per pound)	$2.18	$1.70	$1.70	$1.70	$1.52	$1.35
World: Production	14,400	[3] 18,500	20,100	[3] 21,000	[3] 19,900	19,700

[1] Primary cadmium metal only.
[2] Primary and secondary cadmium metal.
[3] Revised figure.

LEGISLATION AND GOVERNMENT PROGRAMS

General Services Administration, pursuant to Strategic and Critical Materials Stock Piling Act, 53 Stat. 811, as amended, 50 U.S.C. 98b(e), announced in September 1959 the proposed sale (to take place 6 months later) of 4,413 short tons of cadmium-magnesium scrap, 20 percent cadmium content, from the national stockpile of strategic materials.

In February, the U.S. Department of Agriculture Commodity Credit Corporation ended barter of surplus perishable goods for foreign-produced cadmium metal.

DOMESTIC PRODUCTION

The combined production of primary and secondary cadmium metal in 1959 was down to 8.6 million pounds, 11 percent below 1958, a de-

---

[1] Commodity specialist.

crease for the third successive year. Output in 1959 was adversely affected by restrictions on imports of zinc ores and concentrates and strikes at zinc smelter and cadmium refineries.

Foreign flue dust provided 18 percent of the 8.6 million pounds of cadmium produced in 1959. Except for the small quantity of secondary production, an estimated 48 percent of the remainder was derived from domestic zinc ore and 52 percent from foreign zinc ore concentrates and other base-metal concentrates containing zinc and associated cadmium. Mexico, Canada, and Peru were the chief sources of imported zinc concentrates.

Some cadmium was recovered from the purification of zinc sulfate solutions used to make lithopone. A small quantity of secondary cadmium metal was recovered by processing scrap alloys.

Eagle-Picher Co. discontinued cadmium production at its Henryetta (Okla.) plant, and Kentucky Color & Chemical Co. became a division of Harshaw Chemical Co. on October 1, 1959.

Output of cadmium sulfide, including cadmium lithopone and cadmium sulfoselenide (cadmium content), increased 26 percent to 1.2 million pounds in 1959. Statistics were not available for cadmium-mercury lithopone.

The average cadmium oxide production for the 5-year period, 1950–54, was 769,000 pounds gross weight and 672,000 pounds cadmium content. Annual oxide output is withheld to avoid disclosing individual company confidential data.

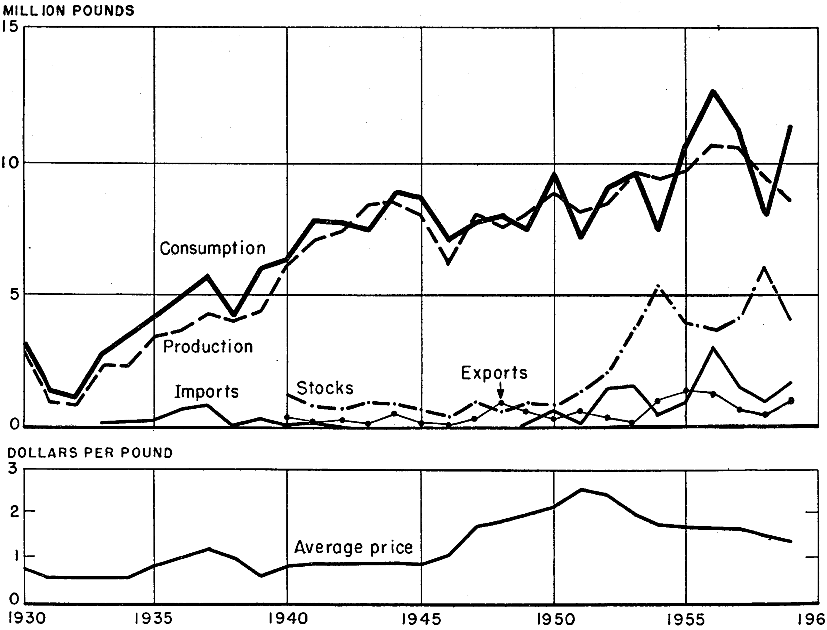

FIGURE 1.—Trends in production, consumption, year-end stocks, imports, exports, and average price of cadmium metal in United States, 1930–59.

TABLE 2.—Cadmium produced and shipped in the United States, in thousand pounds of contained cadmium

	1950–54 (average)	1955	1956	1957	1958	1959
Production:						
Primary:						
Metallic cadmium	8,890	9,754	[1] 10,614	[1] 10,549	[1] 9,673	[1] 8,602
Cadmium compounds [2]	188	(3)	(3)	(3)	(3)	(3)
Total primary production	9,078	9,754	[1] 10,614	[1] 10,549	[1] 9,673	[1] 8,602
Secondary (metal and compounds)[2] [4]	177	286	(3)	(3)	(3)	(3)
Shipments by producers:						
Primary:						
Metallic cadmium	8,085	11,167	[1] 10,936	[1] 10,091	[1] 7,921	[1] 11,273
Cadmium compounds [2]	187	(3)	(3)	(3)	(3)	(3)
Total primary shipments	8,272	11,167	[1] 10,936	[1] 10,091	[1] 7,921	[1] 11,273
Secondary (metal and compounds)[2] [4]	169	286	(3)	(3)	(3)	(3)
Value of primary shipments:						
Metallic cadmium	$16,322	$15,729	[5] $16,283	[5] $14,921	[5] $10,067	[5] $12,054
Cadmium compounds [6]	388	(3)	(3)	(3)	(3)	(3)
Total value	16,710	15,729	[5] 16,283	[5] 14,921	[5] 10,067	[5] 12,054

[1] Total metallic cadmium, including secondary.
[2] Excludes compounds made from metal.
[3] Figure withheld to avoid disclosing individual company confidential data.
[4] Bureau of Mines not at liberty to publish figures separately for secondary cadmium compounds.
[5] Value of metallic cadmium shipments, including secondary.
[6] Value of metal contained in compounds made directly from flue dust or other cadmium raw meterials (except metal).

TABLE 3.—Cadmium sulfide[1] produced in the United States, in thousand pounds

Year	Gross weight	Cadmium content	Year	Gross weight	Cadmium content
1950–54 (average)	3,512	1,140	1957	3,198	1,041
1955	4,191	1,348	1958	2,884	983
1956	3,937	1,258	1959	3,701	1,243

[1] Includes cadmium lithopone and cadmium sulfoselenide.

CONSUMPTION AND USES

The apparent consumption of cadmium metal was 12 percent above the total new supply in 1959 and 40 percent above that in 1958. The gain in consumption was attributed to an increase in the use of cadmium for electroplating, in cadmium compounds as colorants, as heat and light stabilizers in plastics, and in nickel-cadmium batteries.

Cadmium was consumed in electroplating such items as automobile-engine parts, aircraft parts, radio and television parts, and nuts and bolts. Cadmium was also used in bearing and fusible alloys, paint pigments, dentistry, photography, dyeing, and nuclear energy reactors. Cadmium was used in the form of organocadmium compounds to provide heat and light stabilization for plastics.

A mixture of 60 percent cadmium succinate as the active ingredient and 40 percent inert material was marketed as a turf fungicide for control of grass diseases.

Manufacturers of both pocket- and sintered-plate type nickel-cadmium batteries in the United States in 1959 were:

Nickel-Cadmium Battery Corp	East Hampton, Mass.
Nife, Inc	Copiague, N.Y.
The Electric Storage Battery Co	Philadelphia, Pa.
Thomas A. Edison, Inc	West Orange, N.J.

Producers of the sintered-plate type only were:

Burgess Battery Co	Freeport, Ill.
Eagle-Picher Co	Cincinnati, Ohio
Gulton Industries, Inc	Metuchen, N. J.
Sonotone Corp	Elmsford, N.Y.

STOCKS

Stocks of cadmium metal increased in the first quarter of 1959 to a high of 5.94 million pounds and during the rest of the year declined at an average monthly rate of 275,000 pounds to 3.46 million pounds at the end of the year. Stocks of cadmium compounds increased 16 percent over 1958. Total stocks were down 33 percent to 4.1 million pounds.

The Government supplemental stockpile was reported[2] to contain 6,107,756 pounds of cadmium metal at the end of calendar year 1959. Cadmium in the Government's strategic stockpile and that held by the Commodity Credit Corporation continued to be restricted information.

TABLE 4.—Industry stocks at end of year, in thousand pounds of contained cadmium

	1958			1959		
	Metallic cadmium	Cadmium compounds	Total cadmium	Metallic cadmium	Cadmium compounds	Total cadmium
Metal producers	5,367		5,367	3,103		3,103
Compound manufacturers	75	508	583	183	588	771
Distributors [1]	153	51	204	174	59	233
Total stocks	5,595	559	6,154	3,460	647	4,107
Consumers' stocks	(2)	(2)	[3] 1,000	(2)	(2)	[3] 1,000

[1] Comprises principally 8 largest dealers and producers of plating salts; it was estimated that about 76,000 pounds of metal and 14,000 pounds of oxide were in the hands of other dealers and distributors at the end of 1958. Comparable figures for 1959 were 112,000 pounds of metal and 10,000 pounds of oxide.

[2] Data not available.

[3] Estimate.

PRICE

On April 1, 1959, the quoted price of cadmium metal declined from $1.45 to $1.30 a pound for sticks, bars, and shapes in lots under 1 ton; $1.20 a pound was quoted for lots of a ton or more. Principal factors in the price decline were the discontinuance of the U.S. barter program for cadmium, the decline in price on the United Kingdom market, and the increasing stocks of metal in the United States in the first quarter of the year. On October 1, the quoted price increased to $1.40

---

[2] U.S. Department of Agriculture, USDA Reports on Barter Contracts and Exports for October–December Period: Washington, D.C., Mar. 9, 1960.

a pound for lots up to 1 ton and to $1.30 a pound for ton lots. Three factors influenced this price increase: Industrial activity increased; strikes involving various aspects of cadmium production began in July and August; and available stocks of the metal decreased rapidly.

The London quotation declined in March from 9s. 6d. a pound in lots of a hundredweight ($1.33 on the basis of $2.80 a £) to 9s. ($1.26), and in November the price advanced to 9s. 6d. In Italy the price declined in April to 2,100 lire a kilogram or $1.47 a pound on the basis $0.00154 per lire. In France the price declined about August 1 to 1,300 francs a kilogram ($1.40 a pound on the basis of $0.0024 per franc).

Cadmium-mercury lithopone, orange (deep-shade), declined 3 cents to $1.58 a pound in barrel lots in April and increased to $1.61 in November in response to fluctuations in the metal price.

FOREIGN TRADE [3]

Imports.—General imports of cadmium increased 58 percent over 1958, and imports for consumption rose 63 percent.

Mexico supplied all of the 1.5 million pounds of imported flue dust (cadmium content) in 1959, 27 percent more than in 1958.

Exports.—Exports increased 55 percent in 1959, and cadmium metal was the item of principal value in the exports. The United Kingdom received the largest quantity—about 652,000 pounds. The average value of all exports was $1.14 a pound.

Tariff.—The import duty on cadmium metal remained at 3.75 cents per pound in 1959—the rate established January 1, 1948, as a result of action taken at the Geneva Trade Conference of 1947. Cadmium contained in flue dust remained duty free.

WORLD REVIEW

World production of cadmium metal declined slightly owing almost entirely to the drop in U.S. output.

Mexico.—Cadmium was produced in Mexico at the Torreón (Coahuila) smelter of Compañía Metalurgica Penoles, S.A., a subsidiary of American Metal Climax Co. Cadmium was extracted from lead-bearing minerals processed by the lead smelter at Torreón. Cadmium production facilities at the smelter have an annual capacity of approximately 55 short tons.

United Kingdom.—About 2.8 million pounds of cadmium metal was consumed in 1959, an increase of 23 percent over 1958. Supply, comprising 0.3 million pounds of internal production and 2.5 million pounds of metal imports, increased 34 percent over 1958. Quantities (in thousand pounds) used for various purposes were as follows: Plating anodes, 1,404; plating salts, 241; cadmium-copper alloys, 110; other alloys, 95; alkaline batteries, 188; dry batteries, 11; solder, 145; colors, 580; and miscellaneous, 42.

---

[3] Figures on U.S. imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 5.—Cadmium metal and flue dust imported into the United States, by countries

(Thousand pounds and thousand dollars)

[Bureau of the Census]

Country	General imports[1]				Imports for consumption[2]			
	1958		1959		1958		1959	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
METALLIC CADMIUM								
North America:								
Canada	508	$682	839	$920	508	$682	839	$920
Mexico	------	------	91	47	------	------	91	47
Total	508	682	930	967	508	682	930	967
South America: Peru	103	155	110	128	103	155	110	128
Europe:								
Belgium-Luxembourg	119	139	187	209	119	139	180	201
France	11	11	------	------	11	11	------	------
Germany, West	------	------	55	53	------	------	55	53
Italy	14	18	16	16	13	17	16	16
Netherlands	22	28	33	38	13	19	40	45
Norway	------	------	22	24	------	------	22	24
United Kingdom	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)
Total	166	196	313	340	156	186	313	339
Asia: Japan	143	167	116	125	121	142	149	162
Africa:								
Belgian Congo	59	69	163	176	59	69	136	148
Rhodesia and Nyasaland, Federation of	10	15	------	------	10	15	------	------
Total	69	84	163	176	69	84	136	148
Oceania: Australia	45	63	------	------	45	63	------	------
Total metallic cadmium	1,034	1,347	1,632	1,736	1,002	1,312	1,638	1,744
FLUE DUST (CD CONTENT)								
North America: Mexico	1,218	661	1,544	584	1,218	661	1,544	584
Total flue dust	1,218	661	1,544	584	1,218	661	1,544	584
Grand total	2,252	2,008	3,176	2,320	2,220	1,973	3,182	2,328

[1] Comprises cadmium imported for immediate consumption plus material entering bonded warehouses.

[2] Comprises cadmium imported for immediate consumption plus material withdrawn from bonded warehouses.

[3] Less than 1,000.

TABLE 6.—Cadmium metal, alloys, dross, flue dust, residues, and scrap exported from the United States

(Thousand pounds and thousand dollars)

[Bureau of the Census]

Year	Pounds	Value	Year	Pounds	Value
1950-54 (average)	508	$1,102	1957	693	$1,060
1955	1,394	1,938	1958	580	771
1956	1,284	1,932	1959	900	1,024

TABLE 7.—World production of cadmium, by countries,[1] in thousand pounds[2]

[Compiled by Augusta W. Jann and Berenice B. Mitchell]

Country	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada	1,066	1,919	2,339	2,368	1,756	[3] 2,200
Guatemala	------	------	107	84	52	------
Mexico (refined metal)	------	------	------	------	42	[3] 114
United States (primary):						
Metallic cadmium	[4] 8,890	[4] 9,754	[5] 10,614	[5] 10,549	[5] 9,673	[5] 8,602
Cadmium compounds (Cd content)	188	(6)	(6)	(6)	(6)	(6)
South America: Peru [7]	26	138	107	104	190	[3] 190
Europe:						
Austria	------	------	5	25	25	[3] 24
Belgium [3]	1,030	1,433	1,488	1,323	1,488	1,488
France	227	397	240	388	385	542
Germany, West	233	709	645	611	703	926
Italy	352	462	412	492	410	[3] 309
Netherlands [3]	[8] 22	34	36	77	88	88
Norway	187	255	278	244	240	284
Poland [3]	439	550	542	560	573	595
Spain	13	22	25	20	14	[3] 13
U.S.S.R. [3] [9]	329	680	795	1,050	1,040	1,080
United Kingdom	326	337	251	228	278	310
Yugoslavia	------	------	18	57	[3] 55	[3] 55
Asia: Japan	379	757	886	873	964	1,082
Africa:						
Belgian Congo	75	366	611	911	1,075	1,047
Rhodesia and Nyasaland, Federation of: Northern Rhodesia	------	------	117	125	38	------
Oceania: Australia	626	674	618	880	791	[3] 752
World total (estimate) [1] [2]	14,400	18,500	20,100	21,000	19,900	19,700
Mexico [10]	1,668	2,855	1,892	1,673	1,655	[3] 1,151
South-West Africa [10]	1,341	1,402	2,328	2,838	2,698	1,193

[1] Data derived in part from bulletins of the World Non-Ferrous Metal Statistics and annual issues of Metal Statistics (Metallgesellschaft).

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Estimate.

[4] In addition, secondary metal and compounds were as follows: 1950–54 (average) 177,000 pounds and 1955, 286,000 pounds.

[5] Includes secondary.

[6] Figure withheld to avoid disclosing individual company confidential data.

[7] Includes refined metal, beginning in 1955.

[8] One year only, as 1954 was the first year of commerical production.

[9] Estimates based on an assumed average cadmium content of 0.1 percent in zinc concentrates.

[10] To avoid duplicating figures, data are not included in the world total, as the cadmium content of flue dust from Mexico is exported for treatment elsewhere; represents in part shipments from stocks on hand. The cadmium content of concentrates from South-West Africa is also exported for treatment elsewhere.

TECHNOLOGY

A 5-percent cadmium, 15-percent indium, and 80-percent silver alloy was reported in 1959 as a substitute for hafnium as control-rod material in the pressurized-water nuclear reactor. The alloy was said to be metallurgically stable under radiation, resistant to corrosion when in direct contact with pressurized high-temperature water, free of temperature distortion, ductile, a strong neutron absorber, low in cost, and easily fabricated.

Several reports [4] [5] [6] described research on nickel-cadmium batteries to drive electric automobiles or industrial vehicles. Other publica-

---

[4] American Motors, Sonotone to Work on Electric Auto: Wall Street Jour., vol. 153, No. 64, Apr. 2, 1959, p. 3.

[5] Ingraham, Joseph C., Old Electric May Be the Car of Tomorrow: The New York Times, vol. 108, No. 37,073, July 26, 1959, p. X19.

[6] Nickel-Cadmium Battery Points to Economic Feasibility of Electric Auto: American Metal Market, vol. 66, No. 210, Oct. 27, 1959, p. 7.

tions covered the theory and electrical characteristics of alkaline storage batteries;[7] electrochemical oxidation and reduction of cadmium in potassium hydroxide;[8] comparison of the nickel-cadmium battery and other batteries;[9] voltage decays of electrodes in nickel-cadmium cells;[10] investigation by means of X-ray diffraction patterns of the reaction mechanism of the nickel-cadmium cell;[11] charge and discharge characteristics of nickel-cadmium cells containing palladium as a hydrogen gas-oxygen gas recombination catalyst;[12] the power of energy sources used to operate electronic gear in space vehicles depends on the weight of the power source;[13] and use of batteries in missiles.[14]

Cadmium peroxide[15] was prepared, and its structure and some of its properties were determined. Patents[16] were issued on processes for making cadmium-mercury pigments and for producing silver-cadmium oxide powder[17] suitable for fabrication into electrical contacts. In the latter process, cadmium oxide particles are coated with silver oxide, then the dry material is heated to a temperature of 300° C. to 500° C., and the silver oxide is reduced to silver.

A paper[18] discussed the use of cadmium 2-ethylhexanoate in polyvinyl chloride to stabilize the plastic against the action of heat and light.

Two methods were suggested to eliminate hydrogen embrittlement of cadmium-plated steel. In one method[19] a thin, porous cadmium plate was electroplated onto steel, and a bake period was used to eliminate hydrogen before applying full plate thickness required for protecting the steel against corrosion. Another method[20] consisted of electrically vaporizing cadmium inside an evacuated chamber and allowing it to condense on the steel part until the desired plating thickness was achieved. A report[21] claimed that cadmium plating does not contribute measurably to the embrittlement of steel springs, but procedures involving a cathodic or acid pickle before plating do cause

---

[7] Khomyakon, V. G., Mashonets, V. O., and Kuzmin, L. L., Teckhnologiya Elektrokhimicheskikh Proznodstv, 1949, pp. 140–164. [Ch. 3. Alkaline Storage Batteries]: Translation, Sept. 8, 1958, 23 pp.

[8] Croft, George T., Controlled Potential Reactions of Cadmium and Silver in Alkaline Solution: Jour. Electrochem. Soc., vol. 106, No. 4, April 1959, pp. 278–284.

[9] LaFond, Charles D., Batteries Retain Their Power Role: Missiles and Rockets, vol. 5, No. 35, Aug. 24, 1959, pp. 15–17.

[10] Salkind, A. J., and Bruins, P. F., Nickel-Cadmium Cell Electrodes: Jour. Electrochem. Soc., vol. 106, No. 8, August 1959, p. 198c.

[11] Falk, S. Uno, Investigations on the Reaction Mechanism of the Nickel-Cadmium Cell: Jour. Electrochem. Soc., vol. 106, No. 8, August 1959, p. 198c.

[12] Seiger, H. N., Sealed Nickel-Cadmium Cells Containing Palladium: Jour. Electrochem. Soc., vol. 106, No. 8, August 1959, p. 198c.

[13] Zahl, H. A., Ziegler, H. K., and Daniel, A. F., Energy in Space: Pounds vs. Power: Chem. and Eng. News, vol. 37, No. 20, May 18, 1959, pp. 96–99, 133.

[14] Perry, Donald E., Miniature Batteries Have Heavy Missile Use: Missiles and Rockets, vol. 5, No. 8, Feb. 23, 1959, pp. 28–30.

[15] Hoffman, C. W. W., Ropp, R. C., and Mooney, R. W., Preparation, Properties, and Structure of Cadmium Peroxide: Jour. Am. Chem. Soc., vol. 81, Aug. 5, 1959, pp. 3830–3834.

[16] Galiano, Louis John, and Daly, James Ernest (assigned to Imperial Color Chemical & Paper Corp., Glen Falls, N.Y.), Pigments and Process of Making Them: U.S. Patent 2,878,134, Mar. 17, 1959.

[17] Matsukawa, Tatsuo, Process for Producing Composite Powder of Silver and Cadmium Oxide: U.S. Patent 2,894,839, July 14, 1959.

[18] Frye, Alfred H., and Horst, Raymond W., The Mechanism of Poly (Vinyl Chloride) Stabilization by Barium, Cadmium, and Zinc Carboxylates. I. Infrared Studies: Jour. Polymer Sci., vol. 40, 1959, pp. 419–431.

[19] Cash, D. J., and Scheuerman, W., High-Strength Steel Can Be Cadmium Plated Without Embrittlement: Metal Prog., vol. 75, No. 2, February 1959, pp. 90–93.

[20] Materials in Design Engineering, Cadmium-Coated Steel Does Not Embrittle: Vol. 49, No. 4, April 1959, pp. 152 and 154.

[21] Gurklis, J. A., McGraw, L. D., and Faust, C. L., Hydrogen Embrittlement of Plated Steel Springs: Batelle Memorial Inst. for Signal Corps, U.S. Army, December 1956, 45 pp. (Order PB 151125 from OTS, U.S. Department of Commerce, Washington 25, D.C., $1.25.)

embrittlement. The basic reason for hydrogen embrittlement of steel may have been found in studies of the problem carried out at Argonne National Laboratory.[22] Research using a neutron spectrometer revealed that, when hydrogen enters steel, bonds are formed between the hydrogen and metal which are inherently weaker than the original metal-metal bonds.

The Federal Bureau of Mines issued a report[23] describing a procedure for recovering cadmium from magnesium-cadmium alloy by vacuum distillation. Another Bureau paper[24] reported on determinating heats of formation of crystalline cadmium metasilicate and crystalline lead metasilicate from the oxides and elements by hydrofluoric acid solution calorimetry.

Measurement of the vapor pressures of several magnesium-cadmium alloys, as determined by the Knudsen effusion technique, was described.[25]

---

[22] Chemical and Engineering News, Metal Failures Blamed on Bonds: Vol. 37, No. 47, Nov. 23, 1959, pp. 44, 47.

[23] Caldwell, H. S., Jr., and Spendlove, M. J., Recovery of Magnesium and Cadmium From Incendiary Alloys by Vacuum Distillation: Bureau of Mines Rept. of Investigations 5476, 1959, 17 pp.

[24] Barany, R., Heat and Free Energy of Formation Data for Crystalline Cadmium and Lead Metasilicates: Bureau of Mines Rept. of Investigations 5466, 1959, 7 pp.

[25] Borg, Richard J., and Birchenall, C. Ernest, Activity of Cd in Mg-Cd Alloys: Trans. AIME, vol. 215, No. 3, June 1959, pp. 393–395.

Calcium and Calcium Compounds

By C. Meade Patterson[1] and James M. Foley[2]

⁂

CALCIUM and calcium compounds played significant roles in industry and research in 1959. High-purity calcium was obtained by laboratory distillation. Its isotopes were used in research. Calcium was used extensively to reduce rare and refractory metals. Chemical replacement of the element by strontium 90 caused concern.

DOMESTIC PRODUCTION

Nelco Metals, Inc., Canaan, Conn., and Union Carbide Metals Co., Niagara Falls, N.Y., produced calcium.

Purity higher than 99.95 percent was obtained by fractional distillation for reducing uranium tetrafluoride to uranium. Pellets of calcium produced by Nelco Metals were redistilled at the Y–12 plant of Union Carbide Nuclear Co., Oak Ridge, Tenn.[3]

In 1958 shipments of natural and synthetic solid and flake calcium chloride and calcium-magnesium chloride (including 77–80 percent and 94–97 percent $CaCl_2$) were 531,565 short tons, valued at $15.3 million, and brine shipments (40–45 percent $CaCl_2$) were 204,359 short tons, valued at $2 million.[4] Calcium chloride and calcium-magnesium chloride from natural brines during 1955–59 averaged 401,000 short tons annually, valued at $7.2 million.

CONSUMPTION AND USES

Calcium was used commercially in the reduction of chromium, titanium, thorium, uranium, and zirconium from their oxides or fluorides. The reactivity and low strength of calcium precluded any structural use. Lead alloyed with calcium was used in storage batteries, and 0.1 percent calcium yielded an alloy equivalent to 9 percent antimony.[5]

Zircaloy was prepared by reducing zirconium tetrafluoride with calcium in the presence of the alloying metals.[6] More efficient production of ductile iron was achieved with a new alloy, 4–5 percent

---

[1] Commodity specialist.

[2] Supervisory statistical assistant.

[3] McCreary, W. J., High-Purity Calcium: Jour. Metals, vol. 10, No. 9, September 1958, pp. 615–617.

[4] U.S. Department of Commerce, Bureau of the Census, Industry Division, Inorganic Chemicals and Gases, 1958: Facts for Industry Series M28A–08, Nov. 5, 1959, p. 11.

[5] Jackson, W. H., Calcium, 1958: Canada Dept. of Mines and Tech. Surveys, Ind. Min. Div., Ottawa, Rev. 6, June 1959, 4 pp.

[6] Decroly, C., Gerard, J., and Tytgat, D., Contribution to the Study of the Preparation of Zirconium and Some of Its Alloys by Metallo-Thermic Reduction: Revue de Metallurgie, vol. 56, February 1959, pp. 143–162.

calcium, 30–32 percent magnesium, 50–55 percent silicon, and 1 percent mischmetal, made by Union Carbide Metals Co.[7] Saudamet (calcium 16–20 percent, manganese 14–18 percent, and silicon 55–60 percent), by Union Carbide, Ltd. (London) was a ladle addition in the open hearth process and a furnace and ladle addition in electric steelmaking. Containing two extremely active and strong deoxidizers, the alloy produced clean steel, and uniformity and high ductility in steel castings.[8]

Calcium hydride completely dried gases and liquids from below room temperature to 1,400° F. Hydrogen, argon, helium, nitrogen, hydrocarbons, esters, and alcohols were dried commercially by contact in stirred tanks, by percolation, or by vapor passage through stationary calcium hydride beds.[9]

PRICES AND SPECIFICATIONS

The Atomic Energy Commission (AEC) increased the price of calcium 45 from $5 to $6.50 per millicurie.[10] Calcium was quoted in ton lots at $2.05 a pound cast, $2.95 a pound for turnings, and $3.75 a pound distilled (99.9 percent pure). In lots of 100 to 1,999 pounds, the corresponding prices per pound were $2.40, $3.30, and $4.55.[11]

Calcium-silicon alloy (30–33 percent calcium and 60–65 percent silicon) lump, delivered, packed, was quoted at 24 cents per pound in bulk in carloads, 27.95 cents per pound in ton lots, and 29.45 cents per pound in less than ton lots. Calcium-manganese-silicon alloy (16–20 percent calcium, 14–18 percent manganese, and 53–59 percent silicon) lump, delivered, packed, was quoted at 23 cents per pound in bulk in carloads, 26.15 cents per pound in ton lots, and 27.15 cents per pound in less than ton lots.[12]

Prices for calcium chloride were constant throughout 1959: USP granular—$0.32 per lb. (drums); purified granular—$0.27 per lb. (drums); flake, 77–80 percent—$31 per ton (paper bags, carlots, at works frt. equald.); concentrated flake or pellet, 94–97 percent—$37.80 per ton (paper bags, carlots, at works frt. equald.); powdered, 77 percent minimum—$37 per ton (paper bags, carlots, at works frt. equald.); solid, 73–75 percent—$29.50 per ton (drums, carlots, at works frt. equald.); solid, 73–75 percent—$36–$73 (drums, less than carlots, at works frt. equald.); and liquor, 40 percent—$12.50 per ton (tankcars, at works, frt. equald.).[13]

FOREIGN TRADE[14]

Imports.—Canada was the only source of imported calcium. Calcium-silicon alloy imports came from France, 63 percent; Italy, 13

---

[7] Iron and Steel Engineer, Magnesium Alloy: Vol. 36, No. 5, May 1959, p. 227.

[8] Metallurgia (Manchester), vol. 59, No. 355, May 1959, p. 16.

[9] Chemical and Engineering News, vol. 36, No. 47, Nov. 24, 1958, p. 51; vol. 37, No. 18, May 4, 1959, p. 17.

[10] Chemical Week, vol. 84, No. 24, June 13, 1959, p. 106.

[11] Iron Age, vol. 184, No. 4, July 23, 1959, pp. 110, 122.

[12] Work cited in footnote 11.

[13] Oil, Paint and Drug Reporter, vol. 175, Nos. 1–27; vol. 176, Nos. 1–27; Jan. 5–Dec. 28, 1959.

[14] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

percent; and from the Netherlands and West Germany, 12 percent each. Calcium chloride was imported from West Germany, 45 percent; Belgium-Luxembourg, 30 percent; United Kingdom, 16 percent; and the Netherlands, 9 percent.

Exports.—Calcium chloride was exported principally to Canada, Mexico, Cuba, Republic of Korea, and Venezuela, in decreasing amounts, with Canada receiving 91 percent, and the five countries receiving 97 percent. The remaining 3 percent was distributed among 30 other countries in Latin America, Asia, Oceania, Europe, and Africa, in descending order.

TABLE 1.—Calcium, calcium-silicon, and calcium chloride imported into the United States, and calcium chloride exported from the United States

[Bureau of the Census]

Year	Imports						Exports	
	Calcium		Calcium-silicon		Calcium chloride		Calcium chloride	
	Pounds	Value	Pounds	Value	Short tons	Value	Short tons	Value
1950-54 (average)	615,408	$642,989	133,956	$6,707	1,649	$54,670	15,203	$460,510
1955	699,799	834,732	689,114	92,366	1,844	57,881	20,743	607,579
1956	8,387	10,109	194,869	32,191	1,855	59,635	32,523	1,056,958
1957	24,204	39,411	498,735	97,077	1,989	77,058	47,965	1,627,545
1958	15,694	24,084	130,866	25,111	[1] 1,234	[1] 45,977	37,632	1,325,460
1959	7,425	7,506	918,556	138,188	1,756	66,499	39,929	1,376,854

[1] Revised figure.

WORLD REVIEW

NORTH AMERICA

Canada.—Calcium production was 70,259 pounds, valued at Can$85,807 (Can$1.22 a pound) in 1958. Canada's only calcium producer, Dominion Magnesium, Ltd., was also the world's largest producer. Four grades were offered, ranging from Commercial Grade (98 to 99 percent calcium) to Chemical Standards Grade (99.9 percent calcium), only available as granules between 4- and 80-mesh. Granules, crystalline lumps, extruded forms, billets, ingots, wire, tubes, shapes, and strip were offered in other grades. Output had declined, because former markets no longer had pressing needs. Over half of the 1958 calcium exports of 79,028 pounds went to Belgium and the United States, and the rest to West Germany, United Kingdom, and India.[15]

EUROPE

Netherlands.—A Gouda engineering works designed a mobile spraying machine for allaying coal dust with an aqueous calcium chloride solution containing a wetting agent.[16]

---

[15] Work cited in footnote 5.

[16] South African Mining and Engineering Journal (Johannesburg), For Dust-Proofing Coal: Vol. 70, No. 3485, Nov. 27, 1959, p. 1387.

West Germany.—Farbenfabriken Bayer A.G., Leverkusen, developed nonpyrophoric pellets of calcium for dehydrogenation.[17] A contract was made between Degussa, Wolfgang, and Sumitomo Metal Industries, Ltd. (Japan) for exchanging information on reducing uranium tetrafluoride with calcium.[18]

ASIA

China.—Chemical plants near Tientsin were reported producing calcium from sea water.[19]

India.—Import of calcium granules from Dominion Magnesium. Ltd. (Canada) increased in 1958. It was used to reduce uranium tetrafluoride at a new Bombay uranium plant.[20]

TECHNOLOGY

Calcium was extruded at about 420° C. and cast under protective fluxes in a vacuum or inert gas atmosphere.[21] A stainless steel crucible containing 1 kg. of calcium was heated in a retort to 850°–950° C. under helium at a pressure of 2 mm. of mercury. In 30 minutes at 950° C., 100 grams of calcium was deposited as long, slender, discrete crystals covering small granules. Small crystals, that condensed on the upper walls of the retort, burned explosively in air. Redistilled calcium was preserved under helium in screwcap jars, and some contained less than 1 p.p.m. of magnesium, compared with 300–3,000 p.p.m. in the original calcium.[22]

High-purity calcium (99.9 percent) was obtained by the Institute for Atomic Research, Iowa State College, Ames, Iowa, and crystallographic study confirmed its dimorphic nature and transition temperature at 450° C. [23] U.S. AEC signed a research contract with the International Atomic Energy Agency to produce calcium 47 for medical and biological research less expensively than by irradiating calcium 46 (0.003 percent of normal calcium) in a high-flux reactor.[24]

Impurities in calcium were usually transferred to the metal being prepared by reduction. Very pure calcium was obtained by vacuum distillation of commercial calcium. Calcium with 10 p.p.m. carbon and 3–14 p.p.m. nitrogen was prepared for reducing tungsten trioxide in bombs.

Calcium chloride for electrolysis was dewatered by remelting at 850°–900° C. for 30 to 40 minutes. Electrolysis was conducted at 780°–810° C., using either anhydrous calcium chloride alone or a 25:4 calcium chloride-calcium fluoride mixture. Calcium chloride elec-

---

[17] Chemical Week, Dehydrogenation Pellets: Vol. 84, No. 2, Jan. 10, 1959, pp. 32, 34.

[18] U.S. Embassy, Bonn, West Germany, State Department Dispatch 1458, Mar. 25, 1959, p. 14.

[19] Chemical Week, Chemicals—China: Vol. 84, No. 6, Feb. 7, 1959, p. 28.

[20] Work cited in footnote 5.

[21] Work cited in footnote 5.

[22] McCreary, W. J., High-Purity Calcium: Jour. Metals, vol. 10, No. 9, September 1958, pp. 615–617.

[23] Smith, J. F., and Bernstein, B. T., Effects of Impurities on the Crystallographic Modifications of Calcium Metal: Jour. of the Electrochemical Soc., vol. 106, No. 5, May 1959, pp. 448–451.

[24] Chemical and Engineering News, vol. 37, No. 33, Aug. 17, 1959, p. 55. Chemical and Engineering News, U.S. Pushes Peace Plan for Atoms: Vol. 37, No. 42, Oct. 19, 1959, p. 100.

trolysis with a liquid cathode yielded calcium-aluminum, calcium-copper, and calcium-lead alloys. Calcium was separated from calcium-copper alloys, and calcium-aluminum alloys containing up to 50 percent calcium were possible.[25]

A Soviet publication discussed raw materials, the physicochemical properties and uses of calcium, and the methods of producing calcium.[26] As little as 0.5 p.p.m. calcium was detected by a new, dual-source, grating spectroscope.[27]

Calcium counteracted absorption by plants of fallout strontium 90. Additions of calcium to acid soil retarded contamination until the pH had risen to 6.8. Bones of sheep that had grazed on calcium-deficient pastures during fallout contained twice as much strontium 90 as the bones of sheep that had grazed on well-limed pastures at the same time.[28]

Once deposited in skeletons of living animals, only very slowly could strontium 89 and 90 from fallout be replaced by fresh calcium. Milk was the major source of dietary calcium in western countries. Natural, involuntary preferences for calcium over strontium by cows and people reduced the concentration of fallout strontium from 20 parts in cow's food to only 1 part in human bone. In rice-consuming Eastern countries, where dietary calcium came directly from vegetables without benefit of cows (living filters), radiostrontium was expected to be higher in human bone.[29] A 1958 survey in the United Kingdom found that the average diet contained 6 micromicrocuries of strontium 90 per gram of calcium.[30]

Progress was made in removing strontium 85 and 90 from high-calcium environments, like bone tissue, in living organisms.[31] University of Tennessee—Atomic Energy Commission research removed nearly 94 percent of the strontium 90 in milk using a calcium-based resin that exchanged calcium for the radioisotope.[32]

University of Florida Agricultural Experiment Station, Bradenton, Fla., eliminated blackheart in celery and blossom-end rot in tomatoes by spraying with calcium chloride solutions.[33] Accumulation of excess moisture in the upper 2-foot layer of stored, shelled corn was prevented by calcium chloride absorption.[34]

Calcium chloride was used to maintain maximum firmness in canned tomatoes and pickles.[35] The Food and Drug Administration included

---

[25] Voynitskiy, A. I., and Tayts, A. Yu. VAMI Studies in the Field of Calcium Metallurgy: Legkiye Metally (Leningrad), No. 4, 1957, pp. 120–124.

[26] Doronin, N. A., Metallurgiya Kal'tsiya [The Metallurgy of Calcium], Atomizat, Moscow, 1959, 92 pp.

[27] Fisher Scientific, For Quick Qualitative and Semi-Quantitative Spectroscopic Analyses: Bull. FS–214, December 1959, 7 pp.

[28] Trauffer, Walter F., Calcium vs. Fallout: Pit and Quarry, vol. 51, No. 12, June 1959, p. 73.

[29] Hawthorn, J., Food, Fallout and the Isotopes of Strontium: Chem. and Ind. (London), No. 42, Oct. 17, 1959, pp. 1294–1298.

[30] Chemical Age (London), Strontium 90 in Food Far Below Danger Level: Vol. 82, No. 2089, July 25, 1959, p. 68.

[31] Chemistry, Radioactive Strontium Removed from Animals: Vol. 33, No. 2, October 1959, pp. 16–17.

[32] Chemical and Engineering News, vol. 37, No. 27, July 6, 1959, p. 41.

[33] Calcium Chloride Institute News, Calcium Chloride Solution Spray Helps Grow Better Celery and Tomatoes: Vol. 9, No. 4, July–August 1959, p. 8.

[34] Calcium Chloride Institute News, Moisture Absorption in Corn Storage: Vol. 9, No. 2, March–April 1959, p. 2.

[35] Calcium Chloride Institute News, It's in Foods Too: Vol. 9, No. 2, March–April 1959, p. 2.

calcium chloride in its listing of 182 chemicals safe for use in food. It was used as a buffer, neutralizing agent, and sequestrant.[36]

American Concrete Institute recommended 1 to 2 pounds of calcium chloride per bag of cement for attaining high early strength in concrete. To open pavement to traffic early, 2 pounds of calcium chloride per bag of cement was used in the District of Columbia in concrete mix when the temperature was expected to fall to 50° F. or lower during the 24 hours after placing concrete.[37] A Calcium Chloride Institute fellowship at the National Bureau of Standards conducted research on calcium chloride in cement hydration and in precast concrete.[38]

Kentucky Department of Highways spread $300,000 worth of calcium chloride (2.1 lb./sq. yd.) on 750 miles of unpaved roads. The first application was early in 1959, and the second in the summer.[39] Base specifications for a 3.4-mile segment of U.S. Route 70 South, southwest of Nashville, Tenn., called for wet-mixing aggregate with calcium chloride to keep down dust.[40] Michigan Highway Department mixed calcium chloride with gravel for the top layer of the subbase to provide uniform moisture during compaction and paving.[41]

Virginia Department of Highways spread 2 lb./sq. yd. of calcium chloride on the shoulders of U.S. Route 29–A at Lynchburg.[42] Shoulders along Route 11 near Syracuse, N.Y., were stabilized by two applications of 40-percent calcium chloride brine at the total rate of 2.5 lb./sq. yd.[43] To remove guard posts from frozen ground the Minnesota Department of Highways spread calcium chloride around the posts.[44]

The Highway Research Board published an annotated bibliography of 449 references of 1924 to 1956 on soil stabilization with calcium chloride, and a bulletin on ice-melting properties of calcium chloride and salt mixtures.[45]

Laboratory and field experiments in Louisiana used an extremely high-calcium drilling mud (3,000 to 4,000 p.p.m. soluble calcium from calcium chloride). This high-calcium drilling mud reduced shale hydration, that enlarged the bore hole by formation sloughing, and prevented excess mud viscosity, that could permanently reduce well productivity.[46]

---

[36] Chemical and Engineering News, FDA Lists Safe Food Additives: Vol. 37, No. 48, Nov. 30, 1959, p. 32.

[37] Calcium Chloride Institute News, Extending the Season for Construction With Calcium Chloride: Vol. 9, No. 6, November–December 1959, pp. 6–7.

[38] Dickinson, William E., Research, a Major Purpose of the Calcium Chloride Institute: Calcium Chloride Inst. News, vol. 9, No. 5, September–October 1959, pp. 3–4.

[39] Calcium Chloride Institute News, Kentucky Improves 750 Miles of Unpaved Roads With Calcium Chloride: Vol. 9, No. 3, May-June 1959, p. 9.

[40] Calcium Chloride Institute News, Calcium Chloride Aids Construction of Urban Tennessee Highway: Vol. 9, No. 6, November-December 1959, p. 5.

[41] Smith, H. A., Michigan Specifies Calcium Chloride in Gravel Subbase Under Concrete: Calcium Chloride Inst. News, vol. 9, No. 4, July–August 1959, pp. 9–10.

[42] Calcium Chloride Institute News, It's Easy to Spread Calcium Chloride: Vol. 9, No. 3, May-June 1959, pp. 6–7.

[43] Smith, Ken, Shoulders of New York's Route 11 Stabilized With Calcium Chloride: Calcium Chloride Inst. News, vol. 9, No. 1, January-February 1959, p. 9.

[44] Calcium Chloride Institute News, Thawing Frozen Ground: Vol. 9, No. 1, January–February 1959, p. 2.

[45] Slate, Floyd O., and Johnson, A. W., Stabilization of Soil With Calcium Chloride: Highway Research Board, Bibliography 24, Wash., D.C., 1958, 96 pp.

Highway Research Board, Ice Melting Properties of Chloride Salt Mixtures: Bull. 220, 1959, 24 pp.

[46] Monaghan, P. H., and Gidley, J. L., Use High-Calcium Drilling Fluid to Stop Shale Hydration: Oil Gas Jour., vol. 57, No. 16, Apr. 13, 1959, pp. 100–103.

Cement

By D. O. Kennedy[1] and Ardell H. Lindquist[2]

⁂

DEMAND for cement continued to increase in 1959 despite a steel strike and reduced requirements of concrete for the highway construction program. Domestic production and shipments of portland cement in 1959 surpassed the former high record of 1956. A monthly shipment of 37 million barrels established a new record in July 1959. Strikes at a few cement plants had little effect on the national output.

Expansion plans of the cement industry continued almost unabated during 1959, even though plants operated at 77 and 82 percent of their capacity in 1958 and 1959, respectively. Five companies announced plans to erect new plants, and 9 companies planned expansions at 11 existing plants, which will add an estimated total of 20 million barrels to the national capacity.

TABLE 1.—Salient statistics of the cement industry

	1950-54 (average)	1955	1956	1957	1958	1959
United States:						
Production:						
Portland___thousand barrels[1]	247,807	293,260	312,204	292,923	306,609	333,767
Prepared masonry______do____	(2)	16,519	15,906	14,701	14,361	16,205
Natural, slag, and hydraulic lime_____thousand barrels__	[3] 3,618	941	1,128	631	520	438
Total______________do____	251,425	310,720	329,238	308,255	321,490	350,410
Capacity used at portland-cement mills______percent__	88.3	94.1	90.7	78.2	77.3	80.5
Shipments from mills:						
Portland___thousand barrels__	247,445	288,648	304,424	284,146	302,320	330,060
Prepared masonry______do____	(2)	16,526	15,898	14,381	14,451	16,174
Natural, slag, and hydraulic lime______thousand barrels__	[3] 3,623	954	1,074	662	492	441
Total______________do____	251,068	306,128	321,396	299,189	317,263	346,675
Value of shipments[4] thousands__	$649,766	$884,381	$989,234	$961,499	$1,038,672	$1,144,867
Average value per barrel______	$2.59	$2.89	$3.08	$3.21	$3.27	$3.30
Stock at mills, Dec. 31, thousand barrels__	16,647	17,485	22,412	28,748	30,434	31,470
Imports__________________do____	729	5,220	4,456	4,427	3,390	5,265
Exports__________________do____	2,587	1,795	1,981	1,331	641	277
Apparent consumption_____do____	249,210	309,553	323,870	302,285	320,012	351,663
World: Production____________do____	961,091	[5] 1,274,501	[5] 1,381,794	[5] 1,447,012	[5] 1,543,394	1,720,526

[1] Barrel as used in this chapter, unless otherwise stated, refers to a 376-pound barrel.
[2] Not included in tabulation until 1955.
[3] Includes masonry cement from natural, slag, and hydraulic lime cement plants.
[4] Value received f.o.b. mill, excluding cost of containers.
[5] Revised figure.

---

[1] Assistant chief, Branch of Nonmetallic Minerals.
[2] Statistical clerk.

Three classes of hydraulic cement were produced in the United States—portland, natural, and slag cements. In addition, prepared masonry cements were produced at many portland cement plants and at all other cement plants.

LEGISLATION AND GOVERNMENT PROGRAMS

Air-pollution control laws passed by towns in the Lehigh Valley area of Pennsylvania during 1958 resulted in estimated expenditures of $9.5 million by 11 companies for dust-control equipment. In some plants old crushing and clinker-cooling equipment was replaced to permit installation of dust collectors.

PORTLAND CEMENT

PRODUCTION AND SHIPMENTS

Production of portland cement reached a record of 339 million barrels, 22 million barrels above the previous record of 1956. In 1959, 121 of the 168 plants producing in 1958 had larger outputs; the 47 plants that had reduced production were scattered in all sections of the United States. Six new plants reported production in 1959: Phoenix Cement Co., Division of American Cement Co., Clarksdale, Ariz.; Mississippi Valley Portland Cement Co., Vicksburg, Miss.; Ideal Cement Co., Tijeras, N. Mex.; Hudson Cement Corp., Kingston, N.Y.; Columbia-Southern Chemical Co., Barberton, Ohio; and Southwestern Portland Cement Co., Douro, Tex. In addition, two new plants in Hawaii and one in Michigan were under construction.

Descriptions were published of equipment installed as part of expansion plans or in new cement plants in Boettcher, Colo.,[3] Miami, Fla.,[4] Humboldt, Kans.:[5] Wampum, Pa.,[6] Salt Lake City, Utah,[7] and Milwaukee, Wis.[8]

Flintkote Co., which acquired its first cement plant in 1957 at Kosmosdale, Ky., acquired three more in 1959: Glens Falls, N.Y., plant of the Glens Falls Portland Cement Co.; Los Angeles, Calif., plant of the Blue Diamond Corp.; and San Andreas, Calif., plant of the Calaveras Cement Co. The National Gypsum Co. became a cement producer by acquiring the Huron Portland Cement Co. The General Portland Cement Co. took over the management of the plants of the Consolidated Cement Corp. by a merger of the companies in April 1959. The Volunteer Portland Cement Co. (Knoxville, Tenn.) became part of the Ideal Cement Co. in September 1959.

---

[3] Trauffer, W. E., Ideal's Boettcher Plant Features: Pit and Quarry, vol. 51, No. 12, June 1959, pp. 120–125, 128.

[4] Meschter, E., General Portland Moves Into Miami Market: Rock Products, vol. 62, No. 11, November 1959, pp. 88–92.

Trauffer, W. E., Lehigh's New Miami Plant: Pit and Quarry, vol. 52, No. 6, December 1959, pp. 76–86.

Argo, C. F., Modern Industry in the Florida Everglades: Explosive Eng., vol. 37, No. 2, March–April 1959, pp. 46–51.

[5] Meschter, E., Challenge: Build a New Cement Plant Around Old One: Rock Products, vol. 62, No. 2, February 1959, pp. 80–86.

[6] Herod, B. C., A New Chapter in Historic Wampum Operations: Pit and Quarry, vol. 52, No. 4, October 1959, pp. 76–85.

[7] Utley, H. F., Revamping Salt Lake City Cement Plant to Boost Capacity by 1,600 Bbls.: Pit and Quarry, vol. 52, No. 6, December 1959, pp. 87, 91.

[8] Meschter, E., ACL Cement Plant Justifies Marquette's Choice: Rock Products, vol. 62, No. 12, December 1959, pp. 74–81.

TABLE 2.—Finished portland cement produced, shipped, and in stock in the United States (and Puerto Rico), by districts

District	Active plants		Production			Shipments from mills								Stocks at mills on Dec. 31		
			Thousand barrels		Change from 1958 (percent)	1958			1959					Thousand barrels		Change from 1958 (percent)
						Thousand barrels	Value		Thousand barrels	Value		Change from 1958 (percent) in—				
	1958	1959	1958	1959			Total (thousands)	Average per barrel		Total (thousands)	Average per barrel	Barrels	Average value	1958	1959	
Eastern Pennsylvania, Maryland	22	21	36,976	38,335	+4	35,893	$119,956	$3.34	38,070	$132,279	$3.47	+6	+4	5,202	5,058	−3
New York, Maine	11	12	16,920	18,610	+10	16,229	53,907	3.32	18,666	63,205	3.39	+15	+2	2,277	2,060	−10
Ohio	10	11	15,191	18,028	+19	14,960	50,092	3.35	18,141	60,560	3.34	+21	−.3	2,107	1,904	−10
Western Pennsylvania, West Virginia	7	6	11,508	11,700	+2	11,518	38,766	3.37	11,631	39,319	3.38	+1	+.3	1,203	1,204	+.1
Michigan	8	8	19,841	21,561	+9	19,691	65,738	3.34	21,682	72,198	3.33	+10	−.3	2,443	2,322	−5
Illinois	4	4	9,433	9,560	+1	9,205	29,308	3.18	9,486	30,158	3.18	+3	--------	945	855	−10
Indiana, Kentucky, Wisconsin	7	7	20,269	20,430	+1	19,362	64,541	3.33	19,360	64,255	3.32	--------	−.3	1,885	2,030	+8
Alabama	8	8	12,372	13,461	+9	11,915	36,562	3.07	12,998	39,672	3.05	+9	−1	981	1,002	+2
Tennessee	6	6	7,923	8,688	+10	7,678	23,969	3.12	8,381	26,191	3.12	+9	--------	665	695	+5
Virginia, South Carolina	4	4	6,851	8,282	+21	6,892	22,677	3.29	8,406	27,609	3.28	+22	−.3	660	536	−19
Georgia, Florida	6	6	9,650	11,730	+22	9,208	29,940	3.25	11,723	38,902	3.32	+27	+2	853	815	−4
Louisiana, Mississippi	4	5	6,935	7,441	+7	6,849	21,230	3.10	7,247	22,622	3.12	+6	+1	566	700	+24
Iowa	5	5	12,306	13,147	+7	12,260	39,993	3.26	12,701	42,081	3.31	+4	+2	1,243	1,565	+26
Eastern Missouri, Minnesota, South Dakota	6	6	14,156	15,329	+8	13,816	45,621	3.30	15,442	51,028	3.30	+12	--------	1,622	1,454	−10
Kansas	6	6	9,244	10,177	+10	9,298	28,843	3.10	10,056	30,889	3.07	+8	−1	923	1,001	+8
Western Missouri, Nebraska, Oklahoma, Arkansas	7	7	11,908	14,369	+21	12,047	38,243	3.17	13,725	43,960	3.20	+14	+1	895	1,507	+68
Texas	14	15	25,465	27,111	+6	25,209	77,186	3.06	27,215	85,022	3.12	+8	+2	2,083	1,980	−5
Colorado, Arizona, Utah, New Mexico	6	8	9,895	11,025	+11	9,846	33,005	3.35	10,659	35,784	3.36	+8	+.3	491	857	+75
Wyoming, Montana, Idaho	3	3	2,922	3,067	+5	2,956	10,536	3.56	3,017	10,648	3.53	+2	−1	260	310	+19
Northern California	5	5	16,829	17,930	+7	17,281	54,307	3.14	18,063	58,873	3.26	+5	+4	1,031	895	−13
Southern California	8	8	22,227	25,705	+16	22,302	70,060	3.14	25,572	79,633	3.11	+15	−1	1,452	1,584	+9
Oregon, Washington	9	9	7,788	8,081	+4	7,905	28,046	3.55	7,819	27,374	3.50	−1	−1	770	1,032	+34
Puerto Rico	2	2	4,862	5,324	+10	4,748	15,175	3.20	5,392	16,982	3.15	+14	−2	161	93	−43
Total	168	172	311,471	339,091	+9	[2] 307,068	997,701	3.25	[2] 335,452	1,099,244	3.28	+9	+1	[1] 30,718	31,459	+2
Pennsylvania	24	23	40,945	41,208	+1	40,148	135,118	3.37	41,270	143,054	3.47	+3	+3	[1] 5,662	5,377	−5
Missouri	5	5	12,143	13,610	+12	11,813	39,376	3.33	13,583	45,430	3.34	+15	+.3	1,204	1,176	−2

[1] Revised figure.

[2] Does not include finished cement used in manufacturing prepared masonry cement, as follows: 1958, 2,631,000 barrels; 1959, 2,898,000 barrels.

TABLE 3.—Production, shipments from mills, and stocks at mills of finished portland cement in the United States (and Puerto Rico) in 1959, by months[1] and districts, in thousand barrels

District	January	February	March	April	May	June	July	August	September	October	November	December
PRODUCTION												
Eastern Pennsylvania, Maryland	1,473	1,354	2,906	3,666	3,980	4,092	3,777	4,033	3,711	3,544	3,046	2,811
New York, Maine	994	622	1,016	1,296	1,857	1,847	1,828	1,837	1,862	1,894	1,685	1,495
Ohio	459	440	1,129	1,447	1,773	1,957	1,812	1,925	2,110	2,147	1,613	1,098
Western Pennsylvania, West Virginia	498	617	963	1,117	1,221	1,129	1,307	1,204	1,124	871	751	888
Michigan	504	612	773	1,503	2,331	2,510	2,950	2,861	2,530	2,344	1,672	978
Illinois	633	411	523	766	906	897	988	900	941	963	795	837
Indiana, Kentucky, Wisconsin	917	697	1,120	1,879	2,198	2,110	2,475	2,365	2,257	1,442	1,456	1,520
Alabama	961	847	1,102	1,215	1,295	1,158	1,263	1,271	1,235	1,210	1,023	776
Tennessee	588	489	620	751	793	790	807	904	858	784	707	602
Virginia, South Carolina	462	456	695	771	872	766	721	818	657	723	719	623
Georgia, Florida	916	856	874	891	1,064	1,088	970	1,027	1,015	1,078	996	956
Louisiana, Mississippi	587	483	705	684	627	673	692	668	634	653	488	538
Iowa	918	758	629	997	1,282	1,249	1,417	1,367	1,246	1,306	927	1,052
Eastern Missouri, Minnesota, South Dakota	677	690	990	1,281	1,559	1,564	1,721	1,596	1,592	1,416	1,175	1,075
Kansas	499	558	928	962	1,044	1,098	968	1,026	803	857	758	675
Western Missouri, Nebraska, Oklahoma, Arkansas	773	829	986	1,265	1,386	1,442	1,437	1,561	1,438	1,177	1,025	1,051
Texas	1,758	1,880	2,588	2,555	2,699	2,500	2,418	2,599	2,295	2,267	1,822	1,730
Colorado, Arizona, Utah, New Mexico	753	630	841	825	1,114	1,055	910	1,044	975	967	849	1,063
Wyoming, Montana, Idaho	134	87	142	317	293	389	354	341	335	284	214	178
Northern California	1,288	930	1,428	1,556	1,658	1,611	1,770	1,781	1,458	1,629	1,482	1,339
Southern California	1,856	1,596	2,248	2,162	2,290	2,311	2,356	2,533	2,268	2,293	1,917	1,852
Oregon, Washington	559	461	688	772	750	755	737	697	776	855	525	504
Puerto Rico	397	407	443	415	436	464	502	442	470	423	455	470
Total:												
1959	18,604	16,710	24,337	29,093	33,428	33,455	34,180	34,800	32,590	31,127	26,100	24,111
1958	18,230	14,125	18,038	24,001	29,274	30,078	29,833	31,675	31,597	32,847	28,031	23,590
SHIPMENTS												
Eastern Pennsylvania, Maryland	1,267	1,643	2,609	3,888	4,504	3,971	3,682	4,195	3,803	3,670	2,664	2,112
New York, Maine	500	506	803	1,521	2,114	2,014	2,031	2,108	2,190	1,994	1,380	1,183
Ohio	337	466	840	1,431	1,729	2,137	2,241	2,209	2,372	2,298	1,206	849
Western Pennsylvania, West Virginia	360	451	742	1,056	1,154	1,279	1,583	1,453	1,435	1,024	617	496
Michigan	373	384	660	1,368	2,336	3,042	3,130	3,055	2,837	2,455	1,156	883
Illinois	184	218	430	803	960	1,220	1,243	1,194	1,195	1,024	486	529
Indiana, Kentucky, Wisconsin	507	623	1,093	1,812	1,859	2,417	2,552	2,397	2,502	1,523	957	1,118
Alabama	964	842	1,118	1,156	1,196	1,129	1,216	1,305	1,250	1,022	900	899
Tennessee	415	461	663	782	755	809	867	876	861	712	633	549
Virginia, South Carolina	474	479	708	805	902	789	714	744	741	720	683	647
Georgia, Florida	863	865	851	1,048	1,073	970	1,063	1,054	997	1,006	949	982

Louisiana, Mississippi	527	395	707	681	686	626	684	684	604	613	545	495
Iowa	195	244	444	1,085	1,219	1,677	1,852	1,836	1,677	1,525	457	489
Eastern Missouri, Minnesota, South Dakota	312	451	946	1,449	1,419	2,017	2,170	1,772	1,785	1,608	802	712
Kansas	326	515	799	1,040	995	1,127	982	1,018	805	1,104	685	659
Western Missouri, Nebraska, Oklahoma, Arkansas	505	659	965	1,343	1,283	1,475	1,466	1,537	1,378	1,436	840	837
Texas	1,998	1,739	2,858	2,519	2,455	2,504	2,480	2,392	2,272	2,202	1,918	1,879
Colorado, Arizona, Utah, New Mexico	573	587	803	993	1,032	1,096	1,036	1,085	993	913	747	802
Wyoming, Montana, Idaho	103	95	183	286	330	385	399	376	295	272	147	147
Northern California	924	863	1,356	1,547	1,605	1,720	1,976	1,913	1,657	1,806	1,458	1,237
Southern California	1,875	1,437	2,235	2,322	2,298	2,437	2,455	2,381	2,261	2,185	1,856	1,830
Oregon, Washington	406	463	738	765	634	739	779	784	757	729	501	518
Puerto Rico	428	399	476	435	454	502	445	468	431	441	438	476
Total:												
1959	14,416	14,785	23,027	30,135	32,992	36,082	37,046	36,836	35,098	32,282	22,025	20,328
1958	13,593	10,854	17,486	25,318	30,525	30,262	32,281	34,188	34,767	36,615	24,528	16,623
STOCKS (END OF MONTH)												
Eastern Pennsylvania, Maryland	5,364	5,056	5,318	5,058	4,487	4,573	4,621	4,404	4,186	4,021	4,368	5,039
New York, Maine	2,784	2,900	3,102	2,868	2,586	2,404	2,179	1,896	1,576	1,457	1,755	2,053
Ohio	2,237	2,211	2,498	2,500	2,534	2,348	1,910	1,615	1,342	1,181	1,582	1,819
Western Pennsylvania, West Virginia	1,357	1,521	1,734	1,787	1,844	1,684	1,396	1,140	837	681	812	1,204
Michigan	2,467	2,694	2,807	2,942	2,937	2,405	2,225	2,083	1,822	1,711	2,227	2,322
Illinois	1,392	1,579	1,655	1,597	1,527	1,189	916	607	344	266	563	855
Indiana, Kentucky, Wisconsin	2,249	2,273	2,228	2,206	2,452	2,037	1,862	1,732	1,410	1,254	1,692	2,030
Alabama	1,046	1,016	961	978	1,045	1,035	1,040	970	915	1,067	1,161	1,002
Tennessee	829	834	769	706	718	674	582	587	557	606	663	695
Virginia, South Carolina	648	625	612	578	548	525	532	606	522	525	560	536
Georgia, Florida	902	887	908	746	730	846	749	719	734	803	847	815
Louisiana, Mississippi	618	746	703	703	640	682	682	661	685	721	659	699
Iowa	2,035	2,545	2,718	2,610	2,661	2,221	1,773	1,247	774	550	1,005	1,565
Eastern Missouri, Minnesota, South Dakota	1,986	2,224	2,260	2,085	2,218	1,761	1,309	1,132	928	731	1,101	1,454
Kansas	1,089	1,122	1,248	1,170	1,219	1,190	1,164	1,171	1,168	921	995	1,001
Western Missouri, Nebraska, Oklahoma, Arkansas	1,139	1,339	1,354	1,274	1,379	1,345	1,309	1,332	1,392	1,133	1,318	1,506
Texas	1,843	1,984	1,715	1,751	1,996	1,992	1,931	2,138	2,160	2,225	2,129	1,980
Colorado, Arizona, Utah, New Mexico	670	714	752	584	665	607	481	440	422	477	579	840
Wyoming, Montana, Idaho	291	284	242	272	235	239	194	158	199	211	279	310
Northern California	1,395	1,462	1,532	1,541	1,594	1,485	1,279	1,146	948	770	794	895
Southern California	1,448	1,614	1,627	1,467	1,459	1,333	1,234	1,385	1,393	1,500	1,562	1,584
Oregon, Washington	920	912	862	868	984	1,000	960	871	893	1,019	1,044	1,031
Puerto Rico	129	138	106	87	69	30	87	62	101	83	99	93
Total:												
1959	34,838	36,680	37,711	36,378	36,527	33,605	30,415	28,102	25,308	23,913	27,794	31,328
1958	33,235	36,383	36,734	35,170	33,673	33,350	30,646	27,883	24,445	20,415	23,686	[2] 30,800

---

[1] Difference between monthly and annual reports not adjusted.
[2] Revised figure.

TABLE 4.—Portland cement produced and shipped in the United States,[1] by types

Type and year	Active plants	Production (thousand barrels)	Shipments		
			Thousand barrels	Value	
				Total (thousands)	Average per barrel
General-use and moderate-heat (types I and II):					
1950–54 (average)	155	216,729	216,594	$554,050	$2.56
1955	157	[2] 276,248	272,064	768,520	2.82
1956	160	[2] 292,598	285,856	858,767	2.99
1957	163	[2] 275,968	268,855	844,962	3.14
1958	167	[2] 291,688	287,377	922,921	3.21
1959	171	[2] 316,600	312,970	1,012,836	3.24
High-early-strength (type III):					
1950–54 (average)	96	8,051	7,970	23,698	2.97
1955	106	[3] 11,744	11,459	37,550	3.28
1956	101	[3] 12,142	11,808	42,596	3.61
1957	111	[3] 12,853	11,867	43,325	3.65
1958	120	[3] 12,161	12,274	45,107	3.67
1959	129	[3] 14,439	14,363	53,484	3.72
Low-heat (type IV):					
1950–54 (average)	3	352	311	960	3.09
1955	0	-----	-----	-----	-----
1956	2	14	3	9	3.29
1957	2	21	5	16	3.23
1958	2	7	9	35	3.90
1959	3	10	10	46	4.44
Sulfate-resisting (type V):					
1950–54 (average)	4	67	85	295	3.48
1955	6	65	80	302	3.77
1956	6	93	79	312	3.95
1957	9	191	191	712	3.72
1958	9	244	205	767	3.75
1959	11	189	192	743	3.86
Oil-well:					
1950–54 (average)	17	1,736	1,747	4,988	2.85
1955	16	1,898	1,851	6,429	3.47
1956	16	[4] 1,655	1,705	5,687	3.33
1957	16	1,511	1,482	5,161	3.48
1958	15	983	1,058	3,739	3.54
1959	16	1,288	1,182	4,121	3.49
White:					
1950–54 (average)	4	1,124	1,127	5,934	5.27
1955	4	[4] 1,191	1,205	6,580	5.46
1956	3	[4] 1,171	1,133	7,025	6.20
1957	4	[4] 1,087	1,024	6,595	6.44
1958	4	[4] 1,377	1,237	8,001	6.47
1959	4	[4] 1,525	1,515	9,819	6.48
Portland-pozzolan and portland-slag:					
1950–54 (average)	6	2,066	2,026	5,204	3.57
1955	10	[5] 4,906	4,706	13,183	2.80
1956	12	[5] 6,936	6,817	20,940	3.07
1957	11	[5] 5,219	5,237	17,246	3.29
1958	11	[5] 4,096	3,977	13,632	3.43
1959	8	[5] 3,653	3,806	12,864	3.38
Miscellaneous: [6]					
1950–54 (average)	22	936	942	3,021	3.21
1955	22	1,401	1,400	4,962	3.54
1956	26	1,829	1,277	4,684	3.67
1957	26	[4] 1,574	1,037	3,942	3.80
1958	21	[4] 915	931	3,499	3.76
1959	22	[4] 1,387	1,414	5,331	3.77
Grand total:					
1950–54 (average)	155	251,568	251,206	648,826	2.58
1955	[7] 157	297,453	292,765	837,526	2.86
1956	[7] 160	316,438	308,678	940,020	3.05
1957	[7] 164	298,424	289,698	921,959	3.18
1958	[7] 168	311,471	307,068	997,701	3.25
1959	[7] 172	339,091	335,452	1,099,244	3.28

---

[1] Includes Puerto Rico.

[2] Includes air-entrained portland cement as follows (in thousand barrels): 1955, 31,858; 1956, 35,458; 1957, 32,791; 1958, 31,470; 1959, 38,961.

[3] Includes air-entrained portland cement as follows (in thousand barrels): 1955, 3,378; 1956, 3,444; 1957, 3,497; 1958, 4,382; 1959, 5,126.

[4] Includes a small amount of air-entrained portland cement.

[5] Includes air-entrained portland cement as follows (in thousand barrels): 1955, 945; 1956, 1,382; 1957, 2,311; 1958, 2,164; 1959, 1,969.

[6] Includes hydroplastic, plastic, and waterproofed cements.

[7] Includes number of plants making air-entrained portland cement as follows: 1955, 99; 1956, 104; 1957, 112; 1958, 113; 1959, 119.

Two plants, idle for nearly a year, were dismantled in 1959—Ormrod (Pa.) plant of Lehigh Portland Cement Co., and Manheim (W.Va.) plant of the Alpha Portland Cement Co.

TYPES OF PORTLAND CEMENT

General-use and moderate-heat portland cements (types I and II) were produced at 171 of the 172 operating plants and comprised 93 percent of all the portland cement made. High-early-strength portland cement (type III) was produced at 129 plants, 9 more than in 1958.

No output of portland-pozzolan cement was reported during 1959. Eight plants reported production of portland-slag cement, and three plants accounted for 84 percent of the 3.7-million-barrel output. Seven of the eight plants produced other types of portland cement in addition to portland-slag cement.

CAPACITY OF PLANTS

The estimated annual capacity of all portland cement plants on December 31, reported to the Bureau of Mines by producers, was 4 percent greater than that on December 31, 1958. The capacity, 414 million barrels for plants in the United States (excluding Puerto Rico) was 7 million barrels greater than that forecast by the cement industry in December 1954. The 17.6-million-barrel increase in capacity was the result of expansions at 24 of the 167 plants in operation in 1958 and the addition of 6 new plants.

Number of portland cement plants in the United States (including Puerto Rico) in 1959, by size groups

Estimated annual capacity, Dec. 31, million barrels:	*Number of plants*	*Percent of total capacity*
Less than 1	10	1.7
1 to 2	57	20.4
2 to 3	58	32.7
3 to 4	28	21.4
4 to 5	10	10.0
5 to 11	8	13.8
Total	[1] 171	100.0

[1] Does not include clinker-grinding plants.

TABLE 5.—Portland-cement-manufacturing capacity of the United States (and Puerto Rico), by districts

District	Estimated (thousand barrels)		Percent utilized	
	1958	1959	1958	1959
Eastern Pennsylvania, Maryland	52,406	52,529	70.6	73.0
New York, Maine	23,586	25,842	71.7	72.0
Ohio	21,245	23,434	71.5	76.9
Western Pennsylvania, West Virginia	16,160	15,506	71.2	75.5
Michigan	25,742	25,742	77.1	83.8
Illinois	9,880	9,880	95.5	96.8
Indiana, Kentucky, Wisconsin	23,666	23,937	85.6	85.3
Alabama	14,869	16,273	83.2	82.7
Tennessee	8,520	9,554	93.0	90.9
Virginia, South Carolina	9,270	9,390	73.9	88.2
Georgia, Florida	14,500	14,672	66.6	79.9
Louisiana, Mississippi	8,525	9,275	81.3	80.2
Iowa	14,050	14,330	87.6	91.7
Eastern Missouri, Minnesota, South Dakota	17,686	17,722	80.0	86.5
Kansas	12,148	12,441	76.1	81.8
Western Missouri, Nebraska, Oklahoma, Arkansas	16,157	18,117	73.7	79.3
Texas	35,776	37,471	71.2	72.4
Colorado, Arizona, Utah, New Mexico	9,850	12,650	100.5	87.2
Wyoming, Montana, Idaho	3,150	3,150	92.8	97.4
Northern California	18,435	19,235	91.3	93.2
Southern California	31,070	32,320	71.5	79.5
Oregon, Washington	10,095	10,925	77.1	74.0
Puerto Rico	6,000	6,000	81.0	88.7
Total	402,786	420,395	77.3	80.7

TABLE 6.—Capacity of portland cement plants in the United States,[1] by processes

Process	Capacity, Dec. 31						Capacity utilized, percent			Total finished cement produced percent		
	Thousand barrels			Percent of total								
	1957	1958	1959	1957	1958	1959	1957	1958	1959	1957	1958	1959
Wet	217,114	234,130	244,306	57.1	58.1	58.1	77.9	71.3	81.2	56.7	53.6	58.5
Dry	163,272	168,656	176,089	42.9	41.9	41.9	79.2	85.6	79.9	43.3	46.4	41.5
Total	380,386	402,786	420,395	100.0	100.0	100.0	78.5	77.3	80.7	100.0	100.0	100.0

[1] Includes Puerto Rico.

CLINKER PRODUCTION

Output of clinker was 9 percent greater than that in 1958 and reached a record of 32 million barrels per month in May. At yearend the stocks of clinker were 6 percent greater than those at the end of 1958.

TABLE 7.—Portland-cement clinker produced and in stock at mills in the United States,[1] by processes, in thousand barrels[2]

Process	Plants		Production		Stocks on Dec. 31—	
	1958	1959	1958	1959	1958[3]	1959[4]
Wet	100	103	179,853	198,903	7,945	8,422
Dry	67	68	132,954	141,807	7,560	8,048
Total	167	171	312,807	340,710	15,505	16,470

[1] Includes Puerto Rico.
[2] Compiled from monthly estimates of producers.
[3] Revised figure.
[4] Preliminary figures.

TABLE 8.—Production of portland-cement clinker at mills in the United States (and Puerto Rico) in 1959, by months and districts, in thousand barrels

District	January	February	March	April	May	June	July	August	September	October	November	December
Eastern Pennsylvania, Maryland	1,870	1,698	2,996	3,709	4,075	4,002	3,699	3,851	3,628	3,548	3,126	3,024
New York, Maine	1,137	811	1,209	1,310	1,672	1,555	1,581	1,597	1,611	1,701	1,616	1,523
Ohio	837	864	1,420	1,618	1,799	1,709	1,480	1,496	1,737	1,865	1,770	1,409
Western Pennsylvania, West Virginia	544	589	953	1,082	1,106	1,052	1,124	993	952	818	689	844
Michigan	1,629	1,525	1,638	1,740	2,065	1,901	2,066	2,119	1,996	1,947	1,754	1,869
Illinois	786	694	753	838	780	775	823	733	836	871	801	870
Indiana, Kentucky, Wisconsin	1,474	1,619	1,723	1,755	1,834	1,667	2,034	1,853	1,543	1,212	1,732	1,748
Alabama	1,053	955	1,095	1,181	1,287	1,207	1,245	1,233	1,248	1,228	996	890
Tennessee	718	596	604	770	773	777	800	848	847	838	750	711
Virginia, South Carolina	504	473	770	762	806	781	788	841	682	756	723	664
Georgia, Florida	1,020	938	908	868	1,030	1,161	1,071	1,105	1,057	1,065	1,105	995
Louisiana, Mississippi	657	600	644	621	687	642	663	661	699	679	576	603
Iowa	1,034	950	944	1,139	1,210	1,115	1,219	1,224	1,174	1,204	1,051	1,090
Eastern Missouri, Minnesota, South Dakota	1,147	1,038	1,090	1,196	1,453	1,263	1,397	1,359	1,345	1,310	1,331	1,288
Kansas	670	662	961	981	1,030	964	981	948	828	847	729	757
Western Missouri, Nebraska, Oklahoma, Arkansas	994	1,057	1,295	1,297	1,529	1,478	1,511	1,424	1,279	1,127	1,007	866
Texas	1,902	1,885	2,378	2,439	2,580	2,481	2,518	2,492	2,433	2,314	1,818	1,775
Colorado, Arizona, Utah, New Mexico	880	730	877	918	965	982	962	1,031	995	1,042	964	1,431
Wyoming, Montana, Idaho	244	158	166	205	303	270	272	311	243	304	310	284
Northern California	1,438	1,269	1,496	1,418	1,599	1,509	1,564	1,506	1,499	1,556	1,442	1,552
Southern California	1,837	1,598	1,980	1,989	2,076	2,280	2,357	2,322	2,363	2,235	2,152	2,210
Oregon, Washington	592	464	670	828	866	769	654	743	732	723	669	507
Puerto Rico	400	349	406	423	431	413	487	417	394	398	436	480
Total:												
1959	23,367	21,522	26,976	29,087	31,956	30,753	31,296	31,107	30,121	29,588	27,547	27,390
1958	22,873	19,537	21,853	24,171	27,574	27,925	28,240	27,907	28,124	29,905	27,669	27,029

RAW MATERIALS

Approximately 71 percent of the domestic output of portland cement was made from limestone and clay or shale. Argillaceous limestone (cement rock) or a mixture of cement rock and limestone was used for 23 percent of the portland cement produced. Six plants used marl instead of limestone, and nine plants used shells.

Blast-furnace slag was used as a raw material in the production of portland cement at 24 plants, 8 of which used approximately 330,000 tons of slag to produce portland-slag cement.

TABLE 9.—Production and percentage of total output of portland cement in the United States,[1] by raw materials used

Year	Cement rock and pure limestone		Limestone and clay or shale [2] [3]		Blast-furnace slag and limestone	
	Thousand barrels	Percent	Thousand barrels	Percent	Thousand barrels	Percent
1950–54 (average)	51,443	20.5	181,235	72.0	18,890	7.5
1955	71,764	24.1	206,763	69.5	18,926	6.4
1956	72,722	23.0	221,948	70.1	21,768	6.9
1957	64,776	21.7	211,743	71.0	21,905	7.3
1958	71,681	23.0	225,495	72.4	14,295	4.6
1959	79,895	23.5	239,336	70.6	19,860	5.9

[1] Includes Puerto Rico.
[2] Includes output of 4 plants using marl and clay in 1950–54 (average); and 4 plants in 1955–59.
[3] Includes output of 7 plants using oystershell and clay in 1950–54 (average); 8 plants in 1955–56; and 9 plants in 1957–59.

TABLE 10.—Raw materials used in producing portland cement in the United States[1]

Raw material	1957	1958	1959
Cement rock ... thousand short tons	17,152	20,799	25,663
Limestone (including oystershell) ... do	63,903	62,306	65,250
Marl ... do	1,565	1,487	2,006
Clay and shale [2] ... do	9,044	9,400	10,363
Blast-furnace slag ... do	1,455	1,279	1,139
Gypsum ... do	2,366	2,507	2,770
Sand and sandstone (including silica and quartz) ... do	973	1,121	1,311
Iron materials [3] ... do	516	535	671
Miscellaneous [4] ... do	222	107	26
Total	97,196	99,541	109,199
Average total weight required per barrel (376 pounds) of finished cement ... pounds	651	639	644

[1] Includes Puerto Rico.
[2] Includes fuller's earth, diaspore, and kaolin for making white cement.
[3] Includes iron ore, pyrite cinders and ore, and mill scale.
[4] Includes fluorspar, pumicite, pitch, red mud and rock, hydrated lime, tufa, calcium chloride, sludge, air-entraining compounds, and grinding aids.

FUEL AND POWER

More fuels of all types (coal, oil, and natural gas) were used in producing cement in 1959 than in 1958. Coal and oil supplied 55 percent of all the heat used, compared with 58 percent in 1958. The amount of natural gas consumed increased 15 percent, compared with that in 1958. The 172 plants used an average of 1.25 million B.t.u. per barrel of cement produced.

TABLE 11.—Finished portland cement produced and fuel consumed by the portland cement industry in the United States,[1] by processes

Process	Finished cement produced			Fuel consumed		
	Plants	Thousand barrels	Percent of total	Coal (thousand short tons)	Oil (thousand barrels of 42 gallons)	Natural gas (M cubic feet)
1958						
Wet	100	167,044	53.6	4,122	3,714	114,863,171
Dry	68	144,427	46.4	4,305	761	50,131,796
Total	168	311,471	100.0	[2] 8,427	4,475	[3] 164,994,967
1959						
Wet	104	198,427	58.5	4,334	3,686	134,164,350
Dry	68	140,664	41.5	4,334	826	56,355,013
Total	172	339,091	100.0	[4] 8,668	4,512	[5] 190,519,363

[1] Includes Puerto Rico.
[2] Comprises 182,707 tons of anthracite and 8,244,485 tons of bituminous coal.
[3] Includes 39,895 M cubic feet of byproduct gas and 858,725 M cubic feet of coke-oven gas.
[4] Comprises 158,876 tons of anthracite and 8,508,775 tons of bituminous coal.
[5] Includes 44,584 M cubic feet of byproduct gas and 2,144,869 M cubic feet of coke-oven gas.

TABLE 12.—Portland cement produced in the United States,[1] by kinds of fuel

Fuel	Finished cement produced			Fuel consumed		
	Plants	Thousand barrels	Percent of total	Coal (thousand short tons)	Oil (thousand barrels of 42 gallons)	Natural gas (M cubic feet)
1958						
Coal	62	[2] 112,075	36.0	5,928		
Oil	8	[2] 11,737	3.8		2,178	
Natural gas	29	[2] 57,128	18.3			69,893,357
Coal and oil	21	40,162	12.9	1,629	1,591	
Coal and natural gas	23	39,169	12.6	685		[3] 33,606,380
Oil and natural gas	16	35,942	11.5		601	45,001,254
Coal, oil, and natural gas	9	15,258	4.9	185	105	16,493,976
Total	168	311,471	100.0	[4] 8,427	4,475	164,994,967
1959						
Coal	61	[2] 112,429	33.2	5,887		
Oil	7	[2] 13,819	4.1		2,547	
Natural gas	35	[2] 67,153	19.8			[5] 85,830,656
Coal and oil	22	48,257	14.2	2,003	1,008	
Coal and natural gas	20	37,195	11.0	568		35,620,667
Oil and natural gas	18	42,614	12.5		931	49,930,537
Coal, oil,and natural gas	9	17,624	5.2	210	26	19,137,503
Total	172	339,091	100.0	[6] 8,668	4,512	190,519,363

[1] Includes Puerto Rico.
[2] Average consumption of fuel per barrel of cement produced as follows: 1958—coal, 105.8 pounds; oil, 0.1856 barrels; natural gas, 1,223 cubic feet. 1959—coal, 104.7 pounds; oil, 0.1843 barrel; natural gas, 1,278 cubic feet.
[3] Includes 858,725 M cubic feet of coke-oven gas and 39,895 M cubic feet of byproduct gas.
[4] Comprises 182,707 tons of anthracite and 8,244,485 tons of bituminous coal.
[5] Includes 2,144,869 M cubic feet of coke-oven gas and 44,584 M cubic feet of byproduct gas.
[6] Comprises 158,876 tons of anthracite and 8,508,775 tons of bituminous coal.

TRANSPORTATION

The trend continued toward shipping cement in bulk rather than in bags. Nearly 81 percent of all cement was shipped in bulk, and the remainder in paper and cloth bags. Shipments by truck increased 3.5 percent, compared with those of 1958. Most shipments by boat were

TABLE 13.—Electric energy used at portland cement plants in the United States,[1] by processes

Process	Electric energy used: Generated at portland cement plants: Active plants	Electric energy used: Generated at portland cement plants: Million kilowatt-hours	Electric energy used: Purchased: Active plants	Electric energy used: Purchased: Million kilowatt-hours	Electric energy used: Total: Million kilowatt-hours	Electric energy used: Total: Percent	Finished cement produced (thousand barrels)	Average electric energy used per barrel of cement produced (kilowatt-hours)
1958								
Wet	26	691	95	3,226	3,918	56.0	167,044	23.5
Dry	33	1,407	63	1,671	3,078	44.0	144,427	21.3
Total	59	2,098	158	4,897	6,996	100.0	311,471	22.5
Percent of total electric energy used		30.0		70.0	100.0			
1959								
Wet	27	770	97	3,524	4,294	56.2	198,427	21.6
Dry	32	1,455	61	1,896	3,351	43.8	140,664	23.8
Total	59	2,225	158	5,420	7,645	100.0	339,091	22.5
Percent of total electric energy used		29.1		70.9	100.0			

[1] Includes Puerto Rico.

reported from plants in Puerto Rico, Kentucky, and Louisiana; and 30, 24, and 15 percent, respectively, of the total shipments from these areas were by water. Lesser quantities were shipped by boat in Alabama, Missouri, New York, California, and Texas. The tabulations in this chapter represent only shipments from producing companies to consumers and do not include shipments between producing plants or from plants to distribution centers.

TABLE 14.—Shipments of portland cement from mills in the United States,[1] in bulk and in containers, by types of carriers

Type of carrier	In bulk: Thousand barrels	In bulk: Percent	In paper bags[2]: Thousand barrels	In paper bags[2]: Percent	Total shipments: Thousand barrels	Total shipments: Percent
1958						
Truck	84,527	34.8	21,917	34.3	106,444	34.7
Railroad	150,897	62.1	41,838	65.4	192,735	62.8
Boat	7,334	3.0	154	0.2	7,488	2.4
Used at plant	330	0.1	71	0.1	401	0.1
Total	243,088	100.0	63,980	100.0	307,068	100.0
Percent of total	79.2		20.8		100.0	
1959						
Truck	103,481	38.2	24,974	38.8	128,455	38.3
Railroad	157,987	58.3	39,333	61.0	197,320	58.8
Boat	9,213	3.4	73	0.1	9,286	2.8
Used at plant	335	0.1	56	0.1	391	0.1
Total	271,016	100.0	64,436	100.0	335,452	100.0
Percent of total	80.8		19.2		100.0	

[1] Includes Puerto Rico.
[2] Cloth bags included with paper bags to avoid disclosing individual company confidential data.

CONSUMPTION

Net shipments of cement into a State afford a fair index of consumption. Shipments were higher into 41 States and the District of Columbia than those in 1958.

TABLE 15.—Destination of shipments of all types of finished portland and high-early-strength cement from mills in the United States, by States, in thousand barrels.

Destination	Finished portland		High-early-strength	
	1958	1959	1958	1959
Alabama	4,727	5,018	483	473
Alaska [1]	(2)	(2)	(2)	(2)
Arizona	3,575	3,860	1	11
Arkansas	2,129	2,624	27	24
Northern California	13,408	15,227	20	20
Southern California	20,824	23,421	156	126
Colorado	4,183	4,316	8	14
Connecticut [1]	3,207	3,141	291	310
Delaware [1]	853	1,114	81	110
District of Columbia [1]	1,525	1,600	99	90
Florida	[3] 11,409	[3] 13,550	865	1,162
Georgia	5,741	6,564	249	308
Hawaii [1]	(2)	(2)	(2)	(2)
Idaho	1,453	1,230	2	2
Illinois	19,388	18,162	664	614
Indiana	7,328	8,697	346	437
Iowa	7,755	7,585	187	242
Kansas	6,397	6,889	102	114
Kentucky	3,071	4,202	80	114
Louisiana	8,048	8,908	96	80
Maine	956	1,104	70	90
Maryland	4,558	5,280	258	303
Massachusetts [1]	4,762	4,598	435	439
Michigan	13,997	15,214	1,139	1,197
Minnesota	6,197	6,311	338	405
Mississippi	2,778	3,072	12	16
Missouri	7,636	8,825	164	236
Montana	1,394	1,425	8	14
Nebraska	3,833	3,980	124	154
Nevada [1]	580	780	6	5
New Hampshire [1]	584	685	42	51
New Jersey [1]	7,900	8,722	1,203	1,394
New Mexico	2,430	3,087	76	111
New York	19,196	20,563	1,215	1,415
North Carolina [1]	4,451	5,641	177	235
North Dakota [1]	1,657	2,011	5	6
Ohio	16,186	19,339	400	461
Oklahoma	5,131	5,374	22	32
Oregon	2,594	2,913	5	7
Pennsylvania	15,276	15,844	1,010	1,358
Rhode Island [1]	819	639	66	57
South Carolina	2,212	2,613	49	41
South Dakota	1,392	1,666	41	45
Tennessee	4,288	4,983	91	146
Texas	22,323	23,884	738	838
Utah	2,119	2,226	13	26
Vermont [1]	353	364	16	20
Virginia	5,180	6,354	331	437
Washington	6,545	5,721	332	415
West Virginia	2,009	2,076	7	13
Wisconsin	6,751	7,530	62	95
Wyoming	962	1,100	21	6
Unspecified	----------	1	----------	1
Total United States	302,070	330,033	12,233	14,320
Other countries	[4] 4,998	[4] 5,419	[5] 41	[5] 43
Total shipped from cement plants	307,068	335,452	12,274	14,363

---

[1] Non-cement-producing State.

[2] Included with "Other countries" to avoid disclosing individual company confidential data.

[3] Includes shipments from Puerto Rican mills.

[4] Direct shipments by producers to foreign countries, the States of Alaska and Hawaii, and to Puerto Rico, including distribution from Puerto Rican mills.

[5] Direct shipments by producers to other countries, and the States of Alaska and Hawaii.

Response from 147 of the 172 plants representing 85 percent of cement shipments in 1959 indicated that of the 335 million barrels of portland cement shipped, 54 percent (179 million barrels) went to ready-mixed-concrete companies, 13 percent (45 million) to concrete-product manufacturers, 13 percent (44 million) to building material dealers, 12 percent (39 million) to highway contractors, 5 percent (17 million) to other contractors, 1 percent (4 million) to Government agencies, and 2 percent (7 million) to miscellaneous customers.

STOCKS

Stocks of finished portland cement and clinker at portland cement plants on December 31, 1959, were 2 and 6 percent higher, respectively, than those on December 31, 1958. Changes in stocks from 1951 to 1959 are shown in figure 1.

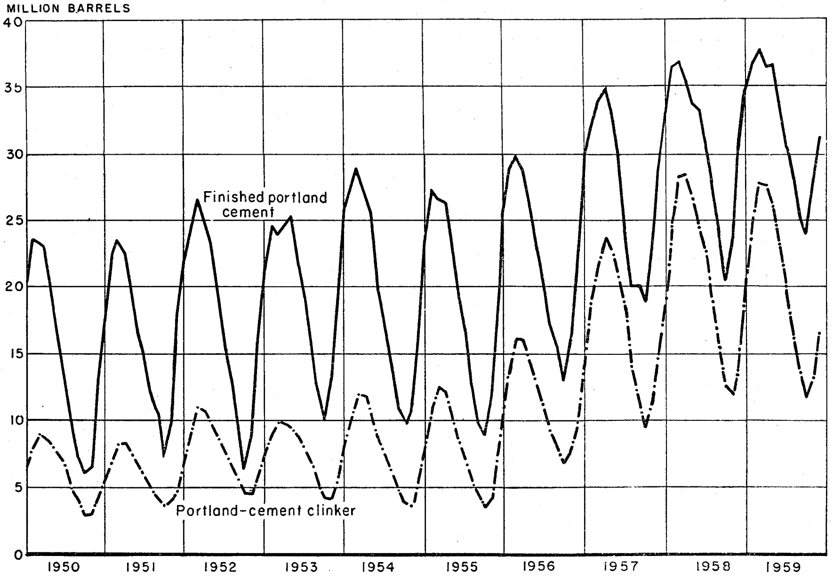

FIGURE 1.—End-of-month stocks of finished portland cement and portland-cement clinker, 1950–59.

PREPARED MASONRY CEMENTS

PRODUCTION AND SHIPMENTS

Prepared masonry cements were produced at 128 portland cement plants, 3 natural cement plants, 2 slag cement plants, and 1 hydraulic-lime cement plant. Production was 13 percent greater than that in 1958. Shipments were greatest to Florida, Ohio, Michigan, North Carolina, and Pennsylvania.

Because prepared masonry cements vary in composition and bulk density, statistics have been converted to equivalent 376-pound barrels for comparison.

TABLE 16.—Stocks of finished portland cement and portland-cement clinker at mills in the United States[1] on Dec. 31, and yearly range in end-of-month stocks

		Dec. 31 (thousand barrels)	Range			
			Low		High	
			Month	Thousand barrels	Month	Thousand barrels
1955	Cement	17,539	October	8,754	February	27,087
	Clinker	7,001	do	3,514	March	12,629
1956	Cement	22,395	do	13,007	do	29,868
	Clinker	9,443	do	6,874	do	16,151
1957	Cement	28,716	do	19,213	April	34,893
	Clinker	14,853	do	9,444	do	23,620
1958	Cement	[2] 30,718	do	20,415	March	36,734
	Clinker	[2] 15,505	November	12,124	April	28,409
1959	Cement	31,459	October	23,913	March	37,711
	Clinker	16,470	do	11,681	do	27,709

[1] Includes Puerto Rico.
[2] Revised figure.

TABLE 17.—Destination of shipments of prepared masonry cement from mills in the United States, by States, in thousand barrels

Destination	1958	1959
Alabama	357	403
Alaska [1]	(2)	(2)
Arizona	5	6
Arkansas	139	162
California	----------	----------
Colorado	206	232
Connecticut [1]	86	78
Delaware [1]	22	21
District of Columbia [1]	185	225
Florida	1,111	1,246
Georgia	632	723
Hawaii [1]	----------	----------
Idaho	13	16
Illinois	605	691
Indiana	452	525
Iowa	153	170
Kansas	170	194
Kentucky	321	369
Louisiana	253	272
Maine	46	53
Maryland	355	378
Massachusetts [1]	186	204
Michigan	913	990
Minnesota	298	325
Mississippi	202	252
Missouri	147	172
Montana	24	23
Nebraska	57	70
Nevada [1]	----------	----------
New Hampshire [1]	41	39
New Jersey [1]	385	433
New Mexico	89	109
New York	858	925
North Carolina [1]	851	986
North Dakota [1]	37	44
Ohio	1,031	1,169
Oklahoma	163	212
Oregon	1	2
Pennsylvania	915	979
Rhode Island [1]	24	24
South Carolina	427	466
South Dakota	39	44
Tennessee	554	661
Texas	637	718
Utah	16	14
Vermont [1]	27	25
Virginia	714	870
Washington	34	38
West Virginia	178	173
Wisconsin	415	425
Wyoming	8	10
Unspecified	55	2
Total United States	14,437	16,168
Other countries [3]	14	6
Total shipped from cement plants	14,451	16,174

[1] Non-cement-producing State.
[2] Included with "Other countries" to avoid disclosing individual company confidential data.
[3] Direct shipments by producers to other countries and to Alaska.

TABLE 18.—Prepared masonry cement produced and shipped in the United States (and Puerto Rico), by districts

District	Active plants		Production (thousand barrels)		Shipments from mills					
					1958			1959		
	1958	1959	1958	1959	Thousand barrels	Value (thousands)	Average	Thousand barrels	Value (thousands)	Average
Eastern Pennsylvania, Maryland	19	19	1,659	1,922	1,715	$5,997	$3.50	1,897	$6,929	$3.65
New York, Maine	13	13	952	844	970	3,355	3.46	851	3,064	3.60
Ohio	9	9	814	818	740	2,951	3.99	853	3,375	3.95
Western Pennsylvania, West Virginia	7	6	842	851	842	3,307	3.93	877	3,406	3.89
Michigan	5	5	1,137	1,349	1,221	4,694	3.84	1,344	5,126	3.81
Illinois	4	4	411	432	413	1,551	3.75	439	1,636	3.73
Indiana, Kentucky, Wisconsin	6	6	1,919	2,115	1,848	6,513	3.52	2,219	7,792	3.51
Alabama	8	8	1,637	1,818	1,673	6,368	3.81	1,821	6,967	3.83
Tennessee	5	5	693	763	697	2,439	3.50	772	2,743	3.55
Virginia, South Carolina	4	4	730	967	728	2,796	3.84	917	3,202	3.49
Georgia, Florida	4	5	952	1,112	935	3,737	4.00	1,107	4,411	3.99
Louisiana, Mississippi	3	3	197	202	194	689	3.54	194	708	3.65
Iowa	4	4	453	481	415	1,748	4.22	469	1,967	4.19
Eastern Missouri, Minnesota, South Dakota	6	6	362	534	437	1,834	4.19	492	2,065	4.19
Kansas	7	7	293	348	302	1,204	3.99	349	1,393	3.99
Western Missouri, Nebraska, Oklahoma, Arkansas	6	7	327	454	310	1,264	4.07	399	1,593	3.99
Texas	12	12	670	783	665	2,570	3.87	776	3,045	3.93
Colorado, Arizona, Utah, New Mexico	2	3	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Wyoming, Montana, Idaho	2	2	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Northern California	1	1	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Southern California	0	0								
Oregon, Washington	5	5	25	56	41	167	4.07	48	189	3.95
Puerto Rico	0	0								
Undistributed			288	356	305	1,329	4.36	350	1,544	4.42
Total	132	134	14,361	16,205	14,451	54,513	3.77	16,174	61,155	3.78
Pennsylvania	21	21	1,912	2,071	1,967	7,281	3.70	2,086	7,864	3.77
Missouri	5	5	314	349	302	1,280	4.24	364	1,544	4.24

[1] Included with "Undistributed" to avoid disclosing individual company confidential data.

NATURAL, SLAG, AND HYDRAULIC-LIME CEMENTS

Natural cement was produced for sale at two plants and slag cement also at two. Output of these cements was small because the four plants made larger amounts of prepared masonry cement. A third natural cement plant and a hydraulic-lime cement plant produced only masonry cement. The six plants reported an annual capacity of less than 1 million barrels. One plant, which formerly made both portland and natural cement, was converted entirely to the production of portland cement. Producers reported using 82,000 tons of limestone, 14,000 tons of slag, and 6,000 tons of lime, 12,000 tons of coal, and 17 million cubic feet of natural gas in processing these cements.

Because the prepared masonry cements made at these plants contained some portland cement, they are included in the tabulations of masonry cement prepared at portland cement plants (tables 17 and 18). Figures on production of natural and slag cements in 1957, 1958, and 1959 are not entirely comparable with figures for preceding years because of changes in the method of reporting by some producers.

TABLE 19.—Natural, slag, and hydraulic-lime cements produced, shipped and in stock at mills in the United States [1]

Year	Production		Shipments		Stocks on Dec. 31 (thousand barrels)
	Active plants	Thousand barrels	Thousand barrels	Value (thousands)	
1950-54 (average)	8	3,618	3,623	$10,754	137
1955	6	941	954	3,019	66
1956	6	1,128	1,074	3,589	116
1957	5	631	662	2,027	79
1958	5	520	492	1,633	107
1959	4	438	441	1,450	103

[1] Includes natural masonry cements through 1954.

PRICES

The average net price of all shipments from all cement plants was $3.30 a barrel, compared with $3.27 in 1958.

Portland cement prices at the plant increased from $3.25 a barrel in the last quarter of 1958 to $3.27 and $3.29 in the first and second quarters of 1959, respectively. The average prices dropped to $3.28 and $3.27 in the third and fourth quarters, respectively. Prices of types I and II portland cement (93 percent of all portland cement produced) increased from $3.21 a barrel in the first quarter to $3.25 in the second quarter and then fell to $3.24 and $3.22 in the third and fourth quarters, respectively.

Average prices of high-early-strength cement increased from $3.67 a barrel in the last quarter of 1958 to $3.73 and $3.75 in the first and second quarters of 1959 and dropped to $3.72 in the third quarter and to $3.70 in the fourth quarter.

The price of prepared masonry cement decreased from $3.78 a barrel in the first quarter of 1959 to $3.77 in the second, and then rose to $3.78 and $3.80 a barrel in the third and fourth quarters, respectively.

The composite wholesale price index of portland cement, f.o.b. destination, according to the Bureau of Labor Statistics index (1947–49=100), was 152.2, compared with 150.6 in 1958.

TABLE 20.—Average mill value per barrel, in bulk, of cement in the United States [1]

Year	Portland cement	Natural, slag, and hydraulic-lime cements	Prepared masonry cement [2]	All classes of cement [3]
1950–54 (average)	$2.58	$2.77	$3.13	$2.59
1955	2.86	3.16	3.41	2.89
1956	3.05	3.34	3.75	3.08
1957	3.18	3.06	3.81	3.21
1958	3.25	3.32	3.77	3.27
1959	3.28	3.28	3.78	3.30

[1] Includes Puerto Rico.
[2] Includes masonry cements made at portland, natural, and slag cement plants.
[3] Includes shipments of masonry cements for 1955–59.

FOREIGN TRADE [9]

Imports.—Imports of hydraulic cement increased from 3.33 million barrels in 1958 to 5.25 million barrels in 1959. Imports into Florida dropped from 50 percent of total imports in 1958 to 28 percent, and imports into New England and New York rose from 37 percent of total imports in 1958 to 48 percent. Canada, Colombia, Belgium-Luxembourg, and West Germany supplied 68 percent of the cement imported in 1959.

Imports of white cement were nearly the same as in 1958; 70 percent came through Florida, and 39 percent came from Belgium-Luxembourg.

Exports.—Exports of hydraulic cement decreased to 43 percent of the 1958 exports. The largest quantities were shipped to Canada, Mexico, and Costa Rica.

TABLE 21.—Hydraulic cement imported for consumption in the United States

[Bureau of the Census]

Year	Roman, portland, and other hydraulic cement		Hydraulic cement clinker		White, nonstaining portland cement		Total	
	Barrels	Value	Barrels	Value	Barrels	Value	Barrels	Value
1950–54 (average)	698,717	[1] $2,072,929	1,172	$6,938	28,593	$159,890	728,482	[1] $2,239,757
1955	4,559,953	[1] 12,712,524	466,962	589,061	192,785	1,052,827	5,219,700	[1] 14,354,412
1956	3,672,527	[1] 11,362,209	483,423	1,068,949	300,170	[1] 1,757,417	4,456,120	[1] 14,188,575
1957	3,856,435	[1] 11,887,440	121,663	221,249	448,949	[1] 2,710,781	4,427,047	[1] 14,819,470
1958	3,110,677	8,059,683	11,673	91,259	267,736	1,530,929	3,390,086	9,681,871
1959	4,978,661	12,267,567	5,994	47,239	280,341	1,458,360	5,264,996	13,773,166

[1] Data not comparable with other years.

---

[9] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 22.—Hydraulic cement imported for consumption in the United States (and Puerto Rico), 1959,[1] by countries and customs districts, in barrels

[Bureau of the Census]

Customs district	Belgium-Luxembourg	Canada	Colombia	Denmark	France	Germany, West	Israel	Japan	Mexico	Sweden	United Kingdom	Yugoslavia	Other [2]	Total
Alaska								150						150
Buffalo		110,860												110,860
Chicago		162,705												162,705
Connecticut	95,620			28,149		82,902	226,660						454,237	887,568
Dakota		20,526												20,526
El Paso									4,132					4,132
Florida	427,717		338,158	101,311	33,896	274,042	101,332	500		52,655	155,443		2,528	1,487,582
Galveston											907			907
Georgia											2,845			2,845
Hawaii								2,692						2,692
Laredo		201							12,160					12,361
Los Angeles	503			9,638	499	480		20,462			5,390			36,981
Maine and New Hampshire		18,951												18,951
Maryland						2,096								2,096
Massachusetts	109,193		11,586			65,478				123,404		55,813		365,474
Michigan		456,389				7,121								463,510
Montana		19,338												19,338
New Orleans	1,081								329		1,000			2,410
New York	2,009		92,976			56,555					8,258			159,798
Ohio		25,420				325								25,745
Oregon	804													804
Philadelphia	20,626					7,326	21,122				2,267	12,195		63,536
Puerto Rico	3,472		335,714	1,495	7,223	324								348,228
Rhode Island			38,646			106,789				104,605			42,611	292,651
Rochester		595,668												595,668
St. Lawrence		29,275												29,275
San Diego				3,388										3,388
San Francisco				3,481	1,554						1,511			6,546
South Carolina	29,712													29,712
Vermont		55,415												55,415
Virginia													53,142	53,142
Total: Barrels	690,737	1,494,748	817,080	147,462	43,172	603,447	349,114	23,804	16,621	280,664	177,621	68,008	552,518	5,264,996
Value	$1,961,505	$4,444,666	$1,682,243	$386,017	$246,251	$1,384,730	$930,462	$109,869	$56,795	$610,748	$581,129	$151,639	$1,227,112	$13,773,166

---

[1] Changes in Minerals Yearbook 1958, p. 290, should read as follows: Sweden (Connecticut customs district) 3,602 barrels; total 239,881 barrels ($503,826); other countries (Connecticut) 335,685 barrels; total other countries 453,616 barrels ($1,106,024). Revisions in the footnote should read, Norway (Connecticut) 335, 685 barrels; total, 453,616 barrels.

[2] Includes Bahamas (Florida customs district) 2,528 barrels; Norway (Connecticut) 454,237 barrels; Poland and Danzig (Rhode Island) 42,611 barrels; United Arab Republic-Egypt Region (Virginia) 53,142 barrels; total, 552,518 barrels.

TABLE 23.—Hydraulic cement exported from the United States, by countries of destination

[Bureau of the Census]

Country	1957		1958		1959	
	Barrels	Value	Barrels	Value	Barrels	Value
North America:						
Bermuda	1, 355	$5, 474	1, 725	$10, 028	1, 040	$8, 939
Canada	294, 969	1, 322, 117	168, 677	730, 060	99, 093	542, 196
Central America:						
British Honduras	1, 133	5, 780	3, 964	18, 678	200	814
Canal Zone	2, 382	9, 756	---------	---------	132	957
Costa Rica	15, 250	49, 796	25, 584	124, 324	17, 912	58, 398
El Salvador	200	2, 061	149	2, 302	---------	---------
Guatemala	1, 600	6, 357	200	1, 989	1, 057	7, 404
Honduras	16, 776	62, 806	16, 626	66, 565	9, 980	42, 666
Nicaragua	10, 350	45, 409	13, 363	55, 466	3, 804	18, 995
Panama	264	1, 832	1, 838	13, 588	1, 300	5, 660
Greenland	---------	---------	125	500	---------	---------
Mexico	312, 830	1, 346, 547	221, 241	988, 608	18, 810	107, 446
West Indies:						
British:						
Bahamas	13, 092	64, 246	14, 520	84, 617	16, 910	73, 129
Barbados	---------	---------	1, 500	7, 673	---------	---------
Jamaica	6, 623	27, 333	383	3, 399	727	4, 615
Leeward and Windward Islands	11, 407	38, 112	9, 268	30, 582	11, 250	37, 572
Trinidad and Tobago	1, 472	8, 146	1, 750	8, 928	412	2, 563
Cuba	145, 489	267, 323	6, 048	38, 827	3, 394	23, 079
Dominican Republic	613	3, 448	300	1, 496	---------	---------
French West Indies	6, 553	16, 856	6, 200	17, 160	5, 625	15, 385
Haiti	50	1, 180	---------	---------	---------	---------
Netherlands Antilles	989	3, 109	3, 082	8, 712	600	1, 560
Total	843, 397	3, 287, 688	496, 543	2, 213, 502	192, 246	951, 378
South America:						
Argentina	3, 476	28, 796	---------	---------	9, 285	51, 398
Bolivia	1, 995	11, 403	2, 483	14, 754	4, 477	32, 695
Brazil	20, 059	89, 569	6	104	1, 216	13, 083
British Guiana	1, 056	4, 776	264	1, 194	---------	---------
Chile	6, 013	41, 460	2, 110	22, 406	5, 834	59, 556
Colombia	16, 120	110, 074	12, 962	83, 540	4, 628	31, 292
Ecuador	48	596	---------	---------	---------	---------
Paraguay	---------	---------	---------	---------	250	1, 125
Peru	943	6, 478	3, 591	11, 205	379	8, 824
Surinam	1, 264	5, 113	187	1, 580	---------	---------
Uruguay	---------	---------	444	9, 187	100	1, 890
Venezuela	353, 106	1, 055, 444	64, 962	205, 947	10, 201	50, 064
Total	404, 080	1, 353, 709	87, 009	349, 917	36, 370	249, 927
Europe:						
Belgium-Luxembourg	953	17, 751	815	13, 733	533	4, 957
Denmark	427	10, 041	14	778	103	1, 249
France	1, 893	12, 544	3, 355	21, 907	3, 900	21, 369
Germany, West	1, 003	25, 617	124	3, 454	639	7, 521
Italy	252	6, 436	37	942	---------	---------
Netherlands	367	10, 854	213	5, 480	65	1, 800
Norway	795	26, 928	234	6, 576	---------	---------
Sweden	722	27, 261	441	13, 201	---------	---------
United Kingdom	300	7, 400	---------	---------	---------	---------
Other Europe	1, 098	20, 208	---------	---------	486	9, 861
Total	7, 810	165, 040	5, 233	66, 071	5, 726	46, 757
Asia:						
Arabian Peninsular States, n.e.c	2, 300	12, 157	3, 500	19, 267	4, 098	31, 023
India	2, 883	14, 808	---------	---------	697	3, 588
Indonesia	3, 272	13, 253	4, 735	20, 819	---------	---------
Iraq	1, 100	6, 314	6, 453	34, 415	10, 750	82, 135
Israel	---------	---------	---------	---------	352	2, 970
Japan	6, 281	144, 039	2, 711	82, 381	2, 918	91, 403
Korea, Republic of	---------	---------	132	962	740	4, 618
Kuwait	8, 595	49, 614	4, 750	25, 282	2, 010	10, 261
Malaya, Federation of	750	3, 871	---------	---------	---------	---------
Pakistan	4, 008	18, 263	---------	---------	1, 892	11, 230
Philippines	2, 924	23, 579	1, 608	14, 386	1, 807	18, 399

TABLE 23.—Hydraulic cement exported from the United States, by countries of destination—Continued

Country	1957		1958		1959	
	Barrels	Value	Barrels	Value	Barrels	Value
Asia—Continued						
Saudi Arabia	856	$11,304	2,246	$34,672	125	$2,300
Turkey	2,600	10,348	625	3,269	----------	----------
Other Asia	783	4,155	50	1,400	----------	----------
Total	36,352	311,705	26,810	236,853	25,389	257,927
Africa:						
British West Africa, n.e.c	----------	----------	----------	----------	4,250	16,585
Liberia	13,156	53,342	14,250	57,400	11,250	46,900
Libya	1,250	6,905	6,612	31,520	1,782	22,003
Somaliland	1,813	8,257	661	3,870	250	1,900
Other Africa	465	5,628	135	1,713	4	1,200
Total	16,684	74,132	21,658	94,503	17,536	88,588
Oceania:						
Australia	----------	----------	93	2,508	----------	----------
British Western Pacific Islands	5,444	23,025	500	2,062	----------	----------
New Guinea	4,648	55,263	2,383	5,794	----------	----------
New Zealand	7,830	32,538	930	3,818	----------	----------
Trust Territory of the Pacific Islands	4,275	18,425	----------	----------	----------	----------
Total	22,197	129,251	3,906	14,182	----------	----------
Grand total	1,330,520	5,321,525	641,159	2,975,028	277,267	1,594,577

WORLD REVIEW

NORTH AMERICA

Canada.—No new plants were opened, but Miron & Freres, Ltd., was constructing a 4-million-barrel plant in the Montreal area.

British Portland Cement Co. of London announced plans to erect a $15 million plant at Cobourg, Ontario; and Inland Cement Co. planned to add a million-barrel kiln at its Edmonton (Alberta) plant.

Two deposits of pozzolanic materials were discovered in British Columbia, one a shale material on Vancouver Island and the other volcanic ash north of Savona. Preliminary tests showed both materials possessed cementitious qualities. Holdfast Natural Resources, Ltd., announced plans to develop the shale deposit, and Industrial Minerals, Ltd., the volcanic ash deposit.

Costa Rica.—A new law, effective November 1959, contained a provision that a cement plant could be closed down while a complaint that the plant had violated the law was being heard in court. The suspension of operations shall be without responsibility to the State or to the complainant.

Haiti.—Duties on regular portland and natural cements were doubled in January 1959. Cement was formerly dutiable at 3 centimes per kilogram ($1.02 per barrel). The increase did not apply to white portland cement.

TABLE 24.—World production of hydraulic cement, by countries, in thousand barrels[1]

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada (sold or used by producers)	18,047	23,430	26,713	32,178	32,729	33,433
Cuba	2,281	2,527	3,512	3,805	4,192	3,670
Dominican Republic	704	1,372	1,448	1,642	1,583	1,114
Guatemala	334	475	469	575	692	680
Haiti	----------	152	264	164	217	223
Jamaica	[2] 322	639	780	657	1,044	1,143
Mexico	9,434	11,815	13,351	15,010	15,127	15,901
Nicaragua	123	170	246	252	235	205
Panama	440	428	410	463	393	[3] 410
Salvador	[4] 252	334	405	498	510	487
Trinidad	[5] 141	721	815	780	879	1,055
United States	255,186	314,913	333,472	313,756	326,352	355,734
Total	287,264	356,976	381,885	369,780	383,953	414,055
South America:						
Argentina	9,434	10,959	11,961	13,861	14,494	13,861
Bolivia	211	223	193	141	170	170
Brazil	10,542	16,247	19.202	19,900	22,222	[3] 22,281
Chile	4,181	4,714	4,521	4,263	4,362	4,867
Colombia	4,397	6,133	7,153	7,194	7,200	7,904
Ecuador	481	856	891	909	938	921
Paraguay	[2] 18	70	82	70	41	76
Peru	2,345	3,195	3,237	3,195	3,547	3,412
Uruguay	1,759	1,560	1,988	2,445	2,539	2,474
Venezuela	4,872	7,517	8,508	10,243	9,475	[3] 10,935
Total	38,240	51,474	57,736	62,221	64,988	66,901
Europe:						
Albania	94	252	381	410	457	[3] 410
Austria	8,408	10,900	11,351	12,483	12,630	14,172
Belgium	24,702	27,493	27,346	27,587	23,787	26,027
Bulgaria	3,981	4,761	5,037	5,160	5,476	8.402
Czechoslovakia	13,081	16,957	18,458	21,530	24,063	27,792
Denmark	6,508	7,382	6,960	6,825	6,262	8,121
Finland	5,072	6,104	5,629	5,547	5,424	6,860
France	50,465	62,274	67,076	73,930	78,650	78,562
Germany:						
East	11,932	17,420	19,167	20,287	20,862	24,655
West [6]	76,692	106,612	110,658	110,277	113,689	133,965
Greece	3,553	6,620	7,259	7,183	7,857	8,349
Hungary	5,640	6,889	5,834	5,799	7,634	8,402
Iceland	----------	----------	----------	----------	193	457
Ireland	2,809	3,940	4,175	3,078	2,533	3,102
Italy	39,800	62,509	66,484	70,072	75,185	83,417
Luxembourg	797	921	956	1,114	1,149	1,126
Netherlands	4,620	6,455	7,364	7,740	8,009	9,381
Norway	4,122	4,691	5,248	5,963	6,045	6,485
Poland	17,086	22,357	23,658	26,361	29,639	31,122
Portugal	4,098	4,568	6,004	5.740	6,004	6,045
Rumania	8,402	11,351	12,301	13,808	15,080	[3] 17,590
Saar	1,454	1,659	1,929	2,058	1,718	1,829
Spain	17,936	25,400	27,710	29,117	31,193	32,711
Sweden	12,800	14,951	14,629	14,365	14,717	16,525
Switzerland	8,414	12,413	13,955	14,723	12,811	15,731
U.S.S.R.	84,250	131,830	145,750	169,426	195,283	227,496
United Kingdom	64,702	74,581	76,059	71,274	68,601	73,807
Yugoslavia	7,464	9,164	9,117	11,627	11,533	13,017
Total	488,882	660,454	700,495	743,484	786,484	885,568
Asia:						
Burma	188	352	229	217	211	211
Ceylon	334	446	498	287	469	557
China	17,865	26,385	37,654	39,911	58,633	[3] 73,291
Cyprus	----------	----------	217	399	487	434
Hong Kong	434	686	709	610	891	833
India	20,879	26,731	29,358	33,362	36,341	40,580
Indonesia	774	874	850	1,472	1,741	[3] 1,759
Iran	346	774	1,343	1,642	2,568	[3] 4,169
Iraq	727	1,859	2,873	3,541	3,923	3,876
Israel	2,691	3,893	3,594	4,216	4,181	4,579
Japan	44,057	61,934	76,364	88,981	87,862	101,247
Jordan	[5] 369	[3] 498	463	627	668	645

See footnotes at end of table.

TABLE 24.—World production of hydraulic cement, by countries, in thousand barrels[1]—Continued

Country	1950–54 (average)	1955	1956	1957	1958	1959
Asia—Continued						
Korea:						
North[3]	1,642	2,111	3,518	4,104	7,177	[3] 11,727
Republic of	188	328	270	539	1,736	2,099
Lebanon	1,747	2,656	2,861	3,283	2,973	4,362
Malaya, Federation of	[4] 346	639	610	668	645	1,132
Pakistan	3,231	4,063	4,609	6,409	6,391	5,875
Philippines	1,771	2,345	2,562	2,996	3,764	4,263
Taiwan	2,609	3,459	3,465	3,541	5,951	6,256
Thailand	1,542	2,263	2,334	2,357	3,025	3,389
Turkey	2,908	4,814	5,687	7,394	8,895	10,167
United Arab Republic (Syria region)	803	1,548	1,911	1,847	2,269	2,621
Viet-Nam, South	1,319	[3] 1,759	[3] 2,052	[3] 2,052	[3] 2,052	[3] 2,052
Total	106,770	150,417	184,031	210,455	242,853	286,124
Africa:						
Algeria	2,832	3,958	3,823	4,169	4,937	5,611
Angola	[4] 205	410	510	762	973	909
Belgian Congo	1,425	2,375	2,691	2,721	2,287	1,994
Cameroons, Republic of	--------	29	76	64	64	[3] 64
Ethiopia	[3] 64	[3] 188	158	147	188	147
Kenya	223	768	1,091	1,208	1,272	1,841
Morocco:						
Northern zone	[5] 29	258	[3] 293	[3] 293	[3] 293	[3] 293
Southern zone	2,809	4,016	3,436	2,556	2,298	2,943
Mozambique	469	803	885	979	1,055	[3] 1,055
Nigeria	--------	--------	--------	--------	663	709
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	[7] 317	534	663	3,858	4,667	3,489
Southern Rhodesia	1,272	2,363	2,732	--------	--------	--------
Senegal	399	756	850	926	874	1,020
Sudan	--------	375	393	352	[3] 381	[3] 422
Tunisia	1,261	2,246	2,111	2,351	2,022	2,592
Uganda	193	293	358	504	622	481
Union of South Africa	11,850	13,697	14,482	14,805	15,948	15,549
United Arab Republic (Egypt region)	6,420	8,039	7,921	8,596	8,865	10,413
Total	29,768	41,108	42,473	44,291	47,409	49,532
Oceania:						
Australia	8,660	11,674	12,530	13,615	14,418	14,834
New Zealand	1,507	2,398	2,644	3,166	3,289	3,512
Total	10,167	14,072	15,174	16,781	17,707	18,346
World total (estimate)[1]	961,091	1,274,501	1,381,794	1,447,012	1,543,394	1,720,526

[1] This table incorporates some revisions.
[2] Average for 1952–54.
[3] Estimate.
[4] Average for 1953–54.
[5] Average for 1 year only, as 1954 was first year of commercial production.
[6] Revised data; excludes clinker.
[7] Average for 1951–54.

Honduras.—The first cement plant in Honduras began producing in 1959. The plant was built by Cementos de Honduras, which raised almost all of its $3.5 million capital from Honduras' leading businessmen. Approximately 200,000 barrels of cement was imported into Honduras in 1958, and it was expected that the new plant (capacity, 300,000 barrels) would supply most of the Honduran market.[10]

Mexico.—The 400,000-barrel plant of Cementos California, S.A., at Ensenada, Baja California, was described.[11] Plans for the construc-

---

[10] Bureau of Mines, Mineral Trade Notes: Vol 49, No. 4, October 1959, p. 34.

[11] Utley, H. F., Baja California Gets Its First Cement Plant: Pit and Quarry, vol. 52, No. 2, August 1959, pp. 82–86.

tion of two new plants, one by Cemento de Atotonilco, S.A., at Atotonilco, Hidalgo, and the other by Cementos Atoyac, S.A., at Puebla, Pueblo, were announced.

Trinidad.—Soconusco Quarries and Development Co., Ltd., planned to construct a million-barrel cement plant 8 miles from Port Said at a cost of $5.8 million.

SOUTH AMERICA

Argentina.—A $3.6 million expansion and modernization program of its cement plants in Salta, Cordoba, and Mendoza provinces was announced by Juan Minetti e Hijos.[12]

Chile.—Cementos Bio-Bio, S.A., planned to erect a cement plant adjoining a large steel mill at Huachipato, 350 miles south of Santiago. Koppers Co., Inc., of Pittsburgh, Pa., Transoceanic Development Corp., Ltd., of Toronto, Ontario, Canada, and the Chilean sponsoring group hold common stock in the company; and the International Finance Corp. announced a commitment of $1 million in the company. The 750,000-barrel plant will use slag from the steel mill to make portland-slag cement.

The Government Economic Development Corp. announced that another new cement plant was to be erected at Antofagasta. The estimated cost of the 175,000-barrel plant was reported to be $100,000.

Colombia.—Nearly 2 million barrels was added to the capacity of Colombia's cement industry by opening new plants in Tolima, Caldas, and Boyaca. Exports of cement increased from 94,000 barrels in 1954 to 745,000 barrels in 1958.

Ecuador.—La Cement Nacional, with a million-barrel plant at Guayaquil, supplied the cement requirements of Ecuador's coastal area. Cemento Chimborazo C. A., with a 150,000-barrel plant at Riobamba, supplied cement chiefly to consumers in the highland region.[13]

Venezuela.—Five plants produced cement in Venezuela during 1959: C. A. Venezolana de Cementos, Pertigalete plant near Puerto La Cruz; Fabrica Nacional de Cementos, La Vega plant; C. A. Cementos Carabobo, Valencia plant; C. A. Cementos Tachira, San Cristobal plant; and Cementos Coro, Coro plant. A fourth kiln was added at the Pertigalete plant, increasing its annual capacity to nearly 400,000 barrels. Gas turbine generators in use at the Pertigalete and Valencia plants were described.[14]

EUROPE

A description of the European cement industry in 1957 and 1958 and the investment program for 1959 was published.[15] Although world production and consumption increased from 1947 to 1958, world trade decreased because in large measure of industrialization in the traditionally importing countries.

---

[12] Pit and Quarry, Argentina Cement Concern Begins $3,600,000 Expansion: Vol. 52, No. 2, August 1959, p. 39.

[13] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 2, August 1959, pp. 40–41.

[14] Walter, L., Gas Turbines Power Venezuelan Cement Plants: Rock Products, vol. 62, No. 7, July 1927, pp. 80–82.

[15] Organization for European Economic Cooperation, The Cement Industry in Europe: November 1958, 29 pp.

Czechoslovakia.—The Senec cement plant, Banska Bystrica, Slovakia, with an annual capacity of about 3 million barrels, began operating in 1958.

Germany, East.—The Government allocated $32 million for erecting an anhydrite-sulfuric acid plant at Losing that would produce 1.3 million barrels of portland cement as a coproduct.

Greece.—A slowdown in building activity throughout the country reduced the growth rate for sales of cement.

Italy.—A 3-million-barrel cement plant to be operated by Cementir, a Government-owned cement producer, was under construction at Arquata Scrivia, 30 miles north of Genoa.[16] Exports of cement from Italy in 1958 were more than double those in 1957.

U.S.S.R.—Several articles published during 1959 described cement programs that would surpass United States production by 1965.[17]

A new plant under construction at Acympt in central Siberia was to utilize the nepheline residue from a nearby alumina processing plant. The 19- by 574-foot kilns were shipped from France in 1959.[18]

United Kingdom.—Cement operations at the Hope works of G. & T. Earle, Ltd., were described in a series of articles. Chert, clay, and fluorspar occurring in the limestone were removed by grizzlies and vibrating screens.[19]

The quarry and plant of the Ketton Portland Cement Co., Ltd., were described.[20]

Yugoslavia.—Nearly 25 percent of the cement production was exported in 1957.

ASIA

Afghanistan.—The Ministry of Mines and Industries contracted with the Technoexport firm (Foreign Trade Corp. for export of complete industrial plants) of Czechoslovakia to supply and install equipment for the Pul-i-Khumri 700,000-barrel cement plant. The Jabal-us-Seraj cement plant (capacity of 200,000 barrels) was constructed by Czechoslovakia in 1957.

China.—New cement plants in China included a 1.8-million-barrel plant in the Vighur region of Sinkiang, a 5.9-million-barrel plant at Wing-On in Fukien, and five plants in Kwangtung with a combined capacity of 1 million barrels. The Liuliko plant, Peiping, added 10 kilns to increase its capacity by 1.2 million barrels. Widespread use of German-designed vertical kilns (Schacht-oven, annual capacity of 20,000 barrels) reportedly was responsible for the rapid expansion of the cement industry.

According to a Rumanian magazine, cement was being made in China from nepheline residue; the process proposed for the new Russian plant in central Siberia.

---

[16] Rock Products, Italian Cement Plant to Use Steel Mill Slag: Vol. 62, No. 8, August 1959, p. 48.

[17] East Europe, The Race to Catch Up: Vol. 8, No. 3, March 1959, pp. 15–17.
Rymarceivicz, H., Cement Production in the Communist Countries: Pit and Quarry, vol. 51, No. 10, April 1959, pp. 98–101.
East Europe, How Shall the Last Be First: Vol. 8, No. 6, June 1959, pp. 36–37.

[18] Comte, J. M. A., Russia Gets World's Largest Cement Kilns: Rock Products, vol. 62, No. 5, May 1959, pp. 128–131.

[19] Mine and Quarry Engineering (London), Cement Production from the Mountain Limestone of Derbyshire: Vol. 25, No. 3, March 1959, pp. 108–114; No. 4, April 1959, pp. 159–165; No. 5, May 1959, pp. 206–210.

[20] Cement Lime and Gravel (London), Cement Production from the Ketton Stone of Rutland: Vol. 34, No. 5, May 1959, pp. 131–135.

Hong Kong.—The Green Island Cement Co., the colony's only producer, supplied less than 40 percent of the cement consumed in 1958.

India.—Two new plants began to produce in 1959, bringing the total for the country to 31 plants.

Indonesia.—The four-kiln cement plant at Padang operated at about 30 percent of capacity during 1958. The N. V. Pabrik Semen Gresik plant was to increase capacity to 2 million barrels with a loan of $6.9 million to the Republic of Indonesia from the Export-Import Bank of Washington, D.C.

Iran.—A 1.1-million-barrel plant at Doroud in southwest Iran began production in 1959.

Japan.—Tokuyama Soda Co. ordered a 2.6-million-barrel cement kiln from the Mitsuibishi Shipbuilding and Engineering Co., Tokyo. The Chichibu Cement Co. purchased a 1.2-million-barrel Allis-Chalmers-Lellek plant, the fifth such plant to be installed in Japan.

Malaya, Federation of.—The Rawang plant of Malayan Cement, Ltd., was expanded to an annual capacity of 1 million barrels by adding a second kiln and two grinding mills. Two new plants were planned—one at Batu Caves near Kuala Lumpur by the Malayan Industrial and Mining Co. and the other at Petaling by the Cement Aids, Ltd.

Pakistan.—The Pakistan Industrial Development Corp. announced plans to erect a 3-million-barrel cement plant at Mangho Pir near Karachi.

Philippines.—The Mindanao Portland Cement Co. planned to build a 700,000-barrel cement plant on Mindanao Island[21] with a $3.7 million loan from the U.S. Government.

Saudi-Arabia.—The Arabian Cement Co. completed a cement plant at Jidda, and Saudi Cement Co. began constructing a cement plant north of Hofuf in the Eastern Province.

Taiwan (Formosa).—Since 1956 five small cement plants with capacities ranging from 50,000 to 90,000 barrels per year were put into operation. It was claimed that they competed successfully with larger cement producers.[22]

Turkey.—Two plants, one at Elazig and the other at Pinarhisar, were completed in 1959, raising to 14 the total number of operating plants in the country. Two more plants, one at Gaziantep and the other at Konya, were under construction. Five State-owned plants were scheduled for construction at Nigde, Soke, Bartin, Batman, and Erzerum.[23] For the first time, Turkey had an excess of cement and began to seek foreign markets for its surplus production.

United Arab Republic (Syria region).—Engineering firms from East Germany began constructing a 500,000-barrel cement plant near Aleppo.

Viet-Nam.—Imports of cement increased from 1.3 million barrels in 1957 to 1.7 million barrels in 1958.

---

[21] Foreign Commerce Weekly, Philippine Cement Firm To Open Plant in Manila: Vol. 62, No. 19, Nov. 9, 1959, p. 38.

[22] Lee, T. Y., Small Cement Plants in Taiwan: Pit and Quarry, vol. 51, No. 9, March 1959, p. 130.

[23] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 5, November 1959, pp. 36–40.

AFRICA

Ghana.—Associated Portland Cement Co. investigated the feasibility of constructing a $12 million cement plant in the Bonyeri area.

Nigeria.—Plans were announced to reopen an abandoned cement-clinker mill at Port Harcourt. The Nigerian Cement Co. began an expansion program to double the capacity of its plant at Nkalagu.

Rhodesia and Nyasaland, Federation of.—Nyasaland Portland Cement Co., Ltd., expanded its plant at Blantyre and continued preparations for a new plant at Changalumi.

Sudan.—The Sudan Portland Cement Co., Ltd., operated the only cement plant in Sudan at Atbara. Capacity of the plant was limited to 300,000 barrels by the size of its one kiln. To help meet domestic requirements, clinker was imported from Egypt and Tunisia and ground locally. Russian cement entered Port Sudan under a barter agreement between the Sudan and the U.S.S.R.[24]

Union of South Africa.—The capacity of the Pretoria Portland Cement Co. plant near the Bechuanaland-Transvaal border was raised to 1.2 million barrels.

United Arab Republic (Egypt region).—Over 15 percent (1.3 million barrels) of the 1957 cement production was exported, principally to Saudi Arabia.

OCEANIA

Australia.—Queensland Cement and Lime Co. began a program to increase the annual capacity of its Darra plant to nearly 3 million barrels.[25] Fourteen plants with a total capacity of 16 million barrels operated in 1959.

TECHNOLOGY

A new publication, the Journal of the Research and Development Laboratories, was issued by the Portland Cement Association. The magazine will present original experimental results from the laboratories of the Association and other organizations concerning the nature and uses of cement and concrete.

The variability of 21 different cements, all meeting the standards of the American Society for Testing Materials, was discussed in terms of tricalcium silicate content, composition of raw materials, control of concrete mixing, low strength associated with periods of peak production, and better control of conditions in the cement making process.[26]

Investigative work during the year included a redetermination of the liquidus region between dicalcium silicate and tricalcium silicate;[27] a study of the hydration of tricalcium and dicalcium silicates in pastes

---

[24] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 1, January 1960, pp. 9–11.

[25] Chemical Engineering and Mining Review (Melbourne), £1¼ mill. Program for Queensland Cement Company: Vol. 51, No. 5, Feb. 16, 1959, p. 79.

[26] National Ready Mixed Concrete Association, Floor Discussion of Paper on Variations in Portland Cement: Supp. to NRMCA Pub. 76, 1959, 11 pp.

[27] Welch, J. H., and Gutt, W., Tricalcium Silicate and Its Stability Within the System CaO–SiO: Jour. Am. Ceram. Soc., vol. 42, No. 1, January 1959, pp. 11–15.

under normal and steam curing conditions;[28] the reaction between portland cement and water;[29] and the errors caused by partial drying during testing of hardened portland cement.[30] A brief review of nine Russian papers on cement [31] and information on the requirements for cements other than portland imposed by the specifications of various countries were published.[32]

The influence of gypsum on the hydration of portland cement was discussed in several papers.[33] The need for a special procedure for determining the alkalies in cements having high alkali content was studied by the Cement Committee of the American Society for Testing Materials. Several papers on the reactions between aggregates and high alkali cements were published.[34] The addition of calcium chloride to raw portland cement mixes to make the alkalies more readily volatile was discussed.[35] A new analytical method for determining magnesium oxide in portland cements was patented.[36] Two discussions of methods for particle-size analysis of cement were published.[37]

A patent was issued for manufacturing portland cement from oil shale, utilizing in part the fuel value of organic material in the shale.[38]

Industrial engineering and scientific management were proposed as tools for solving the problems of large scale production.[39] Two companies replaced truck haulage of limestone from quarry to plant with conveyor belts, resulting in more economic operations.[40]

Grinding.—The commonest causes of trouble in the grinding system of a cement plant were said to be ball charge, moisture, oversize feed, improper set of air separator in dry circuits, and materials handling.[41] Information was collected on the effectiveness of three types of classifiers in general use in wet-grinding cement raw materials; vibrating screens, rake-and-bowl classifiers, and liquid cyclones.[42] Low tem-

---

[28] Jour. of the Amer. Chem. Soc., Chem. Abs.: Vol 42, No. 6, June 1959, p. 148.

[29] Building Science Abstracts (London): Vol. 32, No. 4, April 1959, p. 101.

[30] Building Science Abstracts (London): Vol. 32, No. 7, July 1959, p. 195.

[31] Rockwood, N., Some Russian Research on Cement: Rock Products, vol. 62, No. 7, July 1959, pp. 18, 110, 112.

[32] Cembureau, Review of Standard for Cements Other Than Portland: The Cement Statistical and Tech. Assoc., Malmo, Sweden, 1958, 164 pp.

[33] Haskell, W. E., Three Factors Govern Optimum Gypsum Content of Cement: Rock Products, vol. 62, No. 4, April 1959, p. 108.

Temper, Bailey, Control of Gypsum in Portland Cement: Dept. of Public Works, Div. of Highways, State of Calif., June 1959, 18 pp.

Building Science Abstracts (London): Vol. 32, No. 8, August 1959, p. 228.

Mining Engineering, vol. 11, No. 12, December 1959, p. 1225.

[34] Journal of the American Ceramic Society, Chemical Abstracts: Vol. 42, No. 6, June 1959, p. 149.

Hansen, W. C., Release of Alkalies by Sands and Admixtures in Portland Cement Mortars: ASTM Bull. No. 236, February 1959, pp. 35–38.

[35] Kraeger, E. C., and Geary, E. W., Calcium Chloride in Portland Cement Manufacture: Pit and Quarry, vol. 51, No. 6, December 1958, pp. 120, 121, 126.

[36] Berman, H. A., An Improved 8-Hydroxyquinoline Method for the Determination of Magnesium Oxide in Portland Cement: ASTM Bull. No. 237, April 1959, pp. 51–55.

[37] Wieland, W., How to Measure Super-fine Powders: Rock Products, vol. 62, No. 8, August 1959, pp. 131, 132, 134, 136, 138.

Mining Engineering, vol. 11, No. 12, December 1959, p. 1225.

[38] Seelers, F. B., and Chapin, H. M. (assigned to Texaco Development Corp., New York, N.Y.), Portland Cement Manufacture from Oil Shale: U.S. Patent 2,904,445, Sept. 15, 1959.

[39] Wolfe, J. M., New "Tools" Slice Cement-making Costs: Rock Products, vol. 62, No. 12, December 1959, pp. 86–88, 121, 122.

[40] Pit and Quarry, Shortening Quarry Haul Effects Operating Economy: Vol. 52, No. 4, October 1959, p. 123.

Skillings' Mining Review, Cross-Country Belt Conveyor System Serves Cement Plant: Vol. 48, No. 39, Dec. 26, 1959, pp. 1, 4, 24.

[41] Zacher, W. J., Here's a New Approach to Crushing Problems: Rock Products, vol. 62, No. 12, December 1959, pp. 94–96, 98, 126.

[42] Tonry, J. Richard, Wet Grinding of Cement Raw Materials: Pit and Quarry, vol. 51, No. 8, February 1959, pp. 93–97; No. 9, March 1959, pp. 95–99.

peratures in clinker grinding mills were reported to improve the quality of the portland cement.[43] Modern grinding plants were described in a German publication.[44]

Slurry Thickening.—To increase the fluidity of slurries, small quantities of alkali metal polyphosphatosulfate [45] or small percentages of a polybasic organic acid salt, a sulfonic acid of the naphthalene series, and a carbazoltetra-sulfonic acid were suggested as additives.[46] A British cement plant used filter presses with nylon filter cloth to remove more than half the water from the slurry before kiln drying.[47] A patent was issued on a machine for cutting slurry cake.[48]

Calcination.—Methods of increasing the thermal efficiency of cement kilns were discussed.[49] Television cameras installed at the firing end of the kilns at two plants of Ideal Cement Co. permitted the operator in an air-conditioned room to adjust quickly for correct flame characteristics and proper clinker formation.[50] Oxygen enrichment of primary air in cement kilns was suggested as a means of reducing the velocity of air through kilns, thereby reducing the dust-carrying capacity of the flue gases.[51] Amplidyne speed regulators were said to improve control of cement consistency and quality at a Washington cement plant.[52]

Patents were issued for the following: The construction of a kiln with a removal section in the area most susceptible to ring formation; a cement kiln having at least two tire sections supported on plural rolling elements; a kiln rotating mechanism that does not stop the kiln rotation when there is an electric power failure; and the use of specially shaped metal shims to hold refractory brick lining in cement kilns. Patents also were issued for a mixing and sintering system to treat cement raw materials in deep pallets;[53] for an apparatus to dry and preheat cement pulp while simultaneously precipitating dust from the kiln gases used for drying and preheating;[54] and for an apparatus and method for instantaneously preheating

---

[43] Takemoto, K., Ito, I., and Hirayama, K., Keep Grinding Temperatures Low: Rock Products, vol. 62, No. 10, October 1959, pp. 140, 144–148, 154, 156.

[44] Building Science Abstracts (London), vol. 32, No. 5, May 1959, p. 129.

[45] Shaver, K. J. (assigned to Monsanto Chemical Co., St. Louis, Mo.), Method of Increasing Fluidity of Aqueous Industrial Mineral Slurries: U.S. Patent 2,900,266, Aug. 18, 1959.

[46] Dietz, K., Greune, H., and Stroh, R. (assigned to Farbwerke Hoechst A. G. vormals Meister Lucius & Bruning, Frankfurt-am-Main, Germany)., Aqueous Slurry of Comminuted Argillaceous Limestone Material and Process of Producing Same: U.S. Patent 2,905,565, Sept. 22, 1959.

[47] Chemical Trade Journal and Chemical Engineer (London), Filtering Cement Slurry: Vol. 145, No. 3768, Aug. 21, 1959, p. 196.

[48] Bishop, L. H. (assigned to Associated Portland Cement Manufacturers, Ltd., London), Cutting and Handling Machine for Cement Slurry Cake, Pug, and Like Material: U.S. Patent 2.874,910. Feb. 24, 1959.

[49] Azbe, V. J., Lets Look at Cement Kiln Efficiency: Rock Products, vol. 62, No. 6, June 1959, pp. 81–85, 129–132.

Journal of the American Ceramic Society, Thermal Physics of the Rotary Cement Kilns: Vol. 42, No. 6, June 1959, p. 149.

[50] LeClair, David, From This Room With This TV Camera Kiln Burning is Closely Controlled: Rock Products, vol. 62, No. 3, March 1959, pp. 80–81; Closed Circuit Television in Cement Kiln Operation: Canadian Min. Jour., vol. 80, No. 10, October 1959, pp. 102–103.

Meschter, E., Cement Plant Loses "Factory Look": Rock Products, vol. 62, No. 9, September 1959, pp. 102–104, 106, 108.

[51] LaVelle, M. J., Oxygen Enrichment of Primary Air Can Improve Kiln Production: Rock Products, vol. 62, No. 3, March 1959, pp. 97, 100, 101.

[52] Hand, L. M., and Eliason, J. R., Tiny Amplidyne Forces Correct Kiln Speed: Rock Products, vol. 62, No. 7, July 1959, pp. 102, 104.

[53] McDowell, R. C., and Ban, T. E. (assigned to McDowell Co., Inc.), System for Mixing and Sintering Cement Raw Materials: U.S. Patent 2,876,489, Mar. 10, 1959.

[54] Paley, L. A., Apparatus for Treating Cement Slurry: U.S. Patent 2,879,982, Mar. 31, 1959.

cement raw materials using exhaust gases involving some precalcining of the particles.[55]

Vertical Kilns.—Portland cement made in vertical kilns in Australia was reported to have a higher than average proportion of dicalcium silicate.[56] A new stepped grate used in vertical kilns in West Germany was described.[57] Fuel economies of 582,000 B.t.u. per barrel were claimed. Two patents were issued for methods of making cement where the reactions take place in a mass of fluidized solid particles.[58]

Dust.—Fiber-glass bags, 11 inches in diameter and 25 feet long, were reported to catch virtually all the dust in the flue gases at two cement plants.[59] Low alkali content of the raw materials at one plant allowed reclamation of all the dust. Two 173-tube Hagan Aerostatic Dust Collectors, installed on clinker coolers at a Pennsylvania plant, resulted in a 96.5 percent dust recovery. At many plants, separate dust collectors were installed at crushers and the recovered dust was returned to the stream leaving the crusher. Electrostatic precipitators in use in the North Kent area, England, were said to remove about 90 percent of the dust.[60]

An apparatus was patented for separating dust particles from exit gases in which a controlled amount of liquid was injected into the gases. A method also was patented for treating recovered kiln dust by heating to 1,000°F. to increase the alkali solubility, then leaching to dissolve the water-soluble material before returning the residue to the kiln.

The soil-liming qualities of cement kiln flue dusts were compared with selected pulverized agricultural limestone. Some cement producers developed markets for high-alkali dusts as potash fertilizer but many dusts were too low in potash to enter such a market. Experiments in greenhouses showed that selected cement-kiln dusts compared favorably with agricultural limestone as liming material.[61]

Blast-Furnace-Slag Cements.—Constituents of portland blast-furnace slag were found to oxidize during "loss on ignition" tests, resulting in inaccurate determinations of moisture, combustible, and volatile matter in the cement. Ignition in a helium atmosphere overcame this difficulty and gave accurate values for loss on ignition. The helium procedure was recommended for laboratories that make frequent analyses of portland-slag cement.[62]

---

[55] Laboulais, J. L. (assigned to Kennedy Van Saun Manufacturing & Eng. Corp.), Apparatus and Method for Preheating Portland Cement Raw Materials: U.S. Patent 2,883,173, Apr. 21, 1959.

[56] Rockwood, N. C., Uniform Cement From Vertical Kilns in Australia: Rock Products, vol. 62, No. 3, March 1959, pp. 19, 20, 118.

[57] Spohn, E., and Woermann, E., New Grate Boosts Quality of Shaft Kiln Cement: Rock Products, vol. 62, No. 2, February 1959, pp. 96. 99, 100, 102, 140.

[58] Pyzel, R. (assigned to Pyzel-Fitzpatrick, Inc., New York), Hydraulic Cement Process: U.S. Patent 2,874,950, Feb. 24, 1959.

Smith, A. R. (assigned to U.S. Steel Corp.), Method for Making Cement Clinker: U.S. Patent 2,882,033, Apr. 14, 1959.

[59] Rock Products, Glass Bags, An Answer to Kiln Dust Problems: Vol. 61, No. 12, December 1958, pp. 104, 121.

California Mining Journal, New Cement Plant Filter Will Collect $1,500,000 Worth of Dust in 10 Years: Vol. 28, No. 12, August 1959, p. 20.

Rock Products, Ideal Dedicates New $14 Million Plant: Vol. 62, No. 8, August 1959, pp. 109–110.

[60] Chemistry and Industry (London), Cement Dust Troubles North Kent: No. 1, Jan. 3, 1959, p. 27.

[61] Whittaker, C. W., Erickson, C. J., Love, K. S., and Carroll, D. M., Liming Qualities of Three Cement Kiln Flue Dusts and a Limestone in a Greenhouse Comparison: Agronomy Jour., vol. 51, 1959, pp. 280–282.

[62] Chaiken, B., Determination of Ignition Loss in Portland Blast-Furnace-Slag Cements: ASTM Bull. No. 238, May 1959, pp. 53–58.

A French publication described tests on slag samples, showing that the hydraulic property of the slag was related to the fineness and to withdrawal temperature from the blast furnace.[63] Research was conducted in Poland on the hydraulic properties of slag as a means of expanding its cement industry.[64] The central laboratory of the U.S.S.R. experimented with slag-lime mixtures for making concrete blocks.[65]

Pozzolanic Concrete.—A series of articles on pozzolans discussed potential market areas, distribution of these materials, buffer action of pozzolans in concrete, problems connected with the use of pozzolans, and the establishment of an industry to supply pozzolans. An extensive bibliography was included.[66]

Heavy Concrete.—A method for calculating the thickness of concrete needed for personnel safety from radiation was described.[67] A Hungarian article explained the use of bauxite ore for shielding protection against combined neutron and X-ray radiation.[68] Articles were published on concrete walls at an atomic powerplant,[69] the physical properties of a high-density concrete under standard and heated conditions,[70] and general shielding requirements with particular emphasis on fast-neutron shields.[71]

Soil Cement.—Soil cement was used in California and Texas as a road base where there were shortages of good rock aggregate. An article described three methods of preparing soil cement road bases: (1) Dry blending of broken soil and cement in place; (2) wet blending of broken soil and cement in place; and (3) wet blending of aggregate and cement in a pug mill before placing on a prepared subbase. The blended materials were compacted by rollers, sprayed with a curing coat of asphalt, and allowed to cure for a week before adding the bituminous concrete wearing surface.[72]

---

[63] Journal of the American Ceramic Society, vol. 42, No. 1, January 1959, p. 3.

[64] Journal of the American Ceramic Society, vol. 42, No. 6, June 1959, p. 149.

[65] Chemical Week, Cementless Concrete: Vol. 85, No. 20, Nov. 14, 1959, p. 12.

[66] Bauer, Wolf G., The Coming Role of Pozzolans: Pit and Quarry, vol. 51, No. 12, June 1959, pp. 92–97, 101; vol. 52, No. 1, July 1959, pp. 89–91, 96; No. 3, September 1959, pp. 107–110; No. 7, January 1960, pp. 181, 182, 184.

[67] Journal of the American Ceramic Society, Dimensioning of Shielding Walls Against ν-Radiation: Vol. 42, No. 3, March 1959, p. 73.

[68] Journal of the American Concrete Institute, Bauxite Ore Aggregates for Shielding Concrete: Vol. 31, No. 5, November 1959, p. 430.

[69] Tabler, L. Earl, Jr., Internal Shielding Construction at Shippingport Nuclear Power Plant: Jour. Am. Construction Inst., vol. 30, No. 11, May 1959, pp. 1209–1214.

[70] Davis, H. S., and Borge, O. E., High Density Concrete Made with Hydrous-Iron Aggregates: Jour. Am. Construction Inst., vol. 30, No. 10, April 1959, pp. 1141–1147.

[71] Henrie, J. O., Properties of Nuclear Shielding Concrete: Jour. Am. Construction Inst., vol. 31, No. 1, July 1959, pp. 37–46.

[72] Construction Methods and Equipment, Soil Cement: Vol. 41, No. 5, May 1959, pp. 125, 126, 129.

Chromium

By Wilmer McInnis [1] and Hilda V. Heidrich [2]

⁂

UNITED STATES consumption and imports of chromite were higher than in 1958, even though steel strike cut demand for chromite by the ferroalloy and refractory industries during most of the last half of the year. Prices of foreign chromite ores declined about 20 percent. The Turkish Government increased the export premium on chromite to improve the competitive position of its producers.

TABLE 1.—Salient chromite statistics, short tons

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Production (shipments)	50,000	153,300	[1] 207,700	166,200	143,800	[2] 105,000
Value (thousands)	[3] $2,588	$6,644	$8,715	$7,815	$6,187	[3] $3,765
Imports for consumption	1,628,000	1,834,000	2,175,000	2,283,000	1,263,000	1,554,000
Exports	1,500	1,300	1,700	800	700	73,000
Consumption	1,125,000	1,584,000	1,847,000	1,760,000	1,221,000	1,337,000
Stocks Dec. 31 (consumers')	856,000	1,110,000	1,227,000	1,619,000	1,537,000	[4] 1,799,498
World production	3,615,000	4,020,000	[5] 4,575,000	[5] 5,110,000	[5] 4,165,000	4,255,000

[1] Includes 45,710 short tons of concentrate produced in 1955 and 1956 from low-grade ore and concentrate stockpiled near Coquille, Oreg., during World War II.
[2] Produced for Federal Government only.
[3] Estimated by Bureau of Mines.
[4] Includes stocks at locations other than consumers' plants.
[5] Revised figure.

LEGISLATION AND GOVERNMENT PROGRAMS

The Office of Minerals Exploration (OME) offered financial assistance to private industry to encourage exploration for domestic chromite deposits, but no applications for assistance were received during the year.

In August 1959, the General Services Administration (GSA) announced that approximately 2,050 long tons of Government-owned low-grade chromite ore and concentrate, of domestic origin, had been declared excess to mobilization requirements and could be sold after a statutory wait of 6 months.

The Commodity Credit Corp., Department of Agriculture, continued to acquire chromite ores, chromium ferroalloys, and chromium metal under the surplus agricultural product barter program.

---

[1] Commodity specialist.
[2] Statistical assistant.

DOMESTIC PRODUCTION

Except for small quantities produced (shipped) in California and Washington all domestic chromite output was from the Mouat mine in Montana. The American Chrome Co. shipped 105,000 short tons of concentrate, with an estimated value of $3,765,000, to the Federal Government stockpile under a long-term contract. The concentrate shipped averaged 38.5 percent Cr_2O_3 and had a Cr/Fe ratio of about 1.6:1. In addition to shipments to the Government stockpile, the American Chrome Co. consumed chromite in the manufacture of charge ferrochromium. This was the only domestic chromite reported used in making chromium ferroalloys.

The Bureau of Mines obtained 9 short tons of lumpy chromite ore from the Twin Sisters area in Washington for mineral dressing research, and a small quantity of chromite ore was shipped from the Lambert mine in California.

TABLE 2.—Chromite production (mine shipments) in the United States, by States, in short tons, wet weight

State	1955	1956	1957	1958		1959	
				Shipments	Value	Shipments	Value
Alaska	7,082	7,193	4,207	----------	----------	----------	----------
California	22,105	27,082	34,901	20,588	$1,646,000	(1)	----------
Montana	118,703	118,780	119,149	119,057	[2] 4,539,000	[3] 105,000	[2] $3,765,000
Oregon	5,341	[4] 54,577	7,900	4,133		----------	----------
Washington	22	30	----------	17	2,000	----------	----------
Total	153,253	[4] 207,662	166,157	143,795	6,187,000	[3] 105,000	[2] 3,765,000

[1] Small quantity produced, Bureau of Mines not at liberty to publish.

[2] Estimate.

[3] Dry weight; excludes quantity consumed by American Chrome Co.

[4] Includes 45,710 short tons of concentrate produced in 1955 and 1956 from low-grade ore and concentrate stockpiled near Coquille, Oreg., during World War II.

CONSUMPTION AND USES

Domestic consumption of 1,337,000 short tons of chromite ores and concentrate containing about 395,000 tons of chromium, was approximately 10 percent higher than in 1958. This increase occurred despite the steel strike which resulted in a sharp decrease in the quantities consumed in producing chromium ferroalloys, and chromite refractories during most of the last half of the year.

The metallurgical industry consumed 781,000 short tons of chromite (containing 249,000 tons of chromium) in producing 324,000 tons of chromium ferroalloys and chromium metal (containing 195,000 tons of chromium). In addition, 15,000 tons of chromite containing 5,000 tons of chromium was added directly to steel. Of the chromite consumed in making chromium ferroalloys and metal, 81 percent (47.9 percent Cr_2O_3) was Metallurgical-grade ore, 13 percent (44.5 percent Cr_2O_3) Chemical-grade ore, and 6 percent (34.6 percent Cr_2O_3) was Refractory-grade ore. Sixty-seven percent of the Metallurgical-grade ore had a Cr/Fe ratio of 3:1 and above, 27 percent had a ratio between 2:1 and 3:1, and 6 percent had a Cr/Fe ratio of less than 2:1.

Production of low-carbon ferrochromium declined 17 percent compared with output in 1958, but production of high-carbon ferrochromium increased 11 percent. The decrease in production of low-carbon ferrochromium was probably caused by the smaller quantity produced for delivery to the Federal Government rather than to a major shift in industrial use practice. The average chromium content of the low-carbon ferrochromium produced was 68.3 percent, and the high-carbon ferrochromium was 60.9 percent compared with 67.3 percent and 59.1 percent respectively, in 1958.

Producers of chromite refractories consumed 371,000 short tons of ore (containing 89,000 tons of chromium) in making bricks, mortars, and other refractory products, and 8,000 tons of ore (containing 1,900 tons of chromium) was used directly in furnace repairs. This was 22 percent higher than the quantity consumed in 1958. The increase was due mostly to expanding use of basic roofs in open hearth and other type steelmaking furnaces where chrome-magnesite and magnesite-chrome bricks were used instead of silica bricks.

The chemical industry consumed 162,000 short tons of chromite containing 50,000 tons of chromium (the highest in any year except 1951) in producing 119,000 tons of chromium chemicals, sodium bichromate equivalent.

TABLE 3.—Consumption of chromite and tenor of ore used by primary consumer groups in the United States, in thousand short tons

Year	Metallurgical		Refractory		Chemical		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)
1950–54 (average)	597	47.1	380	34.1	148	44.5	1,125	42.6
1955	994	46.5	431	34.4	159	44.8	1,584	43.0
1956	1,212	46.8	475	34.4	160	45.4	1,847	43.5
1957	1,177	47.1	435	34.8	148	45.0	1,760	43.9
1958	778	46.9	312	35.2	131	45.6	1,221	43.8
1959	796	46.7	379	35.0	162	45.4	1,337	43.2

As shown in figure 1, chromium (in chromite ores and concentrates) consumed by the metallurgical industry during 1940–59 ranged from a low of 49.4 percent in 1949 to a peak of 71.7 percent in 1957, averaging 61.7 percent of the total chromium consumed in the United States during the 20-year period. Chromium, in ores and concentrates, consumed by the refractory industry comprised 24.7 percent of the total for the 20 years, and that used by the chemical industry was 13.6 percent of the total. In terms of gross weight of ores and concentrates the metallurgical industry used 56 percent of the 21.4 million short tons consumed during 1940–59, the refractory industry used 31 percent, and the chemical industry consumed 13 percent.

Based on apparent consumption, the data given in table 4 represent about 94 percent of the total chromium ferroalloys and chromium metal consumed in the United States during 1959.

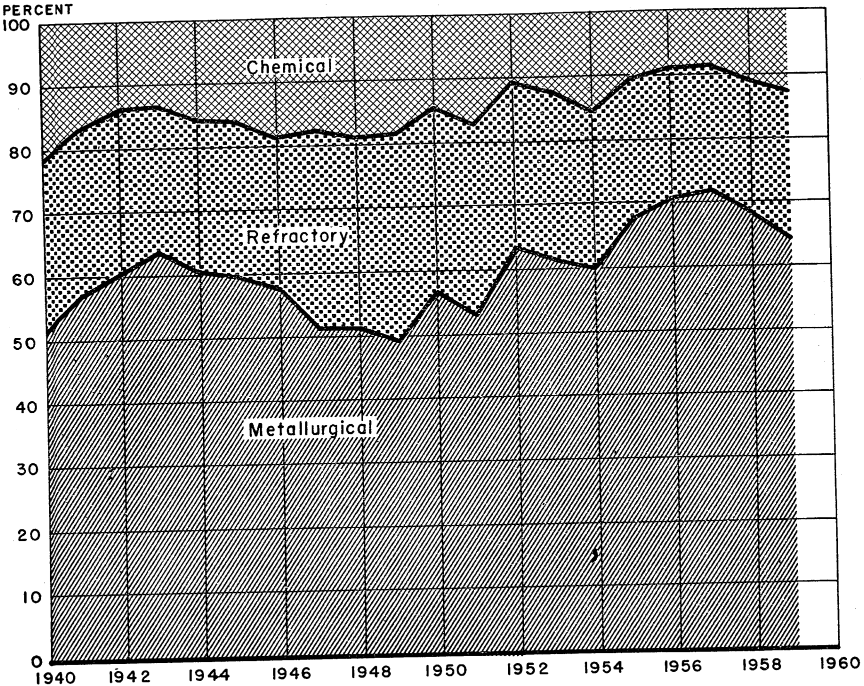

FIGURE 1.—Percent of total chromium contained in chromite consumed by domestic primary consumer groups, 1940–59.

TABLE 4.—Production, shipments, and stocks of chromium ferroalloys and chromium metal, 1959, in short tons, gross weight

Alloy	Net production	Chromium contained	Shipments	Producers stocks Dec. 31, 1959
Low-carbon ferrochromium	143, 811	98, 014	138, 004	27, 535
High-carbon ferrochromium	108, 426	66, 058	111, 446	31, 300
Low-carbon ferrochromium silicon	45, 788	19, 022	42, 736	10, 587
Other [1]	25, 492	11, 690	27, 870	2, 911
Total	323, 517	194, 784	320, 056	72, 333

[1] Includes chromium briquets, chromium metal, exothermic chromium additives, and other miscellaneous chromium alloys.

TABLE 5.—Consumption of chromium ferroalloys and metals in the United States in 1959 by major end uses, and consumers' stocks, in short tons

Alloy	Total		Contained weight								Stocks, Dec. 31, 1959 (gross weight)
	Gross weight	Contained chromium	Stainless steels	High-speed steels	Other tool steels	Other alloy steels [1]	Gray and malleable castings	High-temperature alloys	Nickel-base alloys	Other alloys	
Low-carbon ferrochromium	113,484	76,472	61,848	315	601	9,090	338	3,675	304	301	9,266
High-carbon ferrochromium	90,144	54,316	29,786	523	1,486	19,165	2,416	228	21	691	12,352
Low-carbon ferrochromium silicon	44,158	19,311	17,278		20	1,874	23	106		10	3,609
Exothermic ferrochrome-silicon	5,087	2,006				1,886	120				875
Chromium briquets	10,143	5,866	5,441			184	229	3		9	622
Other [2]	22,697	10,983	36		3	9,027	171	1,043	94	609	2,094
Total	285,713	168,954	114,389	838	2,110	41,226	3,297	5,055	419	1,620	28,818

[1] Includes quantities that were believed used in producing high-speed and other tool steels and stainless steels because some firms failed to specify individual uses.

[2] Includes exothermic high- and low-carbon ferrochromium, chromium metal, and other chromium alloys.

TABLE 6.—End use of individual chromium ferroalloys and chromium metal in the United States, 1959, percent

Alloy	Stainless steel	High-speed steel	Other tool steel	Other alloy steel	Gray and malleable castings	High temperature alloys	Nickel-base alloys	Other alloys
Low-carbon ferrochromium	80.9	0.4	0.8	11.9	0.4	4.8	0.4	0.4
High-carbon ferrochromium	54.8	1.0	2.7	35.3	4.5	0.4	--------	1.3
Low-carbon ferrochromium-silicon	89.5	--------	0.1	9.8	0.1	0.5	--------	--------
Chromium briquets	92.8	--------	--------	3.1	3.9	--------	--------	0.2
Exothermic ferrochrome-silicon	--------	--------	--------	94.0	6.0	--------	--------	--------
Low-carbon exothermic ferrochromium	--------	--------	--------	93.6	0.4	6.0	--------	--------
High-carbon exothermic ferrochromium	--------	--------	--------	97.8	1.4	--------	--------	0.8
Chromium metal	2.0	--------	0.1	5.2	0.6	56.3	5.3	30.5
Other chromium alloys	--------	--------	--------	4.9	95.1	--------	--------	--------

STOCKS

Chromite ores and concentrates held at locations other than consumer plants are not included in industry stocks before 1959. Stocks at the end of 1959 were equivalent to a 16-month supply.

Chromium ferroalloys and chromium metal at producers' and consumers' plants totaled 72,333 tons and 28,818 tons, respectively at the close of 1959.

Chromium chemicals at producers' plants on December 31, 1959, were 19,600 short tons, sodium bichromate equivalent.

TABLE 7.—Stocks of chromite at consumers' plants, December 31, 1955–59, in thousand short tons

Industry	1955	1956	1957	1958	1959
Metallurgical	628	640	849	749	[1] 955
Refractory	313	432	610	612	730
Chemical	169	155	160	176	115
Total	1,110	1,227	1,619	1,537	[1] 1,800

[1] Includes stocks at locations other than consumers' plants.

PRICES

There were no price quotations published for domestic chromite ores and concentrates. E&MJ Metal and Mineral Markets quoted prices for foreign chromite ores and concentrates delivered to east coast ports were about 20 percent lower at the yearend than at the beginning of 1959. Declines in prices for Metallurgical-grade chromite were not uniform. Price declines for ores from Turkey and the Federation of Rhodesia and Nyasaland were greater than for ores from other sources. On May 6, 1959, the Turkish Government increased the export premium on chromite by increasing the total exchange rate from TL 4.9 to TL 9 to the dollar that improved the competitive position of the chromite producers in that country.

Prices quoted for standard-grade high- and low-carbon ferrochromium and chromium metal were not changed. The prices quoted for bulk carlots delivered continental United States were: High-carbon ferrochromium (4 to 9 percent carbon, 65 to 70 percent chromium) 28.75 cents a pound of contained chromium; low-carbon ferrochromium (0.10 percent carbon, 67–72 percent chromium) 38.50 cents a pound of contained chromium; special ferrochromium (0.01 percent carbon, 63 to 66 percent chromium) 37.75 cents a pound of contained chromium; and electrolytic and aluminothermic chromium metal $1.15 a pound. The yearend quotation for charge ferrochromium No. 1 was 22 cents a pound of contained chromium and refined ferrochromium No. 1 was 25 cents a pound of contained chromium in bulk carlots delivered continental United States.

TABLE 8.—Price quotations for various grades of foreign chromite in 1959

[E&MJ Metal and Mineral Markets]

Source	Cr_2O_3 (percent)	Cr Fe ratio	Price per long ton[1]	
			Jan. 1, 1959	Dec. 31, 1959
Rhodesia[2]	48	3:1	$42–44	$34–35
Do	48	2.8:1	39–41	30–32
Do	48	----------	29–31	25–26
Union of South Africa	48	----------	30–32	24–26
Do	44	----------	22–23	18.25–19
Turkey	48	3:1	[2] [3] 43.50–47	36–37
Do	46	3:1	[2] [3] 41–42.50	33.50–34

[1] Quotations are on a dry basis, subject to penalties if guarantees are not met, f.o.b. cars, east coast ports.
[2] Term contract.
[3] February 5, 1959.

FOREIGN TRADE[3]

Imports.—Imports of chromite ores and concentrates contained 455,310 short tons of chromium of which 59 percent was in Metallurgical-grade material, 21 percent in Refractory-grade, and 20 percent in Chemical-grade ore and concentrate. The average value f.o.b. foreign sources for all grades of chromite ores was $22.96 a long dry ton. Average value by grades was: metallurgical (46.4 percent Cr_2O_3) $27.84, refractory (34.2 percent Cr_2O_3) $19.68, and chemical (44.0 percent Cr_2O_3) $13.49 a long dry ton f.o.b. foreign sources.

Compared with 1958, imports of all grades of chromite from the Union of South Africa increased 27 percent, Federation of Rhodesia and Nyasaland 112 percent, Philippines 46 percent, but those from Turkey decreased 53 percent, and were the lowest since 1947.

Metallurgical-grade chromite was imported from 11 countries, but 69 percent of the total was from the Federation of Rhodesia and Nyasaland, and Turkey, the free world's two major sources of high Cr/Fe ratio ore.

---

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 9.—Chromite imported for consumption in the United States, by countries and grades

[Bureau of the Census]

Country	Metallurgical grade			Refractory grade			Total		
	Short tons		Value	Short tons		Value	Short tons		Value
	Gross weight	Cr_2O_3		Gross weight	Cr_2O_3		Gross weight	Cr_2O_3	
1958									
North America: Cuba	10,255	4,359	$282,908	28,809	9,623	$548,721	39,064	13,982	$831,629
Europe: Greece	2,800	1,422	144,950				2,800	1,422	144,950
Asia:									
India	22,024	11,018	597,840	7,382	2,958	92,400	29,406	13,976	690,240
Philippines	28,490	13,096	754,127	216,351	70,653	3,697,447	244,841	83,749	4,451,574
Turkey	340,086	155,074	10,965,304				340,086	155,074	10,965,304
Total	390,600	179,188	12,317,271	223,733	73,611	3,789,847	614,333	252,799	16,107,118
Africa:									
Rhodesia and Nyasaland, Federation of	196,064	93,555	4,543,308	16,622	5,894	386,092	212,686	99,449	4,929,400
Union of South Africa	102,693	46,591	1,816,954	36,137	14,976	419,205	[1] 349,253	[1] 153,863	[1] 5,070,526
Western Portuguese Africa, n.e.c.	1,685	809	21,063				1,685	809	21,063
Total	300,442	140,955	6,381,325	52,759	20,870	805,297	[1] 563,624	[1] 254,121	[1] 10,020,989
Oceania: New Caledonia [2]	43,616	22,123	1,100,923				43,616	22,123	1,100,923
Grand total	747,713	348,047	20,227,377	305,301	104,104	5,143,865	[1] 1,263,437	[1] 544,447	[1] 28,205,609

1959									
North America:									
Cuba	36,876	15,985	897,094	6,856	2,423	166,695	43,732	18,408	1,063,789
Guatemala	1,500	720	75,000				1,500	720	75,000
Total	38,376	16,705	972,094	6,856	2,423	166,695	45,232	19,128	1,138,789
Europe:									
Greece	7,871	3,918	310,064				7,871	3,918	310,064
U.S.S.R.	63,143	30,579	2,196,437				63,143	30,579	2,196,437
Total	71,014	34,497	2,506,501				71,014	34,497	2,506,501
Asia:									
India	8,437	4,005	283,769				8,437	4,005	283,769
Iran	3,360	1,613	123,000				3,360	1,613	123,000
Philippines	47,366	21,594	965,135	310,912	101,276	5,684,950	358,278	122,870	6,650,085
Turkey	159,082	73,737	4,681,158				159,082	73,737	4,681,158
Total	218,245	100,949	6,053,062	310,912	101,276	5,684,950	529,157	202,225	11,738,012
Africa:									
Rhodesia and Nyasaland, Federation of	429,630	200,001	10,133,396	20,700	7,495	479,355	450,330	207,496	10,612,751
Union of South Africa	81,008	36,540	1,143,748	62,752	26,080	717,414	[1] 444,000	[1] 194,937	[1] 5,478,544
Total	510,638	236,541	11,277,144	83,452	33,575	1,196,769	[1] 894,330	[1] 402,433	[1] 16,091,295
Oceania: New Caledonia [2]	13,813	7,180	378,900				13,813	7,180	378,900
Grand total	852,086	395,872	21,187,701	401,220	137,274	7,048,414	[1] 1,553,546	[1] 665,463	[1] 31,853,497

[1] Includes chemical grade 1958: (country of origin adjusted by Bureau of Mines) 210,423 short tons, gross weight, 92,296 short tons Cr_2O_3, valued at $2,834,367; 1959: 300,240 short tons, gross weight, 132,317 short tons Cr_2O_3, valued at $3,617,382.

[2] Assumed source; classified in import statistics under "French Pacific Islands."

Chromium metal imports totaled 2,865 short tons valued at $5,179,482 of which 2,442 tons valued at $4,497,752 entered duty free for the United States Government. The import data for chromium metal in 1958 (Minerals Yearbook, 1958, page 312) were revised to 2,326 short tons valued at $4,716,176 of which 2,093 tons valued at $4,322,246 entered duty free for the United States Government. Ninety-four percent of the ferrochromium containing 3 percent or more carbon, and 69 percent of the ferrochromium containing less than 3 percent carbon imports given in table 9 entered duty free for the United States Government. Sodium chromate and sodium bichromate imports totaled 2,786 short tons valued at $588,018.

TABLE 10.—Ferrochromium imported for consumption in the United States, by countries

[Bureau of the Census]

Country	Low-carbon ferrochromium (less than 3 percent carbon)			High-carbon ferrochromium (3 percent or more carbon)		
	Short tons		Value	Short tons		Value
	Gross weight	Chromium content		Gross weight	Chromium content	
1958						
North America: Canada	----------	----------	----------	9,372	5,099	$2,159,862
Europe:						
France	3,205	2,297	$1,313,284	49	35	13,227
Germany, West	5,287	3,676	2,184,799	----------	----------	----------
Norway	----------	----------	----------	372	258	92,494
Sweden	36	25	15,812	838	559	270,771
Yugoslavia	2,018	1,548	714,464	165	131	23,611
Total	10,546	7,546	4,228,359	1,424	983	400,103
Asia: Japan	1,536	1,052	493,700	1,422	949	335,626
Africa:						
Rhodesia and Nyasaland, Federation of	146	103	62,824	----------	----------	----------
Union of South Africa	277	196	126,207	56	37	11,520
Total	423	299	189,031	56	37	11,520
Grand total	12,505	8,897	4,911,090	12,274	7,068	2,907,111
1959						
North America: Canada	30	22	10,763	3,995	2,706	1,063,281
Europe:						
France	9,813	6,900	3,680,531	2,254	1,546	762,038
Germany, West	4,706	3,364	1,715,135	10,288	7,272	2,779,491
Italy	----------	----------	----------	9,192	6,159	2,326,337
Norway	3,780	2,602	1,467,487	8,728	5,982	2,280,485
Sweden	5,753	4,007	2,190,389	2,543	1,735	623,984
United Kingdom	----------	----------	----------	5,237	3,597	1,443,290
Yugoslavia	1,858	1,315	620,049	----------	----------	----------
Total	25,910	18,188	9,673,591	38,242	26,291	10,215,625
Asia: Japan	9,536	6,322	3,776,561	8,070	5,430	2,562,601
Africa:						
Rhodesia and Nyasaland, Federation of	1,680	1,190	528,641	----------	----------	----------
Union of South Africa	----------	----------	----------	5,868	3,917	1,918,925
Total	1,680	1,190	528,641	5,868	3,917	1,918,925
Grand total	37,156	25,722	13,989,556	56,175	38,344	15,760,432

Exports.—In 1959 domestic exports included 6,127 short tons of ferrochromium valued at $2,095,978; 596 tons of chromic acid valued at $348,948; 6,737 tons of sodium bichromate and chromate valued at $1,541,748, and 7 tons of chromium metal valued at $18,623. Re-exports of ferrochromium totaled 708 tons valued at $198,930.

TABLE 11.—Chromite ore and concentrates exported from the United States

[Bureau of the Census]

Year	Domestic [1]		Foreign [2]	
	Short tons	Value	Short tons	Value
1950–54 (average)	1, 527	$77, 512	9, 101	$416, 426
1955	1, 341	75, 656	2, 950	86, 986
1956	1, 727	99, 169	12, 990	501, 938
1957	837	52, 579	4, 872	193, 546
1958	717	48, 829	52, 303	2, 157, 966
1959	[3] 72, 645	[3] 3, 084, 033	24, 467	976, 431

[1] Material of domestic origin or foreign material that has been ground, blended, or otherwise processed in the United States.

[2] Material that has been imported and later exported without change of form.

[3] Believed to be mostly foreign ore that was re-exported.

Tariff.—There were no changes in tariffs on chromite, chromium alloys, or chemicals.

WORLD REVIEW

Estimated world production of chromite ores and concentrates was slightly higher than in 1958. Although chromite was produced from deposits in 22 countries, 70 percent of the total was produced in 4 countries: Federation of Rhodesia and Nyasaland, Philippines, Union of South Africa, and the U.S.S.R.

TABLE 12.—World production of chromite, by countries,[1] in short tons[2]

[Compiled by Pearl J. Thompson and Berenice B. Mitchell]

Country[1]	1950-54 (average)	1955	1956	1957	1958	1959
North America:						
Cuba	75,771	85,107	59,248	127,126	[3] 82,800	[3] 66,000
Guatemala	413	287	979	[3] 1,100	1,168	452
United States	50,189	153,253	[4] 207,662	166,157	143,795	[5] 105,000
Total	126,373	238,647	267,889	294,383	227,763	171,452
South America: Brazil	3,038	4,546	4,536	8,748	6,336	6,177
Europe:						
Albania	72,091	135,000	154,000	184,000	221,800	[3] 220,000
Greece	29,466	27,902	86,920	82,700	72,217	[3] 71,600
Portugal	46	----------	----------	----------	----------	----------
U.S.S.R.[3] [6]	645,000	750,000	815,000	850,000	880,000	940,000
Yugoslavia	126,334	139,119	130,913	132,570	125,188	117,965
Total[1] [3]	893,000	1,075,000	1,210,000	1,270,000	1,320,000	1,370,000
Asia:						
Afghanistan	138	----------	----------	----------	----------	----------
Cyprus (exports)	13,668	9,599	5,858	5,678	13,260	[3] 14,300
India	40,297	100,071	59,009	87,968	67,668	93,936
Iran[7]	15,767	38,504	36,156	42,549	[3] 38,600	[3] 38,600
Japan	42,200	29,269	43,947	51,216	46,155	62,900
Pakistan	22,027	31,808	25,487	18,114	26,935	17,662
Philippines	460,076	655,882	781,598	799,733	458,903	718,149
Turkey	723,927	715,557	918,305	1,052,665	574,194	395,957
Total[6]	1,318,100	1,580,690	1,870,360	2,057,923	1,225,715	1,341,504
Africa:						
Egypt	171	926	281	114	----------	----------
Rhodesia and Nyasaland, Fed. of: Southern Rhodesia	483,941	449,202	448,965	654,072	618,841	543,104
Sierra Leone	20,205	23.231	21,929	17,602	15,944	22,400
Union of South Africa	658,545	597,368	690,851	733,612	696,057	749,873
Total	1,162,862	1,070,727	1,162,026	1,405,400	1,330,842	1,315,377
Oceania:						
Australia	2,543	----------	6,828	3,415	869	[3] 330
New Caledonia	107,551	50,790	53,932	70,768	52,249	48,463
Total	110,094	50,790	60,760	74,183	53,118	48,793
World total (estimate)[1]	3,615,000	4,020,000	4,575,000	5,110,000	4,165,000	4,255,000

[1] Chromite is also produced in Bulgaria and Rumania, but production data are not available; estimates by senior author of chapter for these countries are included in the world total.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Estimate.

[4] Includes 45,710 short tons of concentrates produced in 1955-56 from low-grade ores and concentrates stockpiled near Coquille, Oregon during World War II.

[5] Produced for Federal Government only; excludes quantity consumed by American Chrome Company.

[6] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.

[7] Year ended March 20 of year following that stated.

NORTH AMERICA

Cuba.—On October 27, 1959 the Cuban cabinet enacted a mining law that empowered the minister to order reactivation of inactive mines within 60 days of official notification, but with a provision that noncompliance automatically cancels concession rights and turns the mine ownership to the State. Another requirement of the law was that mine concessionaries must pay a tax in cash or ore equivalent, at the Government's option, of 5 percent of the value of production. The tax rate increased to 25 percent of the value of the mineral when exported. Chromite production in Cuba declined sharply. Production from the Cayouguan mine was reported to have totaled only 7,450 short tons compared with 11,405 tons in 1958, and 29,818 tons in 1957. The ore produced averaged 37.42 percent Cr_2O_3, 11.33 percent Fe, 3.54 percent SiO_2, 25.12 percent Al_2O_3, 16.33 percent MgO, and 0.84 percent CaO.[4] Chromite was produced in Camaguey Province by Minera Basica, S.A. and Minera Del Valle.

Chromite exports from Cuba totaled 26,162 short tons of which 80 percent was shipped to the United States, 9 percent to Italy, 7 percent to the Netherlands, and 4 percent to Peru.

Guatemala.—Chromite was produced from the Mina La Paz mine in Department of Jalapa and from the Anabella mine in Department of Huehuetenango. Exports of ore from the two mines totaled 452 short tons.

EUROPE

U.S.S.R.—Precise information on chromite production in the U.S.S.R. was not available. Chromite production in the country during 1958 was reported to have comprised 21.7 percent of the world total output.[5] Exports of chromite ore in 1958 were said to have totaled 237,000 short tons of which 59 percent went to free world countries and the rest to Communist nations. In 1959, the U.S.S.R. exported chromite ore to the United States for the first time since 1950.

AFRICA

Rhodesia and Nyasaland, Federation of.—The chromite reserve in the Federation of Rhodesia and Nyasaland was estimated at more than 500 million short tons of ore.[6]

Chromite resources occur in three types of deposits: Large lenticular bodies in the Selukwe, Belingwe, Mashaba, and Kwanda areas; parallel seams in the Great Dyke; and eluvial in flat, poorly drained soils of some areas of the Dyke.[7] All three grades of chromite (Chemical, Metallurgical, and Refractory) were produced during 1959, and it was estimated that the ratio of production was Metallurgical-grade ore 55 percent, Chemical-grade ore 28 percent, and Refractory-grade ore 17 percent.

Union of South Africa.—The Allied Chemical Corp. was reported to have acquired 51 percent of the shares of the Montrose Exploration Co., Ltd., a United Kingdom Company which owns chromite ore deposits and mines in the Transvaal District, Union of South Africa.[8] Allied Chemical Corp. entered into a long-term contract with Montrose Exploration Co. for its requirements of chromite ore. The geology of some chromite deposits in the eastern part of the Bushveld Complex was described.[9] Another report dealt with the

---

[4] U.S. Embassy, Havana, Cuba. State Department Dispatch 1227, Mar. 7, 1960.

[5] Bureau of Mines, Mineral Trade Notes, Special Supplement No. 58: Vol. 50, No. 1, January 1960, p. 11.

[6] U.S. Consulate, Johannesburg, Union of South Africa, State Department Dispatch 78: Sept. 29, 1959, pp. 12–13.

[7] Department of Mines, Salisbury, Southern Rhodesia, Facts and Figures of the Southern Rhodesian Chrome Industry: Oct. 10, 1959, 6 pp.

[8] Chemical Trade Journal and Chemical Engineering (London), vol. 145, No. 3786, Dec. 25, 1959, p. 1279.

[9] Cameron, Eugene N., and Emerson, Mark E., The Origin of Certain Chromite Deposits of the Eastern Part of the Bushveld Complex: Econ. Geol., vol. 54, No. 7, November 1959, pp. 1151–1213.

geology and description of chromite deposits in the Rustenburg area of the Bushveld Complex.[10]

Sierra Leone.—The change from primitive mining at the mines of Sierra Leone Chrome Mines Co., Ltd. in Sierra Leone to modern mechanization using a sectional conveyor system for moving overburden was described.[11] The mines are near the town Hargha and are 8 miles from the nearest railroad. Although 22,400 short tons of chromite was produced from the mines in 1959, only 5,600 short tons was reported exported.

ASIA

Cyprus.—The Cyprus Chrome Company, Ltd. produced about 15,000 short tons of chromite ore and concentrate that averaged about 46 percent Cr_2O_3.

Iran.—The principal productive chromite deposits in Iran are in the northeast and southeast parts of the country. The deposits in northeast Iran near the Village Forumad, are reported to be irregular lenses, pipes, or beds, and those in southeast Iran are tabular with steep dips.[12] The deposits are mostly high-grade, having a Cr_2O_3 content ranging to more than 50 percent and a Cr/Fe ratio up to 3.25:1.

Japan.—The Japanese ferroalloy industry increased capacity to produce both high- and low-carbon ferrochromium. The reported capacity at the end of 1959 was about 114,000 short tons of which approximately 44,000 tons was high-carbon and 70,000 tons low-carbon.[13] Ferrochromium producing firms in Japan include Showa Denko, Nippon, Kokan, Nippon Denki Yakin, Toshiba Denko, Azuma Kako, Nisso Seiko, and Tekkosha. The latter firm produces electrolytic chromium metal, also, and was producing at the rate of about 110 short tons a month at the beginning of the last quarter of 1959.[14]

Philippines.—Refractory-grade chromite comprised 82 percent of the total chromite ores and concentrates produced in the Philippines. All of the Refractory-grade ore was produced from the Masinloc property in Zambales Province, where it was reported estimated ore reserves at the beginning of 1959 totaled about 6,433,000 short tons compared with 5,594,000 tons at the beginning of 1958.[15] The Acoje Mining Co. continued to be the major producer of Metallurgical-grade chromite. Preliminary data indicated that 78 percent of the 572,000 tons of Refractory-grade ore was exported to the United States, 12 percent to the United Kingdom, 6 percent to Japan, and the rest to Belgium, Italy, and the Netherlands. The Metallurgical-grade ore was exported to Japan, United States, and Italy.

Turkey.—Chromite production in Turkey was the lowest since 1948. Many small chromite mines were presumably closed and those that

---

[10] Fourie, G. P., The Chromite Deposits in the Rustenburg Area: Union of South Africa, Department of Mines, Geol. Survey Bull. 27 (Pretoria), 1959, 45 pp.

[11] Journal of Mines, Metals and Fuels (Calcutta, India), Mechanised Handling of Ore in African Chrome Mines: Vol. 7, No. 10, October 1959, pp. 21–22.

[12] Nahai, L., and Murdock, Thomas G., Iran—A Growing Source of Chromite: World Min., vol. 13, No. 2, February 1960, pp. 35–37.

[13] Japan Metal Bulletin, Production Capacity of Ferrochrome Reaches 103,000 Tons: No. 1019, Jan. 26, 1960, p. 1.

[14] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 1, January 1960, p. 11.

[15] Mining World, vol. 21, No. 7, June 1959, p. 89.

continued to operate were reported to have experienced considerable difficulty in finding ready buyers for their output. The Turkish Government increased the premium on chromite exports early in May by allowing conversion of dollars earned from chromite exports at 9 Turkish Lira (T.L.) to the dollar compared with T.L. 4.9 before May. An economic study of chromite mining in Turkey was made by the American Minerals Attache in Ankara.[16] The report compared performance between the Government-owned chromite mines and those of private groups, cost of chromite mining with other minerals, and various other aspects pertaining to the economics of chromite mining and marketing.

The Turkish Ministry of Commerce gave exporters permission to use chromite ore (with a chromic oxide content not exceeding 42 percent) for barter with countries which did not have a trade or payments agreement with Turkey.[17] Negotiations between the Commodity Credit Corp., U.S. Department of Agriculture, and the Turkish Government for the exchange of some 80,000 tons of wheat for chromite ore had not resulted in a contract by yearend. An agreement was made between a United States firm and Turkish firms for the exchange of truck components for chromite ore.

No progress beyond the planning stage was reported in constructing a ferrochromium plant near Antalya.

Exports of chromite ore and concentrate from Turkey, the lowest in any year since 1947, totaled 337,176 short tons compared with 568,796 tons in 1958. The ore was shipped to 15 countries with 36 percent going to the United States.

TECHNOLOGY

Chromium technology described in literature and in patents issued ranged from rapid methods for analyzing chromite and its ores to preparing the metal in ultra pure form. The Federal Geological Survey developed methods for quantitative determination of the major constituents of chromite from aliquots of a solution, prepared by fusing a sample of chromite with sodium peroxide followed by water extraction and acidification.[18] An electrolytic method for preparing high-purity ductile chromium containing 0.005 percent oxygen, less than 0.002 percent nitrogen, and only traces of metallic impurities was described by Federal Bureau of Mines researchers.[19] Another method involving thermal decomposition of chromium iodide was reported to yield chromium of 99.99+percent purity.[20]

American Chrome Co. conducted research to improve the quality of chromite concentrate for use in its ferrochromium plant at Nye, Mont. The work resulted in plans to build an addition to the firm's

---

[16] Bureau of Mines, Mineral Trade Notes: Special Supplement No. 57, Vol. 49, No. 1, July 1959, 34 pp.

[17] Mining Journal (London), Turkish Chrome for Barter: Vol. 253, No. 6477, Oct. 9, 1959, p. 344.

[18] Dinnin, Joseph I., Rapid Analysis of Chromite and Chrome Ore: Geol. Survey, Bull. 1084–B, 1959, 68 pp.

[19] Block, F. E., Good, P. C., and Asai, G., Electrodeposition of High-Purity Chromium: Jour. of Electrochem. Soc., vol. 106, No. 1, January 1959, pp. 43–47.

[20] Battelle Technical Review, New High in Chromium Purity: Vol. 8, No. 11, November 1959, p. 14.

plant for upgrading the concentrate before smelting into ferrochromium.

Contamination of chromium from atmospheric nitrogen during both production and potential high temperature use was investigated. Atmospheric contamination of chromium after heating in air at 950° C. for 200 hours was reported to effect the metal's ductile to brittle transition temperature significantly.[21] Although the test specimens picked up both oxygen and nitrogen, no penetration of oxygen was detected but nitrogen had penetrated to a depth of ¼ inch causing a marked effect on the mechanical properties of the metal. A study to determine the source of nitrogen impurity in chromium deposited from chromic acid electrolytes concluded that dissolved atmospheric nitrogen in the electrolyte had no influence on nitrogen contamination of the electrodeposited metal.[22]

Progress in research on fabricating chromium was reported to have resulted in techniques for extruding thin walled tubing from laboratory-grade chromium powder.[23]

A method was patented for upgrading chromite ore and concentrate by roasting the fine ground chromite with carbonaceous material under reducing conditions followed by leaching the roasted product with a sulfuric acid solution having a pH between about 2.0 and 6.0.[24] Other patents issued during the year included a method for removal of lead from chromium sulfate electrolyte, forging chromium-manganese austenitic steels, heat treating and working chromium steels to effect resistance to creep, coating magnesium articles with chromate, chromizing iron and steel, and plating chromium directly on aluminum.[25]

---

[21] Wilms, G. R., and Rea, T. W., Atmospheric Contamination of Chromium and Its Effect on Mechanical Properties: Jour. of the Less-Common Metals (Amsterdam Netherlands), vol. 1, No. 2, April 1959, pp. 152–156.

[22] Ryan, N., and Lumley, E. J., The Source of the Nitrogen Impurity in Electrodeposited Chromium: Jour. of the Electrochem. Soc., vol. 106, No. 5, May 1959, pp. 388–391.

[23] Metal Progress, Ductile Chromium Metal: Vol. 76, No. 6, December 1959, p. 29.

[24] Harris, Dwight, L. (assigned to American Chrome Co., Nye, Mont.), Chemical Upgrading of Chromium-Bearing Materials: U.S. Patent 2,905,546, Sept. 22, 1959.

[25] Carosella, Michael C., Jacobs, James H., and McNeill, Thomas R. (assigned to Union Carbide Corp.), New York, Lead Removal in the Electrowinning of Chromium: U.S. Patent 2,872,395, Feb. 3, 1959. Mitchell, Joseph R. (assigned to United States Steel Corp. of New Jersey), Method of Forging Chromium Manganese Austenitic Steels: U.S. Patent 2,878,150, Mar. 17, 1959. Harris, Geoffrey, T., and Child, Henry C. (assigned to the Birmingham Small Arms Co., Ltd.), Birmingham, England., Creep Resistant Chromium Steel: U.S. Patent 2,905,577, Sept. 22, 1959. Whitby, Lawrence (assigned to the Dow Chemical Co., Midland, Mich.), Composition for and Method of Chrome Pickling of Magnesium Shapes: U.S. Patent 2,887,418, May 19, 1959. Samuel, George A. (assigned to Metal Diffusion, Inc., Philadelphia, Pa.), Chromizing Coating: U.S. Patent 2,885,301, May 5, 1959. Wasserman, Arthur (assigned to Tiarco Corp., Newark, N.J.), Electroplating: U.S. Patent 2,888,387, May 26, 1959.

Clays

By Taber de Polo[1] and Betty Ann Brett[2]

◆

Contents

TONNAGE of clays sold or used by producers in 1959 increased 13 percent over 1958 and total value was 11 percent larger. Imports and exports also increased. The gain in clay tonnage used was counted in virtually all segments of the industry. Most States likewise reported increases.

The 100 leading firms supply 15 percent of clay production; the next 1,300 firms supply 85 percent.

TABLE 1.—Salient statistics of clays and clay products in the United States

(Thousand short tons and thousand dollars)

	1950–54 (average)	1955	1956	1957	1958	1959
Domestic clays sold or used by producers:						
Quantity	[1] 41,879	48,105	50,774	45,622	43,750	49,383
Value	[1] $120,536	$139,539	$163,048	$155,805	$143,487	$159,659
Imports:						
Quantity	148	192	176	162	[2] 162	176
Value	$2,124	$2,941	$2,969	$2,940	$2,900	$3,288
Exports:						
Quantity	299	406	511	485	450	489
Value	$6,967	$10,891	$12,593	$13,528	$12,129	$13,474
Value of clay refractories, shipments	[3] $149,523	$181,076	$208,608	$207,640	$162,887	$178,522
Value of principal clay construction products, shipments	[4] $399,600	$491,200	$503,400	$437,000	[5] $453,000	$521,500

[1] Includes Puerto Rico 1953–54.
[2] Adjusted by Bureau of Mines.
[3] Does not include value of shipments of ground crude fire clay, high-alumina, and silica fire clay for 1954
[4] 1954 only.
[5] Revised figure.

---

[1] Commodity specialist.
[2] Statistical clerk.

Trends in the clay industry were toward research on improved products, more economical processes, and more efficient equipment; new plant construction, expansion, and modernization; and a closer liaison between producers, architects, and consumers.

The market for lightweight aggregate continued to be strong in the masonry unit, structural, precast, and prestressed concrete fields. Activity in the new all-clay lightweight building block field continued to increase.

TABLE 2.—Value of clays produced in the United States, by States

(Thousand dollars)

State	1958	1959	Kinds of clay produced in 1959
Alabama	[1] $1,787	[1] $2,089	Kaolin, fire clay, miscellaneous clay.
Alaska	—	1	Fire clay.
Arizona	[2] 179	[2] 179	Fire clay, bentonite, miscellaneous clay.
Arkansas	1,578	2,406	Fire clay, miscellaneous clay.
California	5,012	5,646	Kaolin, ball clay, fire clay, bentonite, fuller's earth, miscellaneous clay.
Colorado	1,111	1,160	Fire clay, miscellaneous clay.
Connecticut	299	368	Miscellaneous clay.
Florida	5,808	[1] [3] 6,171	Kaolin, fuller's earth, miscellaneous clay.
Georgia	31,253	36,232	Do.
Idaho	[2] [4] 20	[4] 33	Fire clay, bentonite, miscellaneous clay.
Illinois	5,910	4,950	Fire clay, miscellaneous clay.
Indiana	2,477	2,915	Do.
Iowa	[4] 1,054	1,168	Do.
Kansas	1,145	1,271	Do.
Kentucky	2,957	3,595	Ball clay, fire clay, miscellaneous clay
Louisiana	[2] 755	[2] 904	Bentonite, miscellaneous clay.
Maine	26	26	Miscellaneous clay.
Maryland	[5] 815	[5] 944	Ball clay, fire clay, miscellaneous clay
Massachusetts	111	229	Miscellaneous clay.
Michigan	1,813	1,937	Do.
Minnesota	150	267	Fire clay, miscellaneous clay.
Mississippi	3,338	4,064	Ball clay, fire clay, bentonite, fuller's earth, miscellaneous clay.
Missouri	5,986	6,898	Fire clay, miscellaneous clay.
Montana	[2] [4] 19	[2] [4] 48	Fire clay, bentonite, miscellaneous clay
Nebraska	110	133	Fire clay, miscellaneous clay.
New Hampshire	26	26	Miscellaneous clay.
New Jersey	2,181	1,895	Fire clay, miscellaneous clay.
New Mexico	[4] 73	[4] 77	Do.
New York	1,419	1,714	Miscellaneous clay.
North Carolina	[1] 1,187	[1] 1,522	Kaolin, miscellaneous clay.
North Dakota	[2] 66	[2] 79	Bentonite, miscellaneous clay.
Ohio	13,082	15,346	Fire clay, miscellaneous clay.
Oklahoma	[2] 579	[2] 970	Fire clay, bentonite, miscellaneous clay.
Oregon	293	308	Bentonite, miscellaneous clay.
Pennsylvania	[1] 17,051	17,196	Fire clay, kaolin, miscellaneous clay.
South Carolina	5,156	5,920	Kaolin, miscellaneous clay.
South Dakota	[2] 155	[2] 227	Bentonite, miscellaneous clay.
Tennessee	4,210	4,952	Ball clay, fuller's earth, miscellaneous clay.
Texas	[6] 5,424	[6] 5,703	Fire clay, bentonite, fuller's earth, miscellaneous clay.
Utah	[1] 488	[1] 484	Kaolin, fire clay, bentonite, fuller's earth, miscellaneous clay.
Virginia	1,143	1,396	Miscellaneous clay.
Washington	[4] 183	[4] 171	Fire clay, bentonite, miscellaneous clay.
West Virginia	1,960	2,492	Fire clay, miscellaneous clay.
Wisconsin	167	192	Miscellaneous clay.
Wyoming	[4] 9,968	[4] [3] 9,449	Fire clay, bentonite, miscellaneous clay
Other	[7] 4,963	[7] 5,906	
Total	143,487	159,659	
Puerto Rico	83	83	Miscellaneous clay.

[1] Value of kaolin included with "Other" to avoid disclosing individual company confidential data.

[2] Value of bentonite included with "Other" to avoid disclosing individual company confidential data.

[3] Value of miscellaneous clay included with "Other" to avoid disclosing individual company confidential data.

[4] Value of fire clay included with "Other" to avoid disclosing individual company confidential data.

[5] Value of ball clay included with "Other" to avoid disclosing individual company confidential data.

[6] Value of fuller's earth included with "Other" to avoid disclosing individual company confidential data.

[7] Includes Delaware, D.C., Hawaii, Nevada and Vermont; values indicated by footnotes 1 through 6.

REVIEW OF DOMESTIC PRODUCTION, PRICES, AND FOREIGN TRADE BY TYPE OF CLAY

CHINA CLAY OR KAOLIN

The quantity and value of domestic kaolin sold or used increased 14 percent. The paper, rubber, refractories, and pottery industries continued to be the principal consumers, accounting for 81 percent. The remainder was used for a variety of purposes including cement, floor and wall tile, fertilizers, chemicals, insecticides, paint filler or extender, and linoleum. All large uses for kaolin increased.

Most production came from Georgia, which accounted for 77 percent of the tonnage.

Deposits of kaolin were found in Puerto Rico on Cerro La Tiza Mountain 16 miles southwest of San Juan, by geologists working for the Economic Development Administration of Puerto Rico.[3]

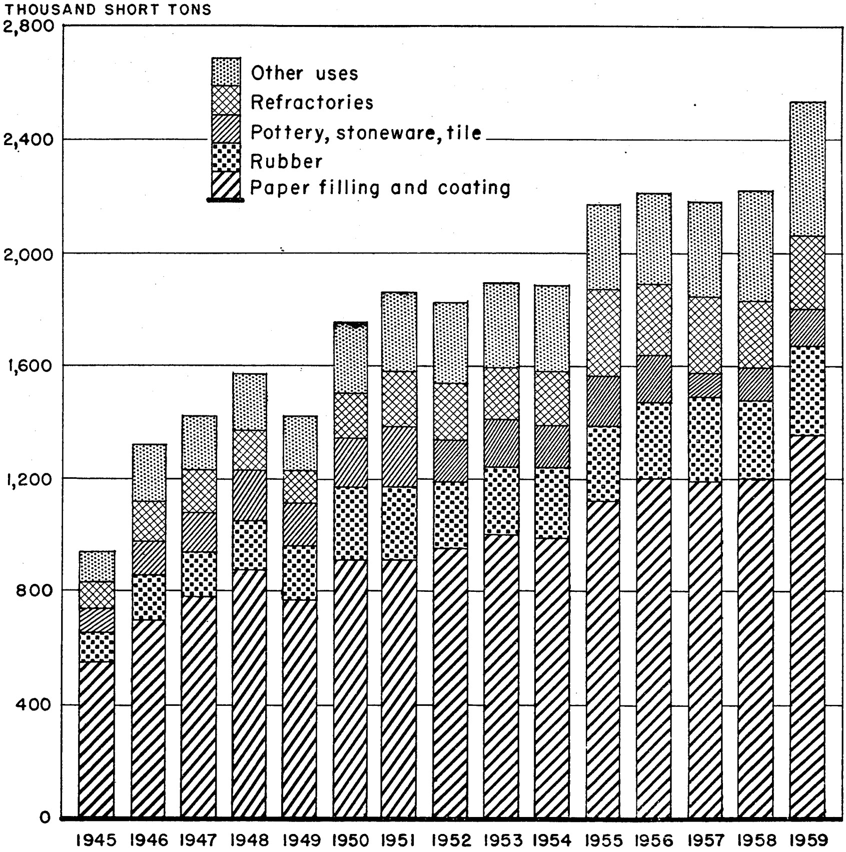

FIGURE 1.—Kaolin sold or used by domestic producers for specified uses, 1945–59.

---

[3] Mining World, International News: Vol. 21, No. 8, July 1959, p. 82.

TABLE 3.—Kaolin sold or used by producers in the United States

	Sold by producers		Used by producers		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
Year						
1950–54 (average)	1,699,734	$25,031,219	140,913	$885,887	1,840,647	$25,917,106
1955	1,942,369	29,943,156	224,031	1,939,878	2,166,400	31,883,034
1956	2,003,087	31,829,389	246,833	2,674,327	2,249,920	34,503,716
1957	1,941,801	33,072,638	241,884	2,525,143	2,183,685	35,597,781
State						
1958						
California	10,516	161,232			10,516	161,232
Florida and North Carolina	31,745	766,702			31,745	766,702
Georgia	1,568,210	28,135,677	128,488	1,212,584	1,696,698	29,348,261
South Carolina	(1)	(1)	(1)	(1)	377,535	4,664,363
Other States [2]	393,055	4,927,702	90,171	1,217,300	105,691	1,480,639
Total	2,003,526	33,991,313	218,659	2,429,884	2,222,185	36,421,197
1959						
California	12,959	203,028			12,959	203,028
Florida and North Carolina	29,288	706,359			29,288	706,359
Georgia	1,809,883	32,919,921	130,396	1,045,108	1,940,279	33,965.029
Pennsylvania	29,607	168,150			29,607	168,150
South Carolina	(1)	(1)	(1)	(1)	446,086	5,292,097
Other States [2]	423,397	5,270,379	99,944	1,369,009	77,255	1,347,291
Total	2,305,134	39,267,837	230,340	2,414,117	2,535,474	41,681,954

[1] Included with "Other States."

[2] Includes States indicated by footnote 1, and Alabama, Pennsylvania (1958 only), and Utah.

TABLE 4.—Georgia kaolin sold or used by producers, by uses

Year	China clay, paper clay, etc.	Refractory uses	Total kaolin		
				Value	
	Short tons (thousands)	Short tons (thousands)	Short tons (thousands)	Total (thousands)	Average per ton
1950–54 (average)	1,148	156	1,304	$19,006	$14.58
1955	1,327	166	1,493	23,376	15.66
1956	1,456	208	1,664	26,605	15.99
1957	1,414	245	1,659	28,210	17.01
1958	1,510	187	1,697	29,348	17.30
1959	1,751	189	1,940	33,965	17.51

Prices quoted in December by Oil, Paint and Drug Reporter for Georgia kaolin were: Dry-ground, air floated, 99 percent through 325-mesh, in bags, carlots, f.o.b. plant, $10 to $12 a short ton; same, less than carlots, $15 a ton; air floated, 99 percent through 300-mesh, in bags, carlots, f.o.b. plant, $13.50 to $14.50 a short ton; same, less than carlots, $35 to $36 a ton.

Prices for imported china clay in December were quoted by Oil, Paint and Drug Reporter as follows: White, lump, carlots, ex dock (Philadelphia, Pa., and Portland, Maine), $20 to $35 a long ton; powdered, ex dock, in bags, $50 a ton; less than carlots, $60 to $70 a ton.

Imports of kaolin increased 5 percent over 1958 to 141,000 short tons. Over 99 percent of the imports came from the United Kingdom. The remainder came from Canada and Mexico.

Exports of china clay or kaolin increased 26 percent over 1958; 67 percent went to Canada, 11 percent to Mexico, and 3 percent each to Venezuela, Cuba, and Italy. Small tonnages also went to other countries in Central America, South America, Europe, Africa, and Asia.

BALL CLAY

Tonnage increased 20 percent, and the value of ball clay sold or used by producers increased 17 percent over 1958. Tennessee continued to be the major producer, accounting for 64 percent of the U.S. total tonnage.

Approximately 58 percent of the ball clay produced was consumed in the pottery industry.

In December 1959 the Oil, Paint and Drug Reporter quoted prices for ball clay as follows: Crushed, shed moisture, bulk, carlots, f.o.b. plant (Tennessee), $8 to $11 a short ton; air floated, in bags, carlots, f.o.b. plant (Tennessee), $17.50 to $21.50 a ton.

Quotations on imported ball clay in Oil, Paint and Drug Reporter for December 1959 were: Air floated, in bags, carlots, Atlantic ports, $42 to $45.75 a short ton; lump, bulk, Atlantic ports, $29.50 to $35.75 a short ton.

Imports of common blue and ball clay increased 43 percent in tonnage and 48 percent in value over 1958. Unmanufactured blue and ball clays represented the major share of the imports; the United Kingdom supplied 99 percent of this classification and most of the imports of manufactured blue and ball clay. Small tonnages of unmanufactured blue and ball clays came from Canada, West Germany, Malta, Gozo, and Cyprus. Imports of Gross Almerode clays, including fuller's earth, totaled 547 short tons, a 39-percent decrease from 1958; Canada, with 175 short tons in 1959, compared with total imports of 582 short tons in 1958, accounted for the decrease. Other imports of Gross Almerode and fuller's earth were from West Germany, United Kingdom, Japan, and Colombia.

TABLE 5.—Ball clay sold or used by producers in the United States

	Short tons	Value		Short tons	Value
Year			*State*		
1950–54 (average)	320,685	$3,843,858	1959		
1955	411,354	5,386,777	Kentucky	111,620	$1,519,345
1956	458,806	6,081,318	Tennessee	303,188	4,163,739
1957	408,286	5,521,195	Other States [1]	60,427	776,818
State			Total	475,235	6,459,902
1958					
Kentucky	94,217	1,332,968			
Tennessee	252,433	3,541,045			
Other States [1]	50,299	628,973			
Total	396,949	5,502,986			

[1] Includes California, Maryland, and Mississippi.

FIRE CLAY

The tonnage and value of fire clay sold or used by producers in the United States increased 12 percent over 1958. A greater demand for fire-clay brick and block was responsible for the increase.

The three States producing the largest quantities—Ohio, Pennsylvania, and Missouri—all reported substantial increases. Together, these states accounted for 59 percent of the total U.S. fire-clay production. Only Illinois and New Jersey reported decreases.

The principal uses of fire clay were for manufacturing refractories, which consumed 54 percent of total output (44 percent in 1958), and heavy clay products, including architectural terra cotta, which consumed 42 percent (51 percent in 1958). About 1 percent was used in floor and wall tile, 1 percent in chemicals, and 2 percent in a variety of applications. Fire clay used in manufacturing refractories increased 39 percent, accounting for the increase in total tonnage used. Decreases were noted for chemicals and floor and wall tile.

The average value per short ton of fire clay sold by producers (as reported to the Federal Bureau of Mines) was $3.47, compared with $3.24 in 1958, $3.20 in 1957, and $2.86 in 1956. The average value of all fire clay, including both sales and captive tonnage, was $4.58, compared with $4.59 in 1958.

Prices quoted on firebrick in December 1959 in E&MJ Metal and Mineral Markets were: Superduty, $185 per thousand; high duty, $140; low duty, $103.

Exports of fire clay increased 9 percent in quantity to 137,389 short tons, and increased 31 percent in value over 1958. The average value was $17.96 a short ton, compared with $14.93 in 1958. Canada received 40 percent, Mexico 34 percent, Japan 17 percent, Netherlands 2 percent, and Italy 1 percent of the exports. The remaining 6 percent comprised small tonnages to many destinations in Central and South America, Europe, Asia, and Africa.

BENTONITE

The quantity of bentonite sold or used by producers increased 6 percent, and the value increased 3 percent from 1958, principally because of higher consumption in foundries and steelworks and in drilling mud for oil exploration.

The foundry and petroleum industries consumed 83 percent of the total tonnage compared with 78 percent in 1958. Wyoming, the largest producer, accounted for 56 percent of total production. Although a 9-percent gain over 1958 production for Wyoming was reported, the value decreased. Mississippi and Texas accounted for substantial production with 15 percent and 10 percent, respectively.

The Oil, Paint and Drug Reporter, December 1959, reported the price of bentonite as follows: 200-mesh, in bags, carlots, f.o.b. mines (Wyoming), $14 a short ton; Imported, Italian white, high gel, in bags, 5-ton lots, ex warehouse, $95.20 a ton and 1-ton lots $99 a ton; Italian, low gel, in bags, 5-ton lots, ex warehouse, $93.40 a ton and 1-ton lots $97.16 a ton.

The average value per short ton, as reported to the Bureau of Mines, was $11.54, compared with $11.86 in 1958.

The Archer-Daniels-Midland Co., Upton, Wyo., completed rebuilding its bentonite plant, which was destroyed by fire in 1958.

TABLE 6.—Fire clay, including stoneware clay, sold or used by producers in the United States [1]

	Sold by producers		Used by producers		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
Year						
1950-54 (average)	2,871,016	$9,107,377	7,476,571	$30,476,857	10,347,587	$39,584,234
1955	3,275,044	10,265,553	7,564,785	31,854,002	10,839,829	42,119,555
1956	3,542,541	10,149,016	8,260,552	43,600,870	11,803,093	53,749,886
1957	2,947,798	9,431,240	7,857,301	41,879,524	10,805,099	51,310,764
State						
1958						
Alabama	139,435	350,798	96,581	267,200	236,016	617,998
Arizona	----------	----------	50	50	50	50
Arkansas	----------	----------	313,150	1,312,784	313,150	1,312,784
California	150,624	422,844	221,731	693,950	372,355	1,116,794
Colorado	207,046	502,164	60,118	267,732	267,164	769,896
Illinois	199,405	1,075,626	525,916	1,657,631	725,321	2,733,257
Indiana	(2)	(2)	(2)	(2)	314,771	517,544
Kansas	----------	----------	183,232	439,493	183,232	439,493
Kentucky	24,250	81,222	165,231	970,641	189,481	1,051,863
Maryland	(2)	(2)	(2)	(2)	47,703	200,291
Missouri	169,119	509,660	1,043,119	4,629,654	1,212,238	5,139,314
Nebraska	----------	----------	2,450	2,450	2,450	2,450
New Jersey	(2)	(2)	(2)	(2)	135,413	1,049,909
Ohio	697,730	2,360,081	1,595,729	7,583,069	2,293,459	9,943,150
Oklahoma	----------	----------	300	3,000	300	3,000
Pennsylvania	327,642	813,505	1,216,633	11,333,900	1,544,275	12,147,405
Texas	(2)	(2)	(2)	(2)	501,648	1,135,043
Utah	4,563	26,164	17,757	48,184	22,320	74,348
West Virginia	(2)	(2)	(2)	(2)	264,107	1,732,634
Other States [3]	356,931	1,227,315	1,089,433	3,841,123	182,722	433,017
Total	2,276,745	7,369,379	6,531,430	33,050,861	8,808,175	40,420,240
1959						
Alabama	185,296	455,735	92,348	281,367	277,644	737,102
Alaska	----------	----------	180	1,458	180	1,458
Arizona	----------	----------	50	50	50	50
Arkansas	----------	----------	398,799	2,022,918	398,799	2,022,918
California	90,681	271,502	345,812	1,296,745	436,493	1,568,247
Colorado	193,339	550,355	77,244	346,560	270,583	896,915
Illinois	(2)	(2)	(2)	(2)	321,593	2,157,582
Indiana	(2)	(2)	(2)	(2)	365,662	564,782
Iowa	(2)	(2)	(2)	(2)	15,820	42,635
Kansas	----------	----------	266,930	516,711	266,930	516,711
Kentucky	78,624	309,986	168,800	947,351	247,424	1,257,337
Maryland	(2)	(2)	(2)	(2)	58,265	235,809
Mississippi	----------	----------	70,000	140,000	70,000	140,000
Missouri	228,861	540,913	1,428,222	5,379,678	1,657,083	5,920,591
Nebraska	----------	----------	2,450	2,450	2,450	2,450
New Jersey	(2)	(2)	(2)	(2)	126,943	947,659
Ohio	568,066	2,296,240	1,790,434	9,649,080	2,358,500	11,945,320
Oklahoma	----------	----------	325	3,250	325	3,250
Pennsylvania	357,465	1,029,239	1,445,704	11,054,956	1,803,169	12,084,195
Texas	25,991	64,570	696,109	1,531,224	722,100	1,595,794
Utah	(2)	(2)	(2)	(2)	37,198	96,145
West Virginia	(2)	(2)	(2)	(2)	328,792	2,178,974
Other States [3]	544,128	2,358,486	805,828	4,140,012	95,683	274,912
Total	2,272,451	7,877,026	7,589,235	37,313,810	9,861,686	45,190,836

---

[1] Includes stoneware clay as follows: 1950-54 (average)—74,692; 1955—62,446; 1956—74,143; 1957—30,089; 1958—26,429; 1959—27,418.

[2] Included with "Other States."

[3] Includes States indicated by footnote 2 and Idaho, Iowa (1958), Minnesota, Mississippi (1958), Montana, Nevada, New Mexico, Washington, and Wyoming.

TABLE 7.—Bentonite sold or used by producers in the United States

	Short tons	Value
Year		
1950–54 (average)	1, 211, 809	$13, 452, 274
1955	1, 480, 205	17, 219, 015
1956	1, 570, 610	18, 414, 807
1957	1, 450, 867	17, 806, 546
State		
1958		
California	5, 843	105, 715
Mississippi	177, 041	2, 080, 801
Texas	121, 106	889, 014
Utah	6, 325	76, 923
Washington	10	200
Wyoming	702, 237	9, 592, 209
Other States [1]	278, 852	2, 572, 388
Total	1, 291, 414	15, 317, 250
State		
1959		
California	5, 979	$123, 047
Idaho	140	1, 400
Mississippi	200, 256	2, 494, 325
Oregon	148	3, 000
Texas	133, 317	946, 588
Utah	6, 703	81, 029
Washington	50	300
Wyoming	763, 834	9, 449, 024
Other States [1]	261, 859	2, 742, 742
Total	1, 372, 286	15, 841, 455

[1] Includes Arizona, Idaho (1958), Louisiana, Montana, Nevada, North Dakota, Oklahoma, and South Dakota.

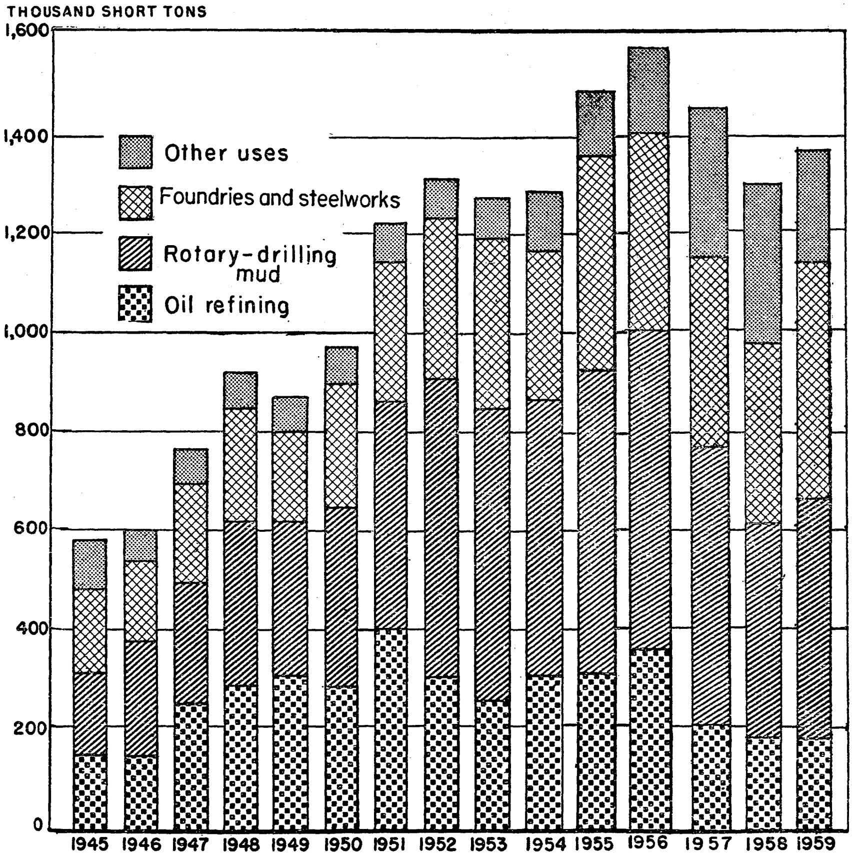

FIGURE 2.—Bentonite sold or used by domestic producers for specified uses, 1945–59.

FULLER'S EARTH

Fuller's earth sold or used by producers increased 14 percent in tonnage and 19 percent in value over 1958. Sixty percent of the production came from Florida, which continued as the leading producer. Absorbent uses accounted for 44 percent of the national consumption; insecticides and fungicides, 23 percent; rotary-drilling mud, 16 percent; mineral oil refining, 10 percent; and other minor uses and exports the remaining 7 percent.

The average value per short ton of fuller's earth reported sold or used in the United States was $22.04, compared with $21.26 in 1958.

TABLE 8.—Fuller's earth sold or used by producers in the United States

	Short tons	Value		Short tons	Value
			State		
Year			1959		
1950–54 (average)	422,932	$7,197,668	Florida	245,288	$6,171,076
1955	369,719	7,620,319	Georgia	99,212	1,719,182
1956	417,715	8,879,324	Tennessee	30,028	456,504
1957	366,101	8,056,841	Utah	2,818	38,700
			Other States [1]	32,276	641,597
State			Total	409,622	9,027,059
1958					
Florida	210,517	5,143,191			
Georgia	83,930	1,425,742			
Tennessee	27,485	389,236			
Utah	3,086	41,400			
Other States [1]	32,865	609,480			
Total	357,883	7,609,049			

[1] Includes California, Mississippi, Nevada (1959), and Texas.

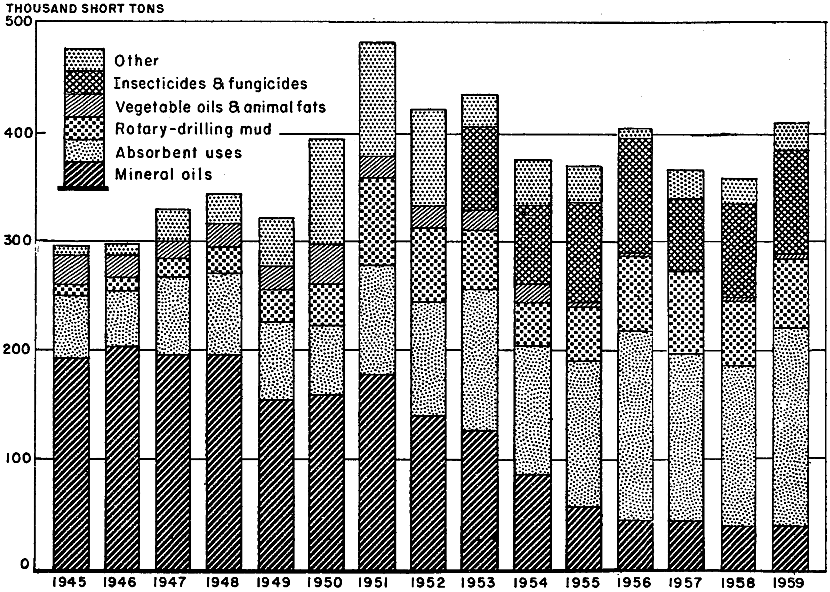

FIGURE 3.—Fuller's earth sold or used by producers for specified uses, 1945–59.

Quotations on domestic fuller's earth in Oil, Paint and Drug Reporter for December 1959 were: In bags, carlots, Illinois mines, $19 a short ton; same, calcined, $20 to $21.75 a ton; Insecticide grade, dried, powdered, in bags, carlots, Georgia or Florida mines, $17.50 a short ton; Oil-Blacking grade, 100-mesh, in bags, carlots, f.o.b. Georgia and Florida mines, $16.30 to $17 a short ton; same basis, 200-mesh, $17.50 to $18; and spent, in bags, carlots, shipping point, $4.50 to $5 a short ton.

Effective January 1, 1955, fuller's earth import statistics were not classified separately but were included under "Other clay." Exports are not given separately in official foreign-trade statistics; however, 9,936 short tons was exported, according to reports made by producers to the Bureau of Mines.

The Florida Company claimed to have reserves of fuller's earth at Quincy and Jamieson, Fla., that would last for 100 years.

MISCELLANEOUS CLAY

This section presents the statistics for the large-tonnage clays and shales—other than those discussed in the preceding pages—used in manufacturing heavy clay products, portland cement, and lightweight aggregate. With these are grouped small tonnages of slip clay, oil well drilling mud, pottery clay, and clays that cannot clearly be identified with one of the types discussed separately in this chapter.

Miscellaneous clays sold or used by producers increased 13 percent in tonnage and 8 percent in value over 1958. Increases in the quantity of miscellaneous clay used in heavy clay products, lightweight aggregate, cement, and floor and wall tile accounted for the rise in production. Captive tonnage—clay produced by mine operators for their own use in manufacturing brick, tile, cement, lightweight aggregate, and other minor products and marketed for the first time as such—was 97 percent of the miscellaneous clay sold or used in 1959. Of the States for which data are shown in table 9, all except four reported increased tonnage. Texas and Ohio reported tonnages exceeding 3 million short tons.

The average reported value of miscellaneous clay sold as crude or prepared clay was $1.74 a short ton, compared with $1.72 in 1958. Some special types of clay included under the miscellaneous-clay classification, however, sold at much higher prices. The value of captive tonnage was computed from individual estimates averaging slightly over $1 a short ton.

The Sunray Mid-Continent Oil Co. of Tulsa, Okla., reported discovery of a million tons of pure clay on a 25,000 acre tract in the Mojave Desert of Southern California, on which they have been core drilling.

TABLE 9.—Miscellaneous clay, including shale and slip clay sold or used by producers in the United States

	Sold by producers		Used by producers		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
Year						
1950-54 (average)[1]	1,485,786	$2,866,520	26,249,920	$27,674,767	27,735,706	$30,541,287
1955	1,099,230	1,642,354	31,738,954	33,668,556	32,838,184	35,310,910
1956	1,487,222	2,044,557	32,786,954	39,374,481	34,274,176	41,419,038
1957	1,097,620	1,588,484	29,310,775	35,923,688	30,408,395	37,512,172
State						
1958						
Alabama	50	45	1,311,731	1,169,720	1,311,781	1,169,765
Arizona	---	---	119,203	179,003	119,203	179,003
Arkansas	---	---	264,678	264,678	264,678	264,678
California	475,763	1,127,817	1,496,766	2,324,739	1,972,529	3,452,556
Colorado	45,435	79,511	135,929	261,284	181,364	340,795
Connecticut	36,540	27,405	162,291	271,725	198,831	299,130
Georgia	---	---	1,161,868	478,598	1,161,868	478,598
Idaho	---	---	27,000	19,950	27,000	19,950
Illinois	(2)	(2)	(2)	(2)	1,609,535	3,176,787
Indiana	62,772	75,908	992,933	1,883,310	1,055,705	1,959,218
Iowa	(2)	(2)	(2)	(2)	837,219	1,053,557
Kansas	---	---	692,209	705,490	692,209	705,490
Kentucky	---	---	453,759	571,800	453,759	571,800
Louisiana	---	---	755,157	755,157	755,157	755,157
Maine	---	---	23,270	25,633	23,270	25,633
Maryland	(2)	(2)	(2)	(2)	556,472	614,399
Massachusetts	---	---	84,999	110,999	84,999	110,999
Michigan	(2)	(2)	(2)	(2)	1,663,078	1,813,043
Mississippi	---	---	293,108	293,108	293,108	293,108
Missouri	---	---	847,751	846,773	847,751	846,773
Montana	---	---	23,370	19,430	23,370	19,430
Nebraska	---	---	105,462	107,087	105,462	107,087
New Hampshire	---	---	26,100	26,100	26,100	26,100
New Jersey	---	---	548,893	1,131,270	548,893	1,131,270
New Mexico	(2)	(2)	(2)	(2)	40,196	73,033
New York	1,036	24,750	1,083,811	1,393,675	1,084,847	1,418,425
North Carolina	---	---	2,046,561	1,187,119	2,046,561	1,187,119
North Dakota	---	---	54,000	65,440	54,000	65,440
Ohio	116,530	102,426	2,809,562	3,036,442	2,926,092	3,138,868
Oklahoma	(2)	(2)	(2)	(2)	575,541	575,541
Oregon	(2)	(2)	(2)	(2)	251,685	293,386
Pennsylvania	125,362	32,301	1,647,963	4,870,945	1,773,325	4,903,246
South Carolina	---	---	550,970	492,257	550,970	492,257
South Dakota	---	---	155,012	155,012	155,012	155,012
Tennessee	---	---	654,814	279,590	654,814	279,590
Texas	(2)	(2)	(2)	(2)	3,096,642	3,400,157
Utah	(2)	(2)	(2)	(2)	125,140	295,363
Virginia	---	---	1,152,850	1,143,160	1,152,850	1,143,160
Washington	(2)	(2)	(2)	(2)	195,776	182,884
West Virginia	---	---	245,699	227,340	245,699	227,340
Wisconsin	---	---	154,177	167,318	154,177	167,318
Wyoming	---	---	372,747	375,854	372,747	375,854
Undistributed [3]	116,077	217,022	9,239,305	11,689,276	404,098	428,148
Total	979,565	1,687,185	29,693,948	36,529,282	30,673,513	38,216,467
1959						
Alabama	---	---	1,508,336	1,351,583	1,508,336	1,351,583
Arizona	---	---	119,488	179,233	119,488	179,233
Arkansas	---	---	383,445	383,445	383,445	383,445
California	413,451	991,647	1,828,643	2,605,015	2,242,094	3,596,662
Colorado	(2)	(2)	(2)	(2)	146,898	263,094
Connecticut	35,485	26,614	244,452	341,037	279,937	367,651
Georgia	---	---	1,312,749	547,831	1,312,749	547,831
Idaho	---	---	39,250	31,850	39,250	31,850
Illinois	28,803	54,906	1,879,008	2,737,358	1,907,811	2,792,264
Indiana	87,735	116,375	1,238,153	2,233,299	1,325,888	2,349,674
Iowa	(2)	(2)	(2)	(2)	895,518	1,125,387
Kansas	---	---	753,630	753,630	753,630	753,630
Kentucky	---	---	625,237	818,370	625,237	818,370
Louisiana	---	---	904,149	904,149	904,149	904,149
Maine	---	---	25,104	26,232	25,104	26,232
Maryland	(2)	(2)	(2)	(2)	602,516	709,092
Massachusetts	---	---	101,124	228,736	101,124	228,736
Michigan	(2)	(2)	(2)	(2)	1,770,685	1,936,842
Mississippi	---	---	430,549	432,169	430,549	432,169

See footnotes at end of table.

TABLE 9.—Miscellaneous clay, including shale and slip clay sold or used by producers in the United States—Continued

	Sold by producers		Used by producers		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
State—continued						
1959						
Missouri	-----	-----	977,636	$977,812	977,636	$977,812
Montana	(2)	(2)	(2)	(2)	46,023	47,730
Nebraska	-----	-----	128,834	130,385	128,834	130,385
New Hampshire	-----	-----	26,150	26,150	26,150	26,150
New Jersey	-----	-----	573,343	946,932	573,343	946,932
New Mexico	(2)	(2)	(2)	(2)	45,388	77,541
New York	2,269	$29,487	1,307,256	1,684,140	1,309,525	1,713,627
North Carolina	-----	-----	2,523,631	1,522,423	2,523,631	1,522,423
North Dakota	-----	-----	61,381	78,648	61,381	78,648
Ohio	171,207	206,365	2,948,889	3,194,158	3,120,096	3,400,523
Oklahoma	-----	-----	966,370	966,770	966,370	966,770
Oregon	(2)	(2)	(2)	(2)	293,904	305,050
Pennsylvania	105,859	32,699	1,527,726	4,910,981	1,633,585	4,943,680
South Carolina	-----	-----	714,081	628,489	714,081	628,489
South Dakota	-----	-----	227,118	227,118	227,118	227,118
Tennessee	-----	-----	812,683	331,388	812,683	331,388
Texas	9,548	25,891	3,004,890	3,134,029	3,014,438	3,159,920
Utah	(2)	(2)	(2)	(2)	137,877	267,826
Virginia	-----	-----	1,346,014	1,396,433	1,346,014	1,396,433
Washington	(2)	(2)	(2)	(2)	179,820	170,668
West Virginia	-----	-----	266,932	312,970	266,932	312,970
Wisconsin	-----	-----	178,363	192,229	178,363	192,229
Undistributed [3]	159,716	282,402	4,732,207	5,454,276	773,294	833,448
Total	1,014,073	1,766,386	33,716,821	39,689,268	34,730,894	41,455,654

[1] Includes Puerto Rico 1953–54.

[2] Included with "Undistributed."

[3] Includes States indicated by footnote 2 and Delaware, District of Columbia, Florida, Hawaii, Minnesota, Nevada, Vermont, and Wyoming (1959).

CONSUMPTION AND USES—ALL CLAYS

Of the total clay consumed in 1959, heavy clay products (building brick, structural tile, and sewer pipe) accounted for 47 percent.

The total tonnage of clays consumed increased 13 percent, contributed by most branches of the clay industry. Some of the increases were: Enameling, 105 percent; exports, 51 percent; fire-clay mortar, 49 percent; firebrick and block, 43 percent; total refractories, 37 percent; insecticides and fungicides, 31 percent; stoneware, 22 percent; whiteware, foundries and steelworks, and absorbent uses, each 21 percent; paper filler, 20 percent; paint, 17 percent; art pottery, 16 percent; lightweight aggregate and rubber, each 14 percent; cement, 11 percent; and rotary drilling mud, 3 percent. Some decreases in consumption were: Glass refractories, 20 percent; filtering and decolorizing for vegetable and animal oils, 7 percent; and chemicals, 2 percent.

Refractories.—Shipments of clay refractories increased 10 percent in value over 1958. Almost all classifications of clay refractories registered increases.

Trends in the refractories industry were toward increased research to develop new forms and improve the quality of refractories. Existing facilities were expanded, new ones built, and new fields of refractories research were entered. Customers demanded a higher standard of quality. The trend toward basic refractories continued.

TABLE 10.—Clay sold or used by producers in the United States in 1959, by kinds and uses, in short tons

	Kaolin	Ball clay	Fire clay and stoneware clay	Benton-ite	Ful-ler's earth	Miscella-neous clay including slip clay	Total
Pottery and stoneware:							
Whiteware, etc	107, 814	270, 959	------	------	------	------	378, 773
Stoneware, including chemical stoneware	228	2, 200	11, 287	------	------	10, 447	24, 162
Art pottery, flower pots, and glaze slip	7, 747	4, 160	16, 131	------	------	65, 042	93, 080
Total	115, 789	277, 319	27, 418	------	------	75, 489	496, 015
Floor and wall tile	15, 162	111, 152	156, 810	------	------	146, 756	429, 880
Refractories:							
Firebrick and block	181, 961	20, 546	4, 283, 771	------	------	6, 303	4, 492, 581
Bauxite, high-alumina brick	------	------	37, 347	------	------	------	37, 347
Fire-clay mortar	------	1, 345	185, 364	------	------	5, 997	192, 706
Clay crucibles	------	------	19, 225	------	------	------	19, 225
Glass refractories	20, 698	29, 559	7, 059	------	------	------	57, 316
Zinc retorts and condensers	------	------	55, 411	------	------	------	55, 411
Foundries and steelworks	7, 099	------	613, 804	470, 349	------	11, 236	1, 102, 488
Saggers, pins, stilts, and wads	7, 421	11, 492	4, 089	------	------	------	23, 002
Other refractories	44, 452	5, 596	158, 764	10	------	275	209, 097
Total	261, 631	68, 538	5, 364, 834	470, 359	------	23, 811	6, 189, 173
Heavy clay products: Building brick, paving brick, drain tile, sewer pipe, and kindred products	------	3, 456	4, 180, 546	------	------	19, 164, 700	23, 348, 702
Architectural terra cotta	------	------	4, 654	------	------	------	4, 654
Lightweight aggregates	------	------	------	------	------	5, 270, 298	5, 270, 298
Filler:							
Paper filling	599, 305	------	------	------	------	------	599, 305
Paper coating	751, 541	------	------	------	------	------	751, 541
Rubber	322, 875	------	------	------	------	287	323, 162
Linoleum and oilcloth	15, 287	------	6, 655	------	------	1, 631	23, 573
Paint	51, 693	------	------	52	------	------	51, 745
Fertilizers	12, 846	------	------	------	------	5, 229	18, 075
Insecticides and fungicides	80, 837	------	427	23, 373	95, 733	------	200, 370
Plaster and plaster products	2, 240	------	------	------	------	------	2, 240
Plastics, organic	9, 362	2, 000	------	------	3, 487	------	14, 849
Other fillers	39, 801	490	6, 564	155	------	------	47, 010
Total	1, 885, 787	2, 490	13, 646	23, 580	99, 220	7, 147	2, 031, 870
Portland and other hydraulic cements	67, 097	------	------	16, 441	------	9, 989, 698	10, 073, 236
Miscellaneous:							
Enameling	2, 697	------	------	------	------	------	2, 697
Filtering and decolorizing: (raw and activated earths)							
Mineral oils and greases	------	------	------	113, 075	41, 794	------	154, 869
Vegetable or animal oils and fats	------	------	------	64, 639	1, 721	------	66, 360
Other filtering and clarifying	------	------	------	2, 638	1, 187	------	3, 825
Rotary-drilling mud	------	------	1, 130	483, 858	65, 882	15, 234	566, 104
Chemicals	23, 310	------	94, 203	3, 421	3, 575	------	124, 509
Absorbent uses	------	------	------	9, 788	178, 327	------	188, 115
Exports	57, 906	6, 505	9, 242	47, 256	9, 936	------	130, 845
Other uses	106, 095	5, 775	9, 203	137, 231	7, 980	37, 761	304, 045
Total	190, 008	12, 280	113, 778	861, 906	310, 402	52, 995	1, 541, 369
Grand total:							
1959	2, 535, 474	475, 235	9, 861, 686	1, 372, 286	409, 622	34, 730, 894	49, 385, 197
1958	2, 222, 185	396, 949	8, 808, 175	1, 291, 414	357, 883	30, 673, 513	43, 750, 119

A new Refractories Bibliography, with data drawn from over 1,150 periodicals, was compiled and published.[4]

A description of the operation of the modernized plant of the Valentine Fire Brick Co. (a Division of A. P. Green Fire Brick Co.) was published.[5]

Articles described the operation of Engineered Ceramics Manufacturing Co., Chicago, Ill., producer of refractories and technical ceramics,[6] and of a new high temperature kiln of the Centralab Division of Globe Union in Milwaukee, Wis.[7]

Cost control in a fire clay refractories plant was discussed.[8]

The new basic refractories plant at Milpitas, Calif., of Kaiser Chemicals Division, Kaiser Aluminum & Chemical Corp. was described.[9]

The Refractories Division of H. K. Porter Company, Inc., opened a $12 million Pascagoula, Miss., works in September.

Harbison-Walker Refractories Co. opened a $2 million Garber Research Center near Pittsburgh, Pa., June 1959.

A. P. Green Fire Brick Co. acquired Climax Fire Brick, Climax, Pa., adding additional items to Green's line of products. The company announced plans to construct a new $2 million basic refractories plant at Tarentum, Pa.

The refractories division of the Norton Co., Worcester, Mass., announced plans to expand its facilities.

Frank B. Pope Co. was building a new refractories plant at Mayport, Pa.

Kaiser Chemical Division, Kaiser Aluminum and Chemical Corp. announced expansion of its Columbiana, Ohio plant for the second time in 3 years. This corporation and Mexico Refractories Company merged during the year.

E. J. Lavino & Company of Philadelphia, Pa., announced plans to build a $3 million refractories plant at Freeport, Tex., and a multimillion dollar plant at Gary, Ind. It will produce a complete line of basic refractories.

Heavy Clay Products.—All segments of the clay industry producing heavy clay products planned for and were looking ahead to a booming business. New products were developed, former products were improved, and more economical production methods were adopted.

Changes in manufacturing processes and equipment were aimed at getting more completely automated plants by many producers of heavy clay products. New plants were under construction and existing ones were being expanded and modernized. Producers emphasized research with construction or expansion of laboratories throughout the industry.

---

[4] Joint Refractory Committee of the American Iron and Steel Institute and the Refractories Institute, Refractories Bibliography, 1947–56 inclusive: Univ. of Okla. press, 1959, Norman, Okla.

[5] Ceramic Age, Mechanization and Control in Semi-Silica Refractory Production: Vol. 73, No. 4, April 1959, pp. 31–35.

[6] Ceramic Age, Flexible Production of High Temperature Ceramics: Vol. 73, No. 6, June 1959, pp. 28–33.

[7] Ceramic Industries, How Centralab Operates New High Temperature Tunnel Kiln: Vol. 72, No. 5, May 1959, pp. 131–133, 163.

[8] Maune, A. R., Direct Labor Cost Control: Ceramic Age, vol. 74, No. 2, August 1959, pp. 22–24.

[9] Utley, H. F., Basic Refractories Plant of Kaiser Chemical Division: Pit and Quarry, vol. 51, No. 10, April 1959, pp. 84–85.

TABLE 11.—Shipments of refractories in the United States, by kinds

[Bureau of the Census]

Product	Unit of quantity	Shipments			
		1958		1959	
		Quantity	Value (thousands)	Quantity	Value (thousands)
Clay refractories:					
Fire-clay brick, standard and special shapes, except superduty.	1,000 9 in. equivalent.	320,034	$56,526	330,199	$51,486
Superduty fire-clay brick and shapes	do	60,163	15,375	73,630	18,649
High-alumina brick and shapes (50 percent Al_2O_3 and over) made substantially of calcined diaspore or bauxite.[1]	do	17,395	7,464	20,031	8,919
Insulating firebrick and shapes	do	38,600	9,386	44,596	10,672
Ladle brick	do	167,654	17,024	220,094	23,175
Sleeves, nozzles, runner brick and tuyeres	do	34,930	7,448	45,468	9,267
Glasshouse pots, feeder parts and upper structure shapes used only for glass tanks.[1]	Short ton	14,534	3,598	15,098	4,065
Hot-top refractories	do	[2] 86,467	3,975	87,040	5,404
Clay-kiln furniture, radiant-heater elements, potters' supplies, and other miscellaneous shaped refractory items.			4,808		6,026
Refractory bonding mortars, air-setting (wet and dry types).[3]	Short ton	73,571	6,864	57,986	6,842
Refractory bonding mortars, except air-setting types.[3]	do	6,499	678	9,472	994
Ground crude fire clay, high-alumina clay, and silica fireclay.[4]	do	498,607	4,646	595,961	4,838
Plastic refractories and ramming mixes [1]	do	104,189	9,030	137,076	11,606
Castable refractories (hydraulic setting)	do	91,812	9,077	92,991	9,155
Insulating castable refractories (hydraulic setting).	do	19,746	2,380	18,292	2,277
Other clay refractory materials sold in lump or ground form.[5]	do	211,856	4,608	232,811	5,147
Total clay refractories			162,887		178,522
Nonclay refractories:					
Silica brick and shapes	1,000 9-in. equivalent.	202,685	42,190	200,566	40,905
Magnesite and magnesite-chrome (magnesite predominating) brick and shapes (excluding molten cast).	do	39,673	30,692	53,549	43,591
Chrome and chrome-magnesite (chrome ore predominating) brick and shapes (excluding molten cast).	do	42,582	30,296	47,106	35,472
Graphite crucibles, retorts, stopper heads, and other shaped refractories, excluding those containing natural graphite.	Short ton	13,537	8,119	21,191	12,328
Carbon refractories; brick, blocks, and shapes, excluding those containing natural graphite.	do				
Mullite brick and shapes made predominantly of kyanite, sillimanite, andalusite or synthetic mullite (excluding molten cast).	1,000 9-in. equivalent.	4,047	4,764	4,429	5,657
Extra-high alumina brick and shapes made predominantly of fused bauxite, fused or dense-sintered alumina (excluding molten cast).	do	2,001	4,099	2,338	3,679
Silicon carbide brick and shapes made substantially of silicon carbide.	do	3,802	8,285	4,315	9,933
Zircon and zirconia brick and shapes made predominantly of either of these materials.	do	547	2,010	899	3,017
Forsterite, pyrophyllite, molten-cast, and other nonclay brick and shapes.			11,793		14,630

---

[1] Excludes data for mullite or extra-high alumina refractories. These products are included with mullite and extra-high alumina brick and shapes in the nonclay refractories section.

[2] Revised figure.

[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 refractory producers for the manufacture of brick and other refractories.

[5] Includes data for calcined clay, ground brick, and siliceous and other gunning mixes.

TABLE 11.—Shipments of refractories in the United States, by kinds—Con.

Product	Unit of quantity	Shipments			
		1958		1959	
		Quantity	Value (thousands)	Quantity	Value (thousands)
Nonclay refractories—Continued					
Nonclay refractory bonding mortars, air-setting (wet and dry types).	Short ton	97,800	$9,615	89,793	$9,549
Nonclay refractory bonding mortars, except air-setting types.	do	19,261	1,521	16,921	1,254
Nonclay refractory castables (hydraulic setting).	do	5,947	730	7,671	1,072
Nonclay plastic refractories and ramming mixes (wet and dry types).	do	188,337	20,578	188,283	21,873
Dead-burned magnesia or magnesite.[4]	do	177,237	8,853	156,346	9,295
Other nonclay gunning mixes	do	147,200	9,420	223,214	12,769
Other nonclay refractory materials sold in lump or ground form.[4]	do				
Total nonclay refractories			[2] 192,965		225,024
Grand total refractories			[2] 355,852		403,546

[2] Revised figure.

[4] Represents only shipments by establishments classified in "manufacturing" industries, and excludes shipments to refractory producers for the manufacture of brick and other refractories.

Producers of clay worked closer with architects on color, shape, and design. Panelization and utilization of load-bearing properties of fired clay structural panels increased sales. Installation of sewer and water systems aided clay and pipe manufacturers. A rapid growth was indicated for lightweight clay-bonded block.

A multimillion-dollar plant for producing lightweight aggregate in the Denver, Colo., area was planned by Great Western Aggregate, Inc., a subsidiary of Ideal Cement Co.

The American Vitrified Products Co. of Cleveland, Ohio, planned to construct a completely automated $4 million plant at Somerville, N.J.

The Triangle Brick Co. announced plans to construct a $1 million brick manufacturing plant at Durham, N.C.

Eastern Brick and Tile Co. announced plans for a new plant at Sumter, S.C.

A new brick plant was under construction at Muirkirk, Md., by the Washington Brick Co. A 356-foot tunnel kiln was being installed.

The Jenkins Brick Co. completed a $1 million brick manufacturing plant at Coosada, Ala., doubling the company's production.

The new lightweight aggregate plant of Florida Solite Corp., at Green Cove Springs, Fla., began production.

Brick production began at the new plant of the Woodbridge Clay Co. in Manassas, Va. Capacity was 50,000 brick per day.

Builders Brick Co., Seattle, Wash., dedicated a new $1.5 million clay products plant in November. The plant was to process 35,000 tons of clay per year.

The Collingwood Shale Brick and Supply Co., Cleveland, Ohio, bought the Fletcher Brick and Tile Co., producers of drain tile and brick.

National Gypsum Co. of New York, N.Y. announced that it was acquiring the Murray Tile Co.

Richland Shale Brick Co. acquired the Mansfield, Ohio, plant of the Ohio Lumber and Face Brick Co. and the firm was renamed the Ohio Brick & Supply Co.

Henderson Clay Products Co., Henderson, Tex., began an $800,000 expansion program to increase production to 250,000 brick a day.

Denver Brick and Tile Co., Denver, Colo., announced plans for a $1 million expansion program, primarily to increase production of vitrified clay sewer pipe.

W. S. Dickey Clay Mfg. Co. planned to expand production to meet increased demands for clay pipe in the St. Louis area, and to build a new plant at Bessemer, Ala.

Articles described the modernizing of facilities at Eastern Illinois Clay Co., St. Anne, Ill., resulting in increased drain tile production,[10] and the modernization, expansion, and operation of Lehigh Pipe and Tile Co., Fort Dodge, Tex.[11]

Discussions of the highlights of the Clay Bonded Block meeting in Columbus, Ohio, in March,[12] and some factors producing a clay-bonded block [13] were published.

A review of the modernization program of the Montezuma, Ind., plant of Clay City Pipe Co. was given.[14]

Articles described the completely mechanized brick manufacturing operations of Clay Products, Inc., Holly Springs, Miss.,[15] and Ampress Brick Co., Inc., Des Plaines, Ill., producers respectively, of 9 million colored brick and 1.5 million lightweight expanded shale block a year.[16]

An account was given of the operation of the plant of North Central Lightweight Aggregate Corp. near Minneapolis, Minn.[17]

Based on data compiled by the U.S. Department of Commerce, the value of clay construction products was $521.5 million, 15 percent more than the 1958 value of $453.1 million. Shipments of the principal clay product, unglazed brick, were approximately 7,260 million with a value of $241.4 million, compared with 6,460 million valued at $209.9 million in 1958.

---

[10] Brick and Clay Record, New Grinding Set-Up Boosts Production, Product Quality: Vol. 134, No. 3, March 1959, pp. 43–44, 59.

[11] Brick and Clay Record, Million Plus for Mechanization: Vol. 134, No. 4, April 1959, pp. 56–61.

[12] Brick and Clay Record, What's Coming for Lightweight Clay Block: Vol. 134, No. 4, April 1959, pp. 62–65.

[13] Tinker, Dean, Commercial Production of Clay Block in Plant: Brick and Clay Record, vol. 134, No. 6, June 1959, pp. 60, 62.

[14] Brick and Clay Record, Indiana Company Switches to Buff Brick: Vol. 135, No. 1, July 1959, pp. 52–53.

[15] Brick and Clay Record, Holly Springs Plant Bases Design on Steps from Pit Control to Final Product: Vol. 135, No. 6, December 1959, pp. 42–47.

[16] Concrete, How Ampress Makes and Sells—9,000,000 Colored Brick a Year: Vol. 67, No. 11, November 1959, pp. 15–18.

[17] Brick and Clay Record, North Central L W Moves Into Twin City Aggregate Market: Vol. 134, No. 4, April 1959, pp. 66–69.

TABLE 12.—Shipments of principal structural clay products in the United States[1]

Product and unit quantity	1957		1958		1959	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Unglazed brick (building) M standard brick	6,305,900	$205,800	6,458,800	$209,900	7,258,000	$241,400
Unglazed structural tile short tons	640,700	8,700	542,900	[2] 8,200	521,300	8,000
Vitrified clay sewer pipe and fittings, short tons	1,629,000	77,500	1,772,300	83,700	1,973,100	98,300
Facing tile, ceramic glazed, including glazed brick, M brick equivalent	381,600	28,200	399,100	29,100	369,600	30,100
Facing tile, unglazed and salt glazed, M tile, 8" x 5" x 12" equivalent	19,900	3,400	17,800	3,000	14,300	2,600
Clay floor and wall tile and accessories, including quarry tile, M square feet	207,100	113,400	215,700	119,100	252,500	141,100

[1] Compiled from information furnished by the Bureau of the Census, U.S. Department of Commerce.
[2] Revised figure.

WORLD REVIEW

NORTH AMERICA

Canada.—A review of clay and clay products in Canada in 1958 was published.[18] The occurrence, use, and export-import information on miscellaneous clay and shale, stoneware clay, fire clay, ball clay, and kaolin were reported. Clay products made in Canada from domestic and imported clays during 1958 reached a value of $66,638,000, an increase of 19 percent from 1957. Production from domestic clays accounted for 64 percent of this total. The value of imports of clay and clay products in 1958 was $44,827,000, and of exports $4,225,000.

Producers' sales of products made from Canadian clays in 1959 were as follows:[19]

	Quantity	*Value (thousands)*
Building brick, M standard brick	550,247	$28,372
Structural tile and floor tile, in tons	175,507	3,522
Drain tile, M pieces	43,366	2,745
Sewer pipe and flue linings	-------	4,795
Fire clay blocks and shapes	-------	366
Pottery, flower pots, stoneware, etc	-------	614
Firebrick, fire clay, china clay, etc	-------	2,335
Total		42,749

An article described the operations of the Clayburn-Harbison, Ltd., plants at Kilgard and Abbotsford, British Columbia, where sewer pipe, agricultural tile, flue liner, refractories, and face brick were made.[20]

Alsam Manufacturing, Ltd., of British Columbia announced plans to build a plant and develop extensive blue shale deposits to produce lightweight aggregate.

---

[18] Brady, J. G., Clays and Clay Products, 1958: Dept. of Mines and Tech. Surveys, Ottawa, Canada, Review 33, July 1959, 8 pp.

[19] Dominion Bureau of Statistics, Ottawa, Canada, Products Made From Canadian Clays: Vol. 18, No. 3, March 1960, 4 pp.

[20] Beaton, R. H., Clayburn-Harbison, Ltd., Operations in British Columbia: Canadian Min. and Met. Bull. (Montreal), vol. 52, No. 562, February 1959, pp. 90–93.

American Nepheline and its parent firm Ventures, Ltd. started an extensive search for kaolin and other clays in the James Bay area, where kaolin deposits are known to exist. The companies were granted a 3-year period of exclusive exploration by the Ontario government.

Cooksville-Laprairie Brick, Ltd., a wholly owned subsidiary of Dominion Tar and Chemical Co., began construction on a new brick plant near Ottawa. Ultimate capacity will be 50 million bricks a year. A new company, Standard Refractories, Limited, was formed to serve Canadian industry with refractory products, manufacturing facilities, and engineered installations.

A ball clay processing plant was put into operation at Assiniboia, Saskatchewan, by National Industrial Minerals, Ltd.[21]

Mexico.—An estimated 90 to 95 percent of all Mexican household and commercial pottery production came from the following four large mechanized factories:[22] Fabrica de Loza Ed Anfora, S.A.; Fabrica de Loza La Favorita, S.A.; Fabrica de Loza Nueva San Isidio, S.A.; and Loza Fina, S.A.

The United States was the principal supplier of imports, including pottery-making machinery, raw materials, and some ceramic products. Providing technical assistance and exploiting known deposits of raw materials are opportunities for foreign investors. Imports of ball clay and kaolin were:

	1958		*1959*	
	Quantity (short tons)	*Value (thousands)*	*Quantity (short tons)*	*Value (thousands)*
Ball clay, total	37, 702	$1, 097	20, 288	$481
From U.S.	37, 675	1, 095	19, 757	463
Kaolin, total	4, 300	184	11, 089	504
From U.S.	4, 271	182	11, 037	500

West Indies (British).—The production of all clays in 1959 was 135,105 short tons valued at $45,085.[23]

SOUTH AMERICA

Brazil.—Imports of clays in 1958 were (1957 figures in parentheses): Kaolin, 45 short tons (246 tons) valued at $4,000 ($27,000); refractory clays 970 tons (120 tons) valued at $110,000 ($21,000); other clays, 1,294 tons (6,178 tons) valued at $85,000 ($369,000).[24]

Peru.—Production of clay for building brick in 1959 totaled 241,000 short tons valued at $491,000. Production of clay for refractories was 2,320 short tons valued at $9,600.[25]

Uruguay.—The production of common clay in 1959 was 18,855 short tons and of refractory clay 156,431 tons.[26]

---

[21] Ceramic Age, Clay Processing in Canada: Vol. 74, No. 1, July 1959, pp. 28–29.

[22] U.S. Embassy, Mexico City, Mexico, State Department Dispatch 1273, Apr. 26, 1960.

[23] U.S. Consulate, Port of Spain, British West Indies, State Department Dispatch 392, Apr. 29, 1960, p. 1.

[24] U.S. Embassy, Rio de Janeiro, Brazil, State Department Dispatch 1137, May 19, 1960, p. 1.

[25] U.S. Embassy, Lima, Peru, State Department Dispatch 615, Apr. 26, 1960, p. 1.

[26] U.S. Embassy, Montevideo, Uruguay, State Department Dispatch 995, May 3, 1960, p. 1.

EUROPE

Austria.—Clay production in Austria in 1959 was as follows: Clay (unspecified), 88,370 short tons; clay sand, 54,323 tons; bentonite, 3,460 tons; and kaolin, 327,936 tons.[27]

Czechoslovakia.—By a trade agreement 3,600 tons of kaolin and 250 tons of bleaching earths were to be supplied to the Benelux countries by March 1, 1960.[28]

Denmark.—Estimated production of kaolin in Denmark in 1959 was 5,510 short tons of crude ($14,500), and 6,612 tons of refined ($101,500).[29]

In 1958, Denmark produced 535 million common brick valued at $9.7 million; 45 million pieces of drain tile valued at $1.45 million; and 16,530 short tons of firebrick valued at $870,000.[30]

Greece.—According to preliminary estimates, Greece produced 27,550 short tons of kaolin, valued at $275,000.[31]

Italy.—Clay production in Italy in 1959 was: Kaolin, 39,346 short tons; bentonite, 66,609 tons; bleaching clays, 157,068 tons; and refractory clays, 154,617 tons. Kaolin and bentonite were valued at $14.60 a short ton, and bleaching and refractory clays at $26.30 to $65.70 a ton, respectively.[32]

United Kingdom.—The Rural Industries Bureau operated a clay testing station to aid small brickworks.[33]

Production of fire clay in Northern Ireland [34] was 32,819 short tons valued at $100,125, compared with 23,556 tons valued at $80,623 in 1958,[35] and other clays totaled 261,524 tons valued at $198,084, compared with 235,798 tons valued at $146,640 in 1958.

Yugoslavia.—Bentonite production facilities were expanded at Petrovac-na Moru, and processing capacity was expanded at Macedonia because of increased export demand, mostly from Italy. Yugoslav bentonite resources were estimated at 60 million tons.[36]

The production of bentonite in Yugoslavia in 1959 was 8,596 short tons. Fire clay production was 118,726 short tons.[37]

ASIA

India.—Production of china clay was 271,100 tons valued at $674,500, and of fire clay, 240,236 tons valued at $235,370.[38] In 1958 output was, china clay, 171,360 short tons valued at $562,380, and fire clay, 239,680 tons valued at $366,870.[39]

---

[27] U.S. Embassy, Vienna, Austria, State Department Dispatch 1154, Apr. 11, 1960, pp. 1–2.

[28] Chemical Trade Journal and Chemical Engineer (London), Czech Pitch for Benelux: Vol. 145, No. 3764, July 24, 1959, p. 8.

[29] U.S. Embassy, Copenhagen, Denmark, State Department Dispatch 780, May 4, 1960, p. 1.

[30] U.S. Embassy, Copenhagen, Denmark, State Department Dispatch 844, May 5, 1959, p. 1.

[31] U.S. Embassy, Athens, Greece, State Department Dispatch 1103, May 20, 1960, p. 2.

[32] U.S. Embassy, Rome, Italy, State Department Dispatch 1068, May 9, 1960, pp. 3, 5.

[33] British Clayworker, Semi-Works-Scale Clay Testing Station: Vol. 67, No. 803, 1959, pp. 327–329.

[34] U.S. Consulate, Belfast, Ireland, State Department Dispatch 70, May 11, 1959, p. 1.

[35] U.S. Consulate, Belfast, Ireland, State Department Dispatch 66, May 2, 1960, p. 1.

[36] Chemical Trade Journal and Chemical Engineer (London), Yugoslavian Bentonite: Vol. 145, No. 3981, November 1959, p. 968.

[37] U.S. Embassy, Belgrade, Yugoslavia, State Department Dispatch 589, Apr. 26, 1960, p. 1.

[38] U.S. Embassy, New Delhi, India, State Department Dispatch 1006, Apr. 25, 1960, p. 1.

[39] U.S. Embassy, New Delhi, India, State Department Dispatch 1431, June 4, 1959, p. 1.

There were 43 pottery manufacturers in the organized section of industry, as well as numerous smaller cottage-type operations. The production of chinaware and stoneware increased greatly from 1957 through 1959. The value of exports of clay products increased from $10,400 in 1957 to $14,600 in 1958 to $36,000 in 1959, while imports decreased in value from $279,000 in 1957 to $65,000 in 1958 to $27,500 in 1959.[40]

The occurrences, uses, production, and potential future development of bleaching clay, bentonite, and fuller's earth in India were discussed.[41]

Iran.—The Sherkate Sahami Kahkashan Company planned a ceramic plant to make floor and wall tile at Tehran.

Israel.—Ball and fire clay production in 1959 totaled 32,992 short tons.[42]

Japan.—The production of kaolin in 1959 was 23,019 short tons; the revised figure for 1958 was 23,553 tons. Fire clay production was 750,593 tons in 1959; the revised 1958 figure was 600,508 tons.[43]

Pakistan.—Total clay production in 1959 was 16,081 short tons valued at $40,000.[44]

Clays were tested for a proposed chinaware and sanitary ware factory in Karachi.

Philippines.—Clay and clay products output in 1959 was as follows:[45]

	Quantity	*Value*
White clay short tons	9, 098 (est.)	$67, 435
Bleaching and cleaning clay do	4, 650 (est.)	7, 529
Pottery, jars, stoves, pipes, pieces	1, 239, 645	103, 640
Brick, assorted, pieces	679, 555	54, 575
Tiles (3" x 6"), (8" x 8") pieces	3, 100, 411	344, 950

A search for china and ball clays was initiated.

Turkey.—An estimated 611,530 short tons of clay valued at $616,585 was produced for use in cement in 1959.[46]

Bentonit Ticaret ve Sanayi Limited Sirket offered special inducements for financial and technical assistance in developing newly found bentonite deposits in Turkey.[47]

AFRICA

Algeria.—In 1958, 152,000 short tons of fuller's earth was produced in Algeria.[48]

British East Africa.—The value of imports of all clay products, including refractories, imported into East Africa for 1959 (1958 figures in parentheses) were as follows: Kenya, $520,000 ($662,000); Uganda, $127,000 ($198,000); Tanganyika, $139,000 ($280,000). The Coast Brick and Tile Works, Ltd., manufacturer of brick, tile, pipe

---

[40] U.S. Embassy, New Delhi, India, State Department Dispatch 1044, May 2, 1960, pp. 1–8, enclosure 1, pp. 1–3, enclosure 2, pp. 1–4, enclosure 3, pp. 1–4.

[41] Sinhi, R. K., Bleaching Clays: Jour. of Mines, Metals and Fuels (Calcutta), vol. 7, No. 4, April 1959, pp. 14–15, 22.

[42] U.S. Embassy, Tel Aviv, Israel, State Department Dispatch 743, May 13, 1960, p. 1.

[43] U.S. Embassy, Tokyo, Japan, State Department Dispatch 1353, May 11, 1960, pp. 2–3.

[44] U.S. Embassy, Karachi, Pakistan, State Department Dispatch 974, Apr. 25, 1960, p. 1.

[45] U.S. Embassy, Manila, Philippines, State Department Dispatch 858, June 9, 1959, p. 84.

[46] U.S. Embassy, Ankara, Turkey, State Department Dispatch 705, Apr. 28, 1960, p. 1.

[47] Foreign Commerce Weekly, Know-How Needed to Mine Bentonite Clay in Turkey: Vol. 62, No. 9, Aug. 31, 1959, p. 20.

[48] U.S. Consulate, Algiers, Algeria, State Department Dispatch 289, June 10, 1959, p. 1.

and other clay products, reported that demand for its products was greater than its capacity. The company sought aid for extensive expansion.[49]

Eritrea.—The production of kaolin in Eritrea, in short tons, was as follows: 1954, 165; 1955, 13; 1956, 13; 1957, 661; and 1958, 705.[50]

Morocco.—Bentonite production in 1959 was 24,668 short tons valued at $225,000.[51]

Mozambique.—Bricks and ceramics, except refractory type, were added to the list of items prohibited import into Mozambique.

Union of South Africa.—G. W. Base and Industrial Minerals (Pty.) Limited of Parys, Orange Free State, reported a proven bentonite reserve of 2 million tons. Monthly production was 300 to 400 tons.[52]

United Arab Republic (Egypt Region).—Production of clays in 1958 was: Common clays 1,196,200 short tons (est.), kaolin 10,040 tons, and fire clay 8,850 tons (est.).[53]

OCEANIA

Australia.—Clay production in Australia for 1957 was (1958 figures in parentheses when available): Bentonite and bentonitic clay, 1,024 short tons; brick clay and shale, 3,891,000 tons (4,168,000 tons); fuller's earth, 237 tons (132 tons); kaolin and ball clay, 47,900 tons; and other clay, 774,300 tons.[54]

New Zealand.—The production of clays, exclusive of common brick clay, in 1958 was 8,715 short tons valued at $49,600. Production of bentonite was 2,017 tons valued at $67,945.[55]

TECHNOLOGY

The 3d edition of a standard reference book, The Chemistry and Physics of Clays, was published. This work provided a comprehensive coverage of all technical aspects of clay and other ceramic material.[56]

A report was published on the results of laboratory tests of 155 samples of clays and shales from 120 localities in Montana.[57]

The proceedings of the Sixth National Conference on Clays and Clay Minerals, held in August 1957 and sponsored by the Committee on Clay Minerals of the National Academy of Sciences—National Research Council and the University of California, were published in

---

[49] U.S. Consulate, Nairobi, British East Africa, State Department Dispatch 460, Apr. 8, 1960, pp. 1–2, enclosure 1, p. 1.

[50] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 2, August 1959, p. 42.

[51] U.S. Embassy, Rabat, Morocco, State Department Dispatch 476, Apr. 25, 1960, p. 1.

[52] U.S. Consulate, Johannesburg, Union of South Africa, State Department Dispatch 251, Mar. 31, 1960, p. 1.

[53] U.S. Embassy, Cairo, United Arab Republic, State Department Dispatch 80, Aug. 4, 1959, p. 1.

[54] Chemical Engineering and Mining Review (Melbourne), Australia Mineral Production: Vol. 51, No. 10, July 15, 1959, p. 40.

[55] U.S. Embassy, Wellington, New Zealand, State Department Dispatch 719, June 5, 1959, p. 1.

[56] Searle, A. B., and Grimshaw, R. W., The Chemistry and Physics of Clays: Interscience Publishers, Inc., 1959, New York, 942 pp.

[57] Sahinan, U. M., Smith, R. I., and Lawson, D. C., Progress Report on Clays of Montana: Montana Bureau of Mines and Geology, Bulletin 13, January 1960, 83 pp.

1959. Selected papers from this volume were of special interest to the clay industry.[58]

Geophysical investigation of clays showed that self-potential and resistivity profiles may be useful in prospecting for clay deposits.[59]

Data were published on the results of a study on the fixation of radioisotopes by clay and other fine-grained naturally occurring materials.[60]

The use of the Brabender Plastograph for evaluating clay-working properties and assessing clay-mineral composition was described and discussed.[61]

Ninety-nine micrographs showing the structure of kaolin and other clays and minerals were published.[62]

A circular of published and unpublished chemical and spectrochemical data on Illinois clays was compiled.[63]

A study was made of 125 samples to determine the effect of water-sensitivity of clays on the permeability of reservoir rocks.[64]

Investigation of a technique developed by Coors Porcelain Co., Golden, Colo., using ceramic sponges, led to a full-scale examination of such sponges for disposal of liquid radioactive wastes. The sponges absorbed up to twice their weight.[65]

The results were published of investigations on clay drying related to the heat efficiency of drying operations.[66]

Equipment was designed and used in investigating pressure distribution in plastic materials and determining forces required for shear and slippage. Detailed data on results were published.[67]

---

[58] Sixth National Conference on Clays and Clay Minerals, Nat. Acad. Sci.-Nat. Res. Council, Washington, D.C., pub. by Pergamon Press, Inc., 1959, 411 pp. Specifically the following papers:

Kelley, F. R., Cleveland, G. B., and Arkley, R. J., Field Trip to the Ione Clay Area, pp. 1–17.

Barshad, Isaac, Factors Affecting Clay Formation, pp. 110–132.

Jackson, M. L., Frequency Distribution of Clay Minerals in Major Great Soil Groups as Related to the Factors of Soil Formation, pp. 133–143.

Harrison, J. L., and Murray, H. H., Clay Mineral Stability and Formation During Weathering, pp. 144–153.

Weaver, C. E., The Clay Petrology of Sediments, pp. 154–187.

Van Olphen, H., Forces Between Suspended Bentonite Particles. Pt. 2. Calcium Bentonite, pp. 196–206.

Kahn, Allan, Studies on the Size and Shape of Clay Particles in Aqueous Suspension, pp. 220–236.

Bates, T. F., and Comer, J. J., Further Observations on the Morphology of Chrysotile and Halloysite, pp. 237–248.

Johansen, R. T., and Dunning, H. N., Water-Vapor Adsorption on Clays, pp. 249–258.

Martin, R. T., Water-Vapor Sorption on Kaolinite, Hysteresis, pp. 259–278.

Takahashi, Hiroshi, Effect of Dry Grinding on Kaolin Minerals, pp. 279–291.

Granquist, W. T., and Sumner, G. G., Acid Dissolution of a Texas Bentonite, pp. 292–308.

Burst, J. F., Jr., Postdiagenetic, Clay Mineral-Environmental Relationships in the Gulf Coast Eocene, pp. 327–341.

[59] Gross, G. E., and Moore, E. J., Spontaneous Polarization Potentials and Clay and Limonite Deposits in the Gatesburg Formation of Central Pennsylvania: Econ. Geol., vol. 54, September–October 1959, pp. 1056–1067.

[60] Kerr, J. M., Preliminary Tests on Clay Sinters to Retain Reactor Wastes: Bull. Am. Ceram. Soc., vol. 38, No. 7, July 1959, pp. 374–377.

[61] West, R. R., and Lawrence, W. G., The Plastic Behavior of Some Ceramic Clays: Bull. Am. Ceram. Soc., vol. 38, No. 4, April 1959, pp. 135–138.

[62] Bates, T. F., Selected Electron Micrographs of Clays and Other Finegrained Materials: Penn. State Univ. Min. Ind. Exp. Sta., Circ. 51, 1958, 61 pp.

[63] White, W. A., Chemical and Spectrochemical Analyses of Illinois Clay Materials: Ill. State Geol. Surv. Circ. 282, 1959, 55 pp.

[64] Morris, F. C., Aune, Q. A., and Gates, G. L., Clay in Petroleum-Reservoir Rock—Its Effect on Permeability, with Particular Reference to Tejon–Grapevine Area, Kern County, Calif.: Bureau of Mines Rept. of Investigations 5425, 1959, 65 pp.

[65] Ceramic Age, U.S. Study on Radioactive Wastes Disposal Using Ceramic Sponges: Vol. 81, No. 2077, May 2, 1959, p. 741.

[66] Niesper, A. A., Clay Drying: Bauverlag G. m. b. H., (Wiesbaden), 1958, 153 pp.; Ceram. Abs., vol. 42, No. 9, September 1959, p. 261.

[67] Andrews, A. I., and Nelson, J. A., Rheological Properties of Clay-Water System Under Pressure: Bull. Am. Ceram. Soc., vol. 38, No. 9, September 1959, pp. 447–455.

A book was published containing data on the occurrences, testing, and possible uses of Indian clays.[68]

The Australian Bureau of Mineral Resources, Geology, and Geophysics published a report on the clays of Australia, covering definitions, uses, occurrences, and detailed production and trade statistics.[69]

A new type of moving-gallery kiln, with excellent firing control, was put into operation in West Germany.[70]

The chemical and physical properties of china clays were related to their uses, and five grades of clay were proposed as standards.[71] The crystalline structure of kaolin minerals and crystalline changes in kaolin clays at high temperatures were studied.[72] It was shown that kaolin possesses a permanent ismorphous replacement charge.[73] In another report the nature of raw material, preparation, mineralogical, chemical and physical properties of kaolin, economic factors, and methods of testing kaolin were given.[74]

Other kaolin reports were published on; the relation between kaolin deposits and volcanic beds;[75] a comparison of the casting qualities of domestic kaolins and English china clays;[76] the properties of china clays and aids to its use in whiteware bodies;[77] and a geological study of mexican kaolin deposits.[78]

Cation adsorption of kaolinite was studied.[79]

Methods of kaolin beneficiation by a centrifugal separator,[80] and by use of synthetic flocculants in treating kaolin slurries were described.[81]

A study showed that when standard fire-clay refractory in soaking-pit lids was replaced by kaolin, lid lining life was about doubled.[82]

The deposits, clay preparation and mineralogy of British ball clays were discussed in detail.[83]

---

[68] Council of Scientific and Industrial Research, New Delhi: Indian Clays—Their Occurrence and Characteristics, pt. 1, Samples Examined During 1950–52; 1958, 156 pp; Ceram. Abs., vol. 42, No. 9, September 1959, p. 262.

[69] Joplin, G. A., Mineral Resources of Australia, Clay: Bureau of Mineral Resources, Geology, and Geophysics, Department of National Development, Summary Report, No. 28, 1959, pp. 1–55.

[70] Launtzen, A., Looking Ahead—Circular Traveling Kiln: Claycraft (London), vol. 32, No. 12, December 1959, pp. 356–358.

[71] Clark, N. O., Standardized China Clay for the Pottery Industry: Trans. Brit. Ceram. Soc., vol. 56, No. 8, August 1957, pp. 389–401; Ceram. Abs., vol. 42, No. 4, April 1959, p. 103.

[72] Slaughter, M., and Keller, W. D., High-Temperature Phases from Impure Kaolin Clays: Bull. Am. Ceram. Soc., vol. 38, No. 12, December 1959, pp. 703–707.

[73] Cashen, G. H., Electric Charges on Kaolin: Trans. Faraday Soc., vol. 55, No. 3, March 1959. pp. 477–486.

[74] Lyons, C.S., Clay (Kaolin): TAPPI Monograph Series No. 20, 1958, pp. 57–115; Battelle Tech. Rev., vol. 8, No. 5, May 1959, p. 257a.

[75] Michler, O., Origin of the Kaolin and the Clay Deposits in the Karlsbad Mines: Ber. deut. keram. Ges., vol. 36, No. 7, July 1959, pp. 191–196; Ceram. Abs., vol. 43, No. 3, March 1960, p. 70.

[76] Phelps, G. W., A Note on Casting Properties of English China Clay: Bull. Am. Ceram. Soc., vol. 38, No. 8, August 1959, pp. 411–414.

[77] Perry, R. F., How to Use China Clays in Whiteware Bodies: Ceram. Ind., vol. 72, No. 5, May 1959, pp. 139–141.

[78] Aguilera, J. F., [Kaolins of the Yextho Land (Hidalgo)]: Publs. Ceramicas (Mexico), vol. 1, No. 1, 1958, pp. 51–57; Ceram. Abs., vol. 43, No. 2, February 1960, p. 44.

[79] Okuda, Susuma, Tanaka, Naoharu, and Inoue, Keikichi, Fixation Phenomena of Adsorbed Cation Caused by the Drying of the Kaolinite: Yogo Kyokai Shi (Tokio), vol. 67, No. 758, 1959, pp. 33–43; Ceram. Abs., vol. 42, No. 9, September 1959, p. 259.

[80] Yakovleva, T. I., and Valchanetshii, [Enriching Prosyanskii Kaolin by the Method of Dry Air Separation]: Ogneupory (Moscow), vol. 21, No. 1, January 1956, pp. 16–20; Ceram. Abs., vol. 42, No. 1, January 1959, p. 23.

[81] South African Mining and Engineering Journal, Organic Flocculant Aids Kaolin Slurries Treatment: Vol. 70, No. 3470, Aug. 14, 1959, pp. 403, 405.

[82] Dygola, M. I., and Oneshko, N. S., Kaolin Refractories for Soaking-Pit Lids: Stal (English), No. 9, September 1959, pp. 706–708.

[83] Iron and Steel, British Ball Clays: Vol. 32, No. 2, February 1959, pp. 555–556.

The properties of ball clays, their uses in whiteware products, and the substitution of one type of ball clay for another were described;[84] and data on dry-pressed and fired bodies of seven types of ball clay were tabulated.[85]

The Bureau of Mines released a comprehensive report covering the occurrence, mining, and use of Colorado refractory clay.[86]

Work was conducted to determine the relationship between workability, drying shrinkage, and bulk density for various grinds of an Illinois fire clay.[87]

Significant deposits of bentonite were reported to occur along the Great Northern Railway's Great Falls-Billings line.[88]

Results were presented of a study of swelling-type bentonite deposits in the Vallecitos, Calif., area.[89]

Data were obtained and published on the corresponding partial water pressures and temperatures at which hydrated montmorillonites will dehydrate reversibly.[90]

The exchange capacity [91] and its relationship to adsorption-desorption of synthetic montmorillonoids was studied.[92] Results of *other* studies on the cation and base-exchange mechanism of bentonite were published.[93]

A paper was published on the results of experiments using bentonite as a forest fire retardant,[94] and specifications were issued by the Forest Service for bentonite to be used as a fire retardant.[95]

Low-swelling Colorado bentonite was said to reduce the cost of sealing irrigation canals.[96]

The genesis and mineralogy of some clay minerals in Japan were investigated.[97]

A book was published on the results of research work on the geology, mineralogy, physical chemistry, and industrial applications of Ukrainian bentonites.[98]

---

[84] Lampman, C. M., How to Use Ball Clays in Ceramic Industry: Ceram. Ind., vol. 73, pt. 1, No. 4, October 1959, pp. 89–91, 134; pt. 2, No. 5, November 1959, pp. 82–85.

[85] Hanks, C. F., Jr., and Kent, W. B., Dry-Press Properties of Various Ball Clay Types: Jour. Can. Ceram. Soc., vol. 27, 1958, pp. 7–21.

[86] Van Sant, J. N., Refractory-Clay Deposits of Colorado, U.S. Bureau of Mines Rept. of Investigations 5530, 1959.

[87] Ekedahl, Charles, Workability, Shrinkage, and Density of Fireclay: Ceram. Age, vol. 74, No. 1, July 1959, pp. 20–22.

[88] Pit and Quarry, Railway Geologists' Report Indicates Mineral Deposits: Vol. 52, No. 5, November 1959, p. 106.

[89] Aune, Q. A., Caraway, W. H., Morris, F. C., and Gates, G. L., Evaluation of a California Bentonitic Clay for Use in Oil-Well Drilling Muds: Bureau of Mines Rept. of Investigations 5487, 1959, 44 pp.

[90] Crowley, M. S., and Roy, Rustum, Equilibrium and Pseudo Equilibrium Low-Temperature Dehydration of Montmorillonoids: Jour. Am. Ceram. Soc., vol. 42, No. 1, January 1959, pp. 16–20.

[91] Koizumi, Mitsue, and Roy, Rustum, Synthetic Montmorillonoids with Variable Exchange Capacity: Am. Mineral., vol. 44, No. 7–8, July-August 1959, pp. 788–805.

[92] Gillery, F. H., Adsorption-Desorption Characteristics of Synthetic Montmorillonoids in Human Atmospheres: Am. Mineral., vol. 44, No. 7–8, July-August 1959, pp. 806–818.

[93] Gorman, W. G., and Guth, E. P., The Cation-Exchange Properties of Bentonite with Application to the Assay of Pharmaceuticals: Jour. Am. Pharm. Assoc., vol. 48, No. 1, January 1959, pp. 21–26.

McAtee, J. L., Jr., Inorganic-Organic Cation Exchange on Montmorillonite: Am. Mineral., vol. 44, No. 11–12, November–December 1959, pp. 1230–1236.

[94] Phillips, C. B., Miller, H. R., Swelling Bentonite Clay, A New Forest Fire Retardant: Forest Service-U.S. Department of Agriculture, Tech. Paper 37, August 1959, 30 pp.

[95] U.S. Department of Agriculture-Forest Service Specification 5100–30, Apr. 10, 1959, 5 pp.

[96] Mining Record, New Studies Show Bentonite Useful in Sealing Canals: Vol. 70, No. 47, Nov. 26, 1959, p. 8.

[97] Iwao, Shuichi, Some Aspects of Hydrothermal Alteration with Special Reference to the Occurrence of Clay Minerals in Japan: Soc. Papers Coll. Gen. Educ., Univ. Tokyo, vol. 8, August 1958, pp. 93–113; Chem. Abs., vol. 53, No. 8, Apr. 25, 1959, p. 6923a.

[98] Ovcharenko, F. D., and Others, Ukrainian Bentonite: Ukrainian S.S.R., Acad. of Sci., 1958, 98 pp.

The occurrence, geology, properties, and potential uses of an extensive bentonitic clay deposit near Kursunlu, Turkey, was discussed.[99]

Star Enterprises, Inc., Cassopolis, Mich., issued a technical bulletin describing its montmorillonite fuller's earth.

High temperature reactions of attapulgite and other clay minerals were studied by X-ray diffraction techniques.[1]

Detailed results were published of tests to improve working properties of whiteware clays.[2]

Chemical additives as clay-body bonding agents were discussed.[3]

Some of the properties and applications of various monolithic refractories were presented and recent developments discussed in detail.[4]

A step was made towards simplification in the range of manufactured fire-clay bricks and in their use in furnace construction in England, by the new British Standard Specifications, B.S. 3056, 1959.

An article was published describing in detail the manufacturing process of a tunnel kiln and plant completed in 1958 by North American Refractories Co., at Farber, Mo. The plant produced a variety of refractory items.[5]

Production was announced of a new refractory not penetrated by molten aluminum.[6]

The production of lightweight refractories using Vladimir (U.S.S.R.) kaolin was described and physical properties of the products were given in detail. Kaolin and combustible products were used as raw materials with the semi-dry pressing technique developed by the Leningrad Institute of Refractories.[7]

The need for research in refractories technology was discussed, and the refractories research work was described of North American Refractories Co., Kaiser Chemicals Division, The A. P. Green Fire Brick Co., Harbison-Walker Refractories, Gladding McBean & Co., Refractories Division of H. K. Porter, Inc., Charles Taylor Sons Co., and General Refractories Co.[8]

The Structural Clay Products Institute, Washington, D.C., published specifications for clay masonry construction.[9]

An improved method of handling brick in large structures was described.[10]

---

[99] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 5, November 1959, pp. 44–50.

[1] Kulbicki, Georges, High Temperature Phases in Sepiolite, Attapulgite, and Soponite: Am. Mineral., vol. 44, No. 7–8, July–August 1959, pp. 788–805.

[2] West, R. R., Gould, R. E., Coffin, L. B., and Lux, J. F., A Method for High-Intensity Dispersion of Clay: Bull. Am. Ceram. Soc., vol. 39, No. 1, January 1959, pp. 1–6.

[3] Gmeiner, Arch, Organic Binders Increase Strength of Clay Bodies: Brick and Clay Record, vol. 134, No. 6, June 1959, pp. 61–62.

[4] Cobaugh, G. D., Monolithic Refractory Constructions in Steel Plant Equipment: Iron and Steel Eng., vol. 36, No. 5, May 1959, pp. 110–116.

[5] Brick and Clay Record, Tunnel Kiln Experience—42 Years of it—Built this New Narco Plant: Vol. 134, No. 4, April 1959, pp. 76–79, 97, 99.

[6] Blast Furnace Steel Plant, Refractory Brick; vol. 47, No. 3, March 1959, p. 323.

[7] Tsigler, V. D., Belukha, P. G., and Shakhnovich, I. G., [Production and Properties of Kaolin Lightweight Refractories]: Ogneupory (Moscow), vol. 22, No. 9, 1957, pp. 385–391; Ceram. Abs., vol. 42, No. 1, January 1959, p. 13.

[8] Brick and Clay Record, Refractories in the Rocket Age: Vol. 134, No. 1, January 1959, pp. 65–66.

[9] Structural Clay Products Institute, Recommended Guide Specifications: Vol. 10, pt. 1, No. 6, June 1959, 4 pp.; pt. 2, No. 7, July 1959, 4 pp.; pt. 3, No. 8, August 1959, 4 pp.; pt. 4, No. 9, September 1959, 4 pp.

[10] Guidi, G., Recent Progress in Production and Use of Brick: Ind. ital. laterizi, vol. 12, No. 5, June 1958, pp. 186–196; Ceram. Abs., vol. 42, No. 6, June 1959, p. 158.

Data on instrumentation for clay drying processes were published,[11] and the use of instrumentation in rotary kiln operation was discussed.[12]

It was shown that brick colors could be improved by controlled kiln atmosphere.[13]

A report was made on studies of the effect of moisture expansion on structural clay products.[14]

The United States Ceramic Tile Co., Canton, Ohio, developed dimension control in ceramic tile, and a grout lock feature on all four edges. A precision grinding operation was claimed to make it possible to install ceramic tile up to 20 per cent faster.[15]

The occurrence, in Alaska, of a lightweight vesicular material made from bloating clay, was described.[16]

A bulletin in Ohio raw materials for lightweight aggregate included occurrences, sampling, and evaluation; mineralogical factors in formation; and use of additives.[17]

Data for use in evaluating material for production of lightweight aggregate were presented.[18]

Articles described processes used and the problems involved in manufacturing lightweight-aggregate clay-bonded blocks.[19]

Patents were issued for the use of bentonite or kaolin as an additive in synthetic rubber [20] and insecticide formulation.[21]

Other patents for use of kaolin were in a color-stable polyvinyl chloride resin composition,[22] and in starch or starch-derivative adhesives.[23]

Other patents for use of bentonite were as a thickener in the polymerization of water-insoluble monomers,[24] as a metal coating composition,[25] a concrete additive to lessen shrinkage,[26] and in lubricants.[27]

---

[11] Ceramic Age, Instrumentation for Drying Ceramic Products—Part One—Convection Type Dryers: Vol. 73, No. 1, January 1959, pp. 16–18, 40.

[12] Brown, R. J., Instrumentation for Successful Rotary Kiln Operation: Ceramic Age, vol. 73, No. 4, April 1959, pp. 38–40.

[13] Brick and Clay Record, Control of Kiln Atmosphere for Better Brick Colors: Vol. 135, No. 3, September 1959, pp. 96, 98.

[14] Young, J. E., and Brownell, W. E., Moisture Expansion of Clay Products: Jour. Am. Ceram. Soc., vol. 42, No. 12, Dec. 1, 1959, pp. 571–581.

[15] Ceramic Industry, Whiteware News: Vol. 72, No. 4, April 1959, p. 42.

[16] Eckhard, R. A., and Plafker, George, Haydite Raw Material in Kings River, Sutton, and Lawing Areas, Alaska: U.S. Geol. Survey Bull. 1039–c, 1959, 63 pp.

[17] Everhart, J. O., Ehlers, E. G., Johnson, J. E., and Richardson, J. H., A Study of Lightweight Aggregates: Ohio State Univ. Eng. Exp. Sta. Bull. 169, 1959, 69 pp.

[18] Everhart, J. O., If Clay or Shale Makes LW Aggregate: Brick and Clay Record, vol. 134, No. 5, May 1959, pp. 58–59, 86.

[19] Goodman, Charles, Material Service Tests Clay Block: Brick and Clay Record, vol. 134, No. 5, May 1959, pp. 56–57, 81.

Poole, Bob, Dry Pressing and Clay Block Production: Brick and Clay Record, vol. 135, No. 1, July 1959, pp. 56, 62.

Caruso, P. A., New Design Data for Clay Bonded Block: Brick and Clay Record, vol. 135, No. 4, October 1959, pp. 69, 71–72, 74, 78, 80, 87.

[20] Cluesenkamp, E. W. (assigned to Monsanto Chemical Co.), Clay Additive: U.S. Patent 2,883,356, Apr. 21, 1959.

[21] Trademan, Leo, Malina, M. A., and Wilks, L. P. (assigned to Velsecol Chemical Corp.), Insecticide Formulation: U.S. Patent 2,875,120, Feb. 24, 1959.

[22] Volkenburgh, R. V. (assigned to J. M. Huber Corp.), Polyvinyl Chloride Resin-Urea-Clay Composition and Method of Making Same: U.S. Patent 2,890,190, June 9, 1959.

[23] Claxton, A. W. (assigned to Minerals and Chemical Corp.), Adhesives Containing Kaolin: U.S. Patent 2,892,731, June 30, 1959.

[24] Wiley, R. M. (assigned to The Dow Chemical Co.), Clay Thickened Suspension Polymerization Process with Plug Flow: U.S. Patent 2,886,559, May 12, 1959.

[25] Schneider, E. B., and Stevens, E. G. (assigned to North American Aviation, Inc.), High Temperature Protective Coating for Metals: U.S. Patent 2,898,253, Aug. 4, 1959.

[26] Drummond, J. V., Concrete Additive: U.S. Patent 2,876,123, Mar. 3, 1959.

[27] Stratton, C. A. (assigned to Phillips Petroleum Co.), Use of Organophilic Bentonite as Bodying Material in Lubricants: U.S. Patent 2,879,229, Mar. 17, 1959.

Some patents for beneficiating kaolin were for: Dewatering clay by centrifugal action on a flocculated clay-water mix,[28] a method of naturally reducing particle size of finely divided calcined kaolinitic clay,[29] treating kaolin in the preparation of petroleum catalysts,[30] improving brightness by froth flotation,[31] acid activation of kaolin to produce an adsorptive contact material in the form of hard spherical particles,[32] and producing kaolin slip of desired consistency for use in paper making.[33]

Other clay-processing patents were for a method to remove discoloring impurities, such as iron and organic materials, from kaolin or other clays,[34] and processes for producing acid activated clays.[35]

Patents were issued for the use of fuller's earth to increase the viscosity-characteristics of organic liquids,[36] and for a method of making a clay-refractory mixture suitable for spraying with a gun to provide a monolithic furnace lining.[37]

---

[28] Billue, R. F., and Williamson, J. T. (assigned to Thiele Kaolin Co.), Method of Dewatering Clay: U.S. Patent 2,905,643, Sept. 22, 1959.

[29] Lyons, S. C. (assigned to Georgia Kaolin Co.), Method of Treating Kaolinitic Clay: U.S. Patent 2,904,267, Sept. 15, 1959.

[30] Donovan, J. J. and Milliken, T. H., Jr., (assigned to Houdry Process Corp.), Preparation of Active Contact Masses from Kaolin Clays: U.S. Patent 2,904,520, Sept. 15, 1959.

[31] Duke, J. B. (assigned to Minerals and Chemical Corp. of America), Clay Brightness by Flotation: U.S. Patent 2,894,628, July 14, 1959.

[32] Powell, M. J., and Cecil, T. A. (assigned to Minerals and Chemical Corp. of America), Preparation of Spherical Contact Masses: U.S. Patent 2,898,304, Aug. 4, 1959.

[33] Lyons, S.C. (assigned to Georgia Kaolin Co.), Method of Handling and Conditioning Paper Making Clay for Use: U.S. Patent 2,915,412, Dec. 1, 1959.

[34] Autrey, E. A., Method of Mineral Beneficiation: U.S. Patent 2,882,211, Apr. 14, 1959.

[35] Farnand, J. R., and Puddington, I. E. (assigned to National Research Council, Ottawa), Activated Bleaching Clay: U.S. Patent 2,872,419, Feb. 3, 1959.

Gloss, G. H., and Ittlinger, R. (assigned to International Minerals and Chemical Corp.), Decolorizing of Clays: U.S. Patent 2,903,434, Sept. 8, 1959.

[36] Haden, W. L., Jr., and Martin, C. O. (assigned to Minerals & Chemical Corp. of America), Clay Bodied Organic Liquids and a Process for the Preparation Thereof: U.S. Patent 2,885,360, May 5, 1959.

[37] Jacobs, L. J. (assigned to the S. Okermeyer Co.), Refractory Gunning Composition and Method of Producing the Same: U.S. Patent 2,870,032, Jan. 20, 1959.

Cobalt

By Joseph H. Bilbrey, Jr.,[1] and Dorothy T. McDougal[2]

⁂

COBALT shared in the 1959 economic recovery with an increase in domestic consumption of 31 percent to 9.9 million pounds, the highest in 6 years. Calera Mining Company, the largest domestic producer of cobalt, closed its mine and refinery after completing its contract with the Government by delivering 6.5 million pounds of cobalt. World production of cobalt increased 21 percent, and U.S. imports reached a new peak of 21.2 million pounds. The Defense Production Act inventory of cobalt was 22,737,000 pounds as of December 31, 1959, an increase of 9,458,000 pounds in the year.

TABLE 1.—Salient statistics of cobalt, in thousand pounds of contained cobalt

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Domestic mine production of ore or concentrate	1,266	2,609	3,595	4,144	4,844	2,994
Recoverable cobalt	882	1,857	2,544	3,303	4,023	2,331
Imports	13,808	18,732	15,577	17,379	[1] 15,149	21,213
Stocks, Dec. 31 (consumers')	1,137	1,299	1,244	977	874	1,403
Consumption	9,427	9,740	9,562	9,157	7,542	9,899
Price per pound of metal	$1.65–$2.60	$2.60	$2.60–$2.35	$2.35–$2.00	$2.00	$2.00–$1.75
World: Production	22,000	29,400	31,800	31,800	29,200	35,400

[1] Revised figure.

DOMESTIC PRODUCTION

Domestic mines produced 3 million pounds of cobalt in concentrates compared with 4.8 million pounds in 1958. The decreased production was due largely to Calera Mining Co. closing its Blackbird mine at Cobalt, Idaho, in June. The company produced 1,049,000 pounds of cobalt in concentrates in 1959, compared with 3,061,000 pounds in 1958; the concentrate was shipped to its refinery in Garfield, Utah, for conversion to metal.

The Bethlehem Corp. produced 29 percent less cobalt in concentrate from its magnetite iron ore at Cornwall, Pa., because the mine was closed during the steel strike. The Pyrites Co., Wilmington, Del., processed the concentrate into metal, oxides, and hydrate.

---

[1] Commodity specialist, assisted technically by Isaac E. Weber.

[2] Statistical assistant.

At the Kellogg (Idaho) Bunker Hill Zinc plant 80 tons of residue containing 7,008 pounds of cobalt was recovered. No shipments were made.

TABLE 2.—Cobalt ore or concentrate produced and shipped in the United States

	1950–54 (average)	1955	1956	1957	1958	1959
Produced:						
Gross weight ..... short tons..	23, 973	28, 398	35, 985	38, 417	47, 345	45, 834
Cobalt content.... thousand pounds..	1, 266	2, 609	3, 595	4, 144	4, 844	2, 994
Recoverable cobalt ..... do....	882	1, 857	2, 544	3, 303	4, 023	2, 331
Shipped from mines:						
Gross weight ..... short tons..	23, 708	25, 101	36, 956	39, 744	46, 294	40, 896
Cobalt content.... thousand pounds..	1, 249	2, 439	3, 657	4, 123	4, 832	2, 944
Recoverable cobalt ..... do....	897	1, 735	2, 655	3, 281	4, 017	2, 316

Refinery production from domestic ores and concentrates was 33 percent less than in 1958. At its Garfield refinery, Calera Mining Co. produced 1,210,000 pounds of cobalt metal or 52 percent less than 1958. This completed its contract for delivery of cobalt to the Government, and the company closed its refinery in September. Howe Sound Company, acting for its subsidiary, Calera Mining Company, requested that the Government investigate the allegation that national security would be threatened and domestic cobalt production sharply reduced unless government action were taken. The request was rejected, as investigation showed that cobalt imports were not threatening to impair national security.[3]

From its mining and refining facilities near Fredericktown, Mo., the St. Louis Smelting and Refining Division of National Lead Co. produced 24 percent more cobalt metal than in 1958.

Based on cobalt content, domestic production of cobalt oxide declined 19 percent from 1958, hydrate 2 percent, and salts 7 percent. Production of driers increased 18 percent.

TABLE 3.—Cobalt materials consumed by refiners or processors in the United States, in thousand pounds of contained cobalt

Form [1]	1950–54 (average)	1955	1956	1957	1958	1959
Alloy and concentrate	3, 279	4, 880	6, 399	5, 793	4, 645	3, 342
Metal	750	884	884	877	999	1, 098
Hydrate	75	79	91	82	57	24
Carbonate	4	----------	1	----------	----------	3
Purchased scrap	100	114	96	93	250	----------
Other		63	61	93	56	55

[1] Total consumption is not shown because the metal, hydrate, and carbonate originated from alloy and concentrate.

---

[3] Civil and Defense Mobilization, Office of Memorandum of Decision by the Director: Sec. 8, 1958 Trade Agreements, Extension Act, OCDM release 692, Oct. 2, 1959, 23 pp.

TABLE 4.—Cobalt products produced and shipped by refiners and processors in the United States, in thousand pounds

Product	1958				1959			
	Production		Shipments		Production		Shipments	
	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content
Metal	3,702	3,638	4,272	4,196	2,477	2,462	2,639	2,620
Oxide	292	202	420	296	233	163	228	159
Hydrate	227	116	256	132	200	114	210	120
Salts:								
Acetate	112	26	99	23	115	27	105	25
Carbonate	297	138	295	137	246	113	233	108
Sulfate	479	107	447	101	566	125	503	114
Other	262	62	251	59	176	46	209	53
Driers	11,252	649	11,263	650	13,361	768	13,005	745
Total	16,623	4,938	17,303	5,594	17,374	3,818	17,132	3,944

CONSUMPTION AND USES

Mainly because of improved business conditions, industry used 9.9 million pounds of cobalt, the largest quantity since 1953 and 31 percent more than in 1958. Cobalt consumed for metallic uses increased 38 percent. Consumption for salts, driers, and other nonmetallic uses also increased.

Again, the leading single use of cobalt was for permanent magnet alloys—30 percent of the total, and 27 percent greater than 1958. The second largest use of cobalt was for high-temperature, high-strength alloys—24 percent of the total and 10 percent more than in 1958.

TABLE 5.—Cobalt consumed in the United States, by uses, in thousand pounds of contained cobalt

Use	1950–54 (average)	1955	1956	1957	1958	1959
Metallic:						
High-speed steel	232	209	259	237	88	214
Other steel	145	151	123	109	100	619
Permanent magnet alloys	2,202	2,818	2,787	2,927	2,340	2,979
Cutting and wear-resisting materials	4,322	194	270	264	161	139
High-temperature high-strength alloys		3,221	3,019	2,755	2,193	2,423
Alloy hard-facing rods and materials	473	536	625	501	361	404
Cemented carbides	314	307	253	249	148	339
Other	219	291	365	237	252	654
Total	7,907	7,727	7,701	7,279	5,643	7,771
Nonmetallic (exclusive of salts and driers):						
Ground-coat frit	444	568	525	474	457	543
Pigments	129	236	232	205	251	200
Other	62	115	115	188	161	254
Total	635	919	872	867	869	997
Salts and driers: Lacquers, varnishes, paints, inks, pigments, enamels, glazes, feed, electroplating, etc. (estimate)	885	1,094	989	1,011	1,030	1,131
Grand total	9,427	9,740	9,562	9,157	7,542	9,899

TABLE 6.—Cobalt consumed in the United States, by forms in which used, in thousand pounds of contained cobalt

Form	1950–54 (average)	1955	1956	1957	1958	1959
Metal	6,960	7,226	7,321	7,028	5,403	7,630
Oxide	635	906	857	755	754	877
Purchased scrap	944	514	395	363	355	261
Salts and driers	885	1,094	989	1,011	1,030	1,131
Total	[1] 9,427	9,740	9,562	9,157	7,542	9,899

[1] Includes a small quantity of ore and alloy.

PRICES

Effective February 1, 1959, the major supplier reduced the price of cobalt metal granules and regular fines 25 cents to $1.75 per pound, f.o.b. carrier, Port of New York, packed in 500-pound drums. Other producers also lowered their prices, except International Nickel Co. of Canada, Ltd., which maintained its price of $2.00 per pound. Ceramic-grade oxide (72½–73½ percent, in 350-pound kegs) was reduced 10 cents to $1.33 a pound, east of the Mississippi River, f.o.b. shipping point, freight allowed.

FOREIGN TRADE [4]

Imports.—Imports of 21.2 million pounds of cobalt contained in metal, oxide, and salts reached an alltime high and 40 percent above 1958. The Belgian Congo continued to be the main supplier of cobalt, providing 56 percent of all imports. Belgium supplied 26 percent. The Belgian metal and oxide were produced from Belgian Congo white alloys, so that 82 percent of U.S. imports originated in the Belgian Congo.

Imports of cobalt as metal from West Germany were 6 percent of the total, 93 percent more than in 1958. The Federation of Rhodesia and Nyasaland provided 5 percent, 20 percent more than in 1958.

Exports.—Exports of cobalt-bearing materials totaled 705,426 pounds. Scrap (5 percent or more cobalt) was the main item, and 10,785 pounds was in fabricated forms. The remainder was ore, concentrate, metal, and alloys in crude form.

Shipments to West Germany were 44 percent of the total, to the United Kingdom 20 percent, and to the Netherlands 19 percent.

All forms of cobalt metal remained on the positive list of commodities requiring validated export license for shipment to any destination other than Canada. On September 24, 1959, the Bureau of Foreign Commerce announced less restrictive controls on cobalt alloys and cobalt chemicals.

Tariff.—The duties on cobalt materials remained unchanged in 1959.

---

[4] Figures on U.S. imports and exports (unless otherwise indicated) compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 7.—Cobalt imported for consumption in the United States, by classes, in thousand pounds

[Bureau of the Census]

Year	White alloy[1]		Ore and concentrate[2]		Metal		Oxide		Salts and compounds		Total	
	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Value (thousands)	Gross weight	Value (thousands)	Gross weight	Value (thousands)	Gross weight	Cobalt content (estimated)
1950-54 (average)	4,978	2,262	278	26	[3] 11,100	[3] $24,680	[3] 554	[3] $787	129	$81	17,039	13,808
1955	5,646	2,464	2	(4)	15,535	38,585	1,073	1,792	362	249	22,618	18,732
1956	4,708	2,013	77	6	12,974	32,910	828	1,413	398	247	18,985	15,577
1957	1,883	817	140	15	[5] 16,173	[5] 32,431	647	853	364	179	19,207	17,379
1958	-----	-----	-----	-----	[6] 14,538	[6] 28,664	837	1,116	234	145	[6] 15,609	[6] 15,149
1959	-----	-----	-----	-----	20,087	35,926	1,561	1,856	278	134	21,926	21,213

[1] Reported by importer to Bureau of Mines, which adjusted the figures for "Ore and concentrates" for 1950-57 as reported by the Bureau of the Census, to exclude "white alloy" from the Belgian Congo.
[2] Figures exclude receipts of "white alloy" from Belgian Congo.
[3] Adjusted by Bureau of Mines.
[4] Less than 1,000 pounds.
[5] Includes 4,903 pounds of scrap, valued at $1,698.
[6] Revised figure.

TABLE 8.—Cobalt metal and oxide imported for consumption in the United States, by countries, in thousand pounds

[Bureau of the Census]

Country	Metal		Oxide (gross weight)	
	1958	1959	1958	1959
North America: Canada	1,065	539	64	128
Europe:				
Belgium-Luxembourg	2,355	4,477	773	1,433
France	[1] 26	68	-----	-----
Germany, West	[1] 712	1,377	-----	-----
Norway	737	746	-----	-----
United Kingdom	13	(2)	-----	-----
Total	3,843	6,668	773	1,433
Asia: Japan	-----	10	-----	-----
Africa:				
Belgian Congo	[1] 8,812	11,887	-----	-----
Rhodesia and Nyasaland, Federation of	[1] 818	983	-----	-----
Total	9,630	12,870	-----	-----
Grand total	[1] 14,538	20,087	837	1,561

[1] Revised figure.
[2] Less than 1,000 pounds.

WORLD REVIEW

World production of cobalt increased 21 percent. Output from the Belgian Congo, which supplied 53 percent of the 1959 total, increased 31 percent. The second largest production, 13 percent, came from the Federation of Rhodesia and Nyasaland. Canada produced 9 percent and the United States 7 percent of the estimated world production.

NORTH AMERICA

Canada.—Cobalt was obtained mainly as a byproduct of smelting and refining nickel-copper ores from the Sudbury district, Ontario, and Lynn Lake, Manitoba. Silver-cobalt ores of the Cobalt-Gowganda area of northern Ontario continued to be a source. The International Nickel Company of Canada, Ltd, (Inco), produced electrolytic cobalt from its nickel refinery operations at Port Colborne, Ontario. Impure cobalt oxide shipped to Inco's refinery in Clydach, Wales, was converted to high-grade oxide, metal, and salts. Inco delivered 2.4 million pounds of cobalt, an increase of 11 percent over 1958.[5] Falconbridge Nickel Mines, Ltd., delivered 732,000 pounds of cobalt, 3 percent less than in 1958. This electrolytic cobalt was produced in refining Canadian nickel-copper matte exported to the Falconbridge refinery at Kristiansand, Norway.[6] Sherritt Gordon Mines, Ltd., produced 314,343 pounds of cobalt, an increase of 15 percent over 1958. The nickel-copper ore used for this cobalt came from its mine at Lynn Lake, Manitoba, and was refined at Fort Saskatchewan, Alberta.[7]

---

[5] The International Nickel Company of Canada, Ltd., 1959 Annual Report, p. 9.
[6] Falconbridge Nickel Mines, Ltd., 1959 Annual Report, p. 5.
[7] Sherritt Gordon Mines, Ltd., 1959 Annual Report, pp. 3–4.

TABLE 9.—World production of cobalt, by countries,[1] in short tons of contained cobalt [2]

[Compiled by Augusta W. Jann and Berenice B. Mitchell]

Country [1]	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada [3]	681	1, 659	1, 758	1, 961	1, 355	1, 649
United States (recoverable cobalt)	438	929	1, 272	1, 652	2, 012	1, 165
Total	1, 119	2, 588	3, 030	3, 613	3, 367	2, 814
Africa:						
Belgian Congo (recoverable cobalt)	7, 624	9, 443	10, 019	8, 945	7, 166	9, 374
Morocco: Southern zone (content of concentrates)	757	834	710	500	1, 021	1, 391
Rhodesia and Nyasaland, Federation of: Northern Rhodesia (content of white alloy, cathode metal, and other products)	843	741	1, 205	1, 583	1, 792	2, 372
Total	9, 224	11, 018	11, 934	11, 028	9, 979	13, 137
Oceania:						
Australia (recoverable cobalt in zinc concentrates)	11	13	13	14	17	[4] 14
New Caledonia (content of concentrates)	-------	-------	-------	-------	44	[4] 160
Total	11	13	13	14	61	[4] 174
World total (estimate) [1] [2]	11, 000	14, 700	15, 900	15, 900	14, 600	17, 700

[1] Cobalt is also recovered, principally in Germany, from pyrites produced in Finland and other European countries; estimates are included in the world total.

[2] This table has some revisions. Data do not add to totals shown because of rounding where estimated figures are included in the detail.

[3] Figures comprise cobalt content of Canadian ore processed in Canada and exported (irrespective of year mined), plus the cobalt recovered from nickel-copper ores at Port Colborne, Ontario; Port Saskatchewan, Alberta; and Kristiansand, Norway; consequently, the figures exclude the cobalt recovered at Clydach, Wales, from Canadian nickel-copper ores, for which an estimate has been included in the world total.

[4] Estimate.

Deloro Smelting and Refining Co., Ltd., smelted silver-cobalt ores from the Cobalt-Gowganda area on a toll basis for such companies as Agnico Mines, Ltd., Langis Silver & Cobalt Mining Company, Ltd., and Castle Trethewey Mines, Ltd.[8]

Cuba.—Minerals Law 617 took effect on October 27, 1959. It required reregistration of all mining claims at a cost of $100 each, as well as payment of an annual tax of $10 per hectare on exploited claims and $20 per hectare on unexploited claims. Owners of concessions pay 5 percent tax on the value of minerals extracted and 25 percent duty on minerals exported, based on the highest average world quotation. Failure to pay the tax or reregister results in loss of the concession. Under this law the Department of Mines and Petroleum became part of the Ministry of Agriculture, and the latter was empowered to exploit any canceled mining concessions.

In November the Freeport Nickel Company at its Moa Bay plant began producing nickel-cobalt sulfide concentrate, which was successfully tested at the company refinery at Port Nickel, La. However, by the end of the year the future operation of the plant became doubtful, largely owing to the uncertain effect of the new minerals law. Ap-

---

[8] Canadian Mining Journal, Cobalt: Vol. 81, No. 2, February 1960, p. 154.

proximately $61.5 million had been spent in Cuba on this project to produce, in addition to nickel, 4.4 million pounds of cobalt a year.

An article describing the nickel-cobalt process was published.[9]

EUROPE

Finland.—Copper-bearing pyrite from the Outokumpu mine in eastern Finland, containing about 0.2 percent cobalt, was concentrated and roasted, and the sinter was shipped to Duisburg, West Germany, for recovery of cobalt, copper, iron, and zinc.

Germany, West.—The major West German cobalt producer, The Duisburger Kupferhütte refinery at Duisburg, recovered cobalt mainly from pyrite sinter imported from Finland and other European countries. Cobalt-bearing scrap, residues, and speiss were treated at the refinery of Gebrüder Borchers A.G., at Goslar.

AFRICA

Belgian Congo.—The Union Minière du Haut-Katanga produced 9,374 tons of cobalt, 53 percent of the estimated world production and 31 percent more than in 1958. Good progress was made in constructing the new hydrometallurgical plant on the Luilu River. The plant was to process copper-cobalt ores from the Western Zone containing less than 0.5 percent cobalt. Wide use will be made of electronic automation to control the metallurgical processes. Initially 1,900 tons of electrolytic cobalt of improved quality is to be produced by the more efficient methods. The Panda smelter and the Shituru and Luilu hydrometallurgical plants will provide an annual capacity of 13,000 tons of cobalt by the end of 1960.

Morocco.—Production of concentrate in Morocco was 13,306 tons containing 1,391 tons of cobalt, or 36 percent over 1958. The Société Minière de Bou-Azzer et du Graara completed a new washing plant at its Bou-Azzer cobalt mines at a cost of 1,200 million francs. The plant can handle about 13,200 tons of ore a month to produce about 1,000 tons of concentrates. These are shipped by truck to Marakech and then by rail to Casablanca for export to France and Belgium.[10]

Rhodesia and Nyasaland, Federation of.—Rhokana Corporation, Ltd., milled 4,149,000 short tons of ore averaging 0.16 percent cobalt in the fiscal year ending June 30, 1959. This quantity was 7 percent less than was milled in fiscal year 1958, when the average grade was 0.19 percent cobalt. Cobalt concentrate produced from the copper-cobalt ore of the Nkana mine was 84,148 short tons containing 2.81 percent cobalt. Total production was 1,092 tons of cobalt compared with 1,269 tons in fiscal year 1958.[11] During the fiscal year ending June 30, 1959, Chibuluma Mines, Ltd., produced 29,008 short dry tons of cobalt-copper concentrate containing 3.30 percent copper and 3.57 percent cobalt. Of this quantity, 28,276 short tons was smelted at its Ndola plant, yielding 7,741 tons of matte with a cobalt content of 9.19 percent and a copper content of 12.37 percent. The matte was shipped to Belgium for refining; 830 tons of cobalt was returned, compared with 657

---

[9] Lee, J. A., New Nickel Process on Stream: Chem. Eng., Sept. 7, 1959, pp. 145–152.
[10] U.S. Consulate, Casablanca, Morocco, State Department Dispatch 20; Aug. 20, 1959.
[11] Rhokana Corporation Ltd., Annual Report, June 30, 1959.

tons in fiscal year 1958. The estimated ore reserve at Chibuluma on June 30, 1959, was 7,984,000 tons with an average grade of 0.22 percent cobalt and 5.04 percent copper. An additional reserve of 2 million tons of ore, containing 4.74 percent copper and 0.05 percent cobalt, was delineated by diamond drilling at Chibuluma West, 9,000 feet west of the Chibuluma ore body.[12]

Uganda.—The Kilembe Mines, Ltd., in western Uganda, British East Africa, owns 5,268 acres in the Ruwenzori Mountain Range. By January 1959 the company had installed an additional plant and equipment at its concentrator at Kilembe to increase annual production of copper and cobalt concentrates one-third. Yearly productive capacity of the enlarged plant is about 45,000 tons each of cobalt and copper concentrate. The cobalt concentrate contains about 1.5 percent cobalt. This is stockpiled for future treatment.[13]

TECHNOLOGY

The Bureau of Mines, as part of its pure-metals program, carried out research on separating nickel and cobalt by solvent extraction from crude nickel-cobalt products obtained from laterites and serpentines, on recovering alloy components from nickel- and cobalt-base high-temperature alloy scrap, and on methods for preparing high-temperature alloys from scrap. Several research projects were devoted to developing methods for preparing superpure nickel and cobalt. Some fundamental data on the physical and mechanical properties of the prepared metals were determined, and the alloy character of high-purity cobalt was studied. Basic research also was performed on developing precise analytical methods for nickel- and cobalt-bearing materials. An electrolytic process was developed by the Bureau of Mines for recovering nickel and cobalt from the basic carbonates produced at the Nicaro (Cuba) plant owned by the U.S. Government.[14]

A report was published on mineralogical research by the Bureau of Mines on the Nicaro nickel ores and plant products. Basic studies, including differential thermal analysis in controlled atmospheres, were made to provide data that would help improve recoveries of nickel and cobalt at the Nicaro plant. The work was done under a cooperative agreement with the General Services Administration.[15] Results of field investigations by the Bureau of Mines on seven deposits of nickel-cobalt-iron-bearing laterite and weathered serpentine near the west coast of Puerto Rico, east and south of Mayaguez, indicated a reserve of 90.5 million tons based on a cutoff of 0.6 percent nickel. The average nickel content was 0.88 percent; the average cobalt and iron contents were 0.09 and 23.2 percent, respectively.[16]

The Bureau of Mines reported on the preparation and properties of cobalt catalysts and their use in the Fischer-Tropsch synthesis

---

[12] Rhodesian Selection Trust Limited, Annual Report 1959, pp. 51, 53, 54.

[13] Canadian Mines Handbook, 1959, p. 119.

[14] Ferrante, M. J., and Butler, M. O., An Electrolytic Method for Separating Nickel and Cobalt: Bureau of Mines Rept. of Investigations 5543, 1959, 23 pp.

[15] Fisher, R. B., and Dressel, W. M., The Nicaro (Cuba) Nickel Ores. Basic Studies, Including Differential Thermal Analysis in Controlled Atmospheres: Bureau of Mines Rept. of Investigations 5496, 1959, 54 pp.

[16] Heidenreich, W. L., and Reynolds, B. M., Nickel-Cobalt-Iron-Bearing Deposits in Puerto Rico: Bureau of Mines Rept. of Investigations 5532, 1959, 68 pp.

(the catalytic hydrogenation of carbon monoxide),[17] also on the kinetics of the Fischer-Tropsch synthesis with cobalt catalysts.[18]

The Bureau of Mines investigated oxygen production by metal chelates and concluded that cobalt chelates of the salcomine type offered possibilities for small-scale production of oxygen.[19]

A bibliography was published on the extractive metallurgy of nickel and cobalt, 1900–1928.[20]

Sherritt Gordon Mines, Ltd., developed a process for treating leaching plant tailings to extract the residual nickel, copper, and cobalt, leaving the iron in a form suitable for use as an iron ore.[21]

Articles were published [22] on cobalt-base alloys, cobalt in steel, permanent magnets, cobalt oxide as a catalyst, and the application of dispersion hardening to cobalt.

Platinax II, a cobalt-platinum alloy claimed to be one of the most powerful permanent-magnet materials, was developed by Johnson, Matthey, and Co., Ltd., of London, England. It contains 23.3 percent by weight of cobalt and lends itself to the manufacture of magnets of complex shape and extremely small size.[23]

The Metropolitan-Vickers Electrical Co., Ltd., made a high-intensity cobalt 60 container for industrial radiography. The cobalt source of 1,500 curies is used for the radiographic examination of welded seams in steel plate up to 5 inches thick.[24]

A new precipitation-hardened cobalt-alloy spring wire for use at temperatures of 400° to 1,400°F. was produced by National Standard Company, Niles, Mich. It contained 46 to 53 percent cobalt, 19 to 21 percent chromium, 14 to 16 percent tungsten, 9 to 11 percent nickel, and 0.05 to 0.15 percent carbon; it is designated Alloy HS 25 or No. L-605.[25]

---

[17] Shultz, J. F., Hofer, L. J. E., Cohn, E. M., Stein, K. C., and Anderson, R. B., Synthetic Liquid Fuels From Hydrogenation of Carbon Monoxide: Bureau of Mines Bull. 578, 1959, pp. 4–28, 56–72.

[18] Anderson, R. B., Shultz, J. F., Hofer, L. J. E., and Storch, H. H., Physical Chemistry of the Fischer-Tropsch Synthesis: Bureau of Mines Bull. 580, 1959, p. 16.

[19] Stewart, R. F., Estep, P. A., and Sebastian, J. J. S., Investigation of Oxygen Production by Metal Chelates: Bureau of Mines Inf. Circ. 7906, 1959, 38 pp.

[20] Jones, C. A., Bibliography on Extractive Metallurgy of Nickel and Cobalt, 1900–1928: Bureau of Mines Inf. Circ. 7883, 1959, 33 pp.

[21] Sherritt Gordon Mines, Ltd., 1959 Annual Report, p. 6.

[22] Battelle Memorial Institute, Cobalt: Cobalt Inf. Center, quarterly pub., 1959.

[23] Mining Journal (London), A Cobalt-Platinum Magnetic Alloy: Vol. 252, No. 6445, Feb. 27, 1959, p. 233.

[24] Metallurgia (Manchester), A High Intensity Cobalt Container for Industrial Radiography: Vol. 59, No. 356, June 1959, pp. 311–312.

[25] American Metal Market, Super-Alloy Cobalt Wire Produced by National-Standard: Vol. 46, No. 151, Aug. 4, 1959, p. 7.

Patents were issued on recoverying nickel and cobalt from ores and leach solutions,[26] separating nickel and cobalt,[27] separating impurities from cobalt-containing materials,[28] preparing of catalysts,[29] preparing cobalt compounds,[30] preparing vitreous enamels,[31] chemical plating,[32] and alloy compositions.[33]

---

[26] Roy, T. K. (assigned to Chemical Construction Corp.), Cobalt and Nickel Recovery using Carbon Dioxide Leach: U.S. Patent 2,867,503, Jan. 6, 1959.

Schaufelberger, F. A. (assigned to American Cyanamid Co.), Beneficiation of Laterite Ores: Canadian Patent 568,706, Jan. 6, 1959.

Morrow, J. G. (assigned to Freeport Sulphur Co.), Recovery of Cobalt and Nickel from Ores: U.S. Patent 2,872,306, Feb. 3, 1959.

Bare, C. B., and Clauser, R. L. (assigned to Bethlehem Steel Co.), Nickel and Cobalt Recovery from Ammoniacal Solutions: U.S. Patent 2,879,137, Mar. 24, 1959.

Queneau, P. E., and Illis, A. (assigned to International Nickel Co. of Canada, Ltd.), Recovery of Cobalt and High-Purity Nickel from Laterite Ores: Canadian Patent 575,076, Apr. 28, 1959.

Nossen, E. S., Process for Nitric Acid Leaching of Low-Grade Ores, e.g., Laterites: Canadian Patent 576,372, May 26, 1959.

Donaldson, J. W., and Davis, Jr., H. F. (assigned to Quebec Metallurgical Industries, Ltd.), Treating Nickel Ore Concentrates Containing also Cobalt: Canadian Patent 579,219, July 7, 1959.

Bailey, R. P. (assigned to Quebec Metallurgical Industries, Ltd.), Method for Extracting Nickel from Laterite Ores: U.S. Patent 2,899,300, Aug. 11, 1959.

Forward, F. A., and Mackiw, V. M. (assigned to Sherritt Gordon Mines, Ltd.), Method of Extracting Non-Ferrous Metals from Metal-Bearing Material: Canadian Patent 584,305, Sept. 29, 1959.

[27] Merre, M. de (assigned to Soc. Gen. Metallurgique de Hoboken), Separation of Nickel from Cobalt: Canadian Patent 568,643, Jan. 6, 1959.

Evans, D. J. I., and Tao-I-Chiang, P. (assigned to Sherritt Gordon Mines, Ltd.), Production of Metal from Solutions Containing Copper, Cobalt and/or Nickel: Canadian Patent 580,508, July 28, 1959.

Hyde, R. W., and Feick III, G. (assigned to Freeport Sulphur Co.), Separate Recovery of Nickel and Cobalt from Mixed Compounds Containing the Same: U.S. Patent 2,902,345, Sept. 1, 1959.

Merre, M. de (assigned to Soc. Gen. Metallurgique de Hoboken), Separation of Nickel from Cobalt: Canadian Patent 585,158, Oct. 13, 1959.

Goldstein, E. M. (assigned to the United States of America as represented by the Administrator, General Services Administration), Process for Separating Cobalt and Nickel from Ammoniacal Solutions: U.S. Patent 2,910,354, Oct. 27, 1959.

Dean, J. G. (assigned to the United States of America as represented by the Administrator, General Services Administration), Process for Separating Cobalt and Nickel from Ammoniacal Solutions: U.S. Patents 2,913,334, 2,913,335, 2,913,336, Nov. 17, 1959.

Lyle, A. G., Brubaker, P. E., and Beyer, A. J. (assigned to American Cyanamid Co.), Separation of Nickel and Cobalt: U.S. Patent 2,915,388, Dec. 1, 1959.

Dean, J. G. (assigned to the United States of America as represented by the Administrator, General Services Administration), Process for Separating Cobalt and Nickel from Ammoniacal Solutions: U.S. Patent 2,915,389, Dec. 1, 1959.

Mackiw, V. N., Kunda, V., and Benoit, R. L. (assigned to Sherritt Gordon Mines, Ltd.), Method for Separating Metal Values from Nickel and Cobalt in Ammoniacal Solutions: Canadian Patent 586,406, Nov. 3, 1959.

[28] Nowacki, H., Schackmann, H., Teworte, W., and Vossel, P. (assigned to Duisburger Kupferhutte), Method for the Separation of Impurities from Cobalt-Containing Materials: U.S. Patent 2,879,158, Mar. 24, 1959.

[29] Erickson, H. (assigned to Sinclair Refining Co.), Process for Preparing Cobalt-Molybdenum-Alumina Catalyst: U.S. Patent 2,897,161, July 28, 1959.

Malley, T. J., Pennell, J. D., and Schindler, H. D. (assigned to American Cyanamid Co.), Preparation of Desulfurization Catalysts: U.S. Patent 2,911,374, Nov. 3, 1959.

Erickson, H. (assigned to Sinclair Refining Co.), Preparation of a Cobalt Oxide-Molybdenum Oxide-Alumina Catalyst: U.S. Patent 2,915,478, Dec. 1, 1959.

[30] Hayden, W. M. (assigned to Chemetals Corp.), Recovery of Copper, Nickel or Cobalt in Wrought Form: Canadian Patent 575,468, May 5, 1959.

West, D. H., Townshend, S. C., and Llewelyn, D. M. (assigned to The International Nickel Co., Inc.), Production of Brown Cobaltous Oxide and Cobalt Salts: U.S. Patent 2,909,408, Oct. 20, 1959.

[31] Earl, J. A. (assigned to Consolidated Electrodynamics Corp.), Vitreous Enamel: U.S. Patent 2,916,388, Dec. 8, 1959.

[32] Hays, S. A. (assigned to North American Aviation, Inc.), Chemical Nickel and Cobalt Plating Process: U.S. Patent 2,871,142, Jan. 27, 1959.

[33] Timmons, G. A., and Semchyshen, M. (assigned to American Metal Climax, Inc.), Molybdenum-Titanium-Cobalt Alloy: U.S. Patent 2,884,324, Apr. 28, 1959.

Coffinberry, A. S. (assigned to the United States of America as represented by the Chairman of the Atomic Energy Commission), Plutonium-Cerium-Cobalt and Plutonium-Cerium-Nickel Alloys: U.S. Patent 2,901,345, Aug. 25, 1959.

Nelson, J. A. (assigned to Continental Copper & Steel Industries, Inc.), High-Temperature Alloy: U.S. Patent 2,908,565, Oct. 13, 1959.

Columbium and Tantalum

By F. W. Wessel[1]

◆

DURING 1959 columbium and tantalum became more clearly defined as desirable metals for service at temperatures above 2,000° F. Productive capacity was estimated at 700,000 pounds annually. The electron-beam furnace was recognized as an important tool for refining.

A report of the Materials Advisory Board on columbium and tantalum reviewed raw material supply and applications separately.[2] The panel concluded that columbium (Cb) resources are adequate to support a manyfold increase in mill product requirements but that tantalum (Ta) resources will support an increase of not over five times present production.

DOMESTIC PRODUCTION

Porter Bros. Corp. continued to ship euxenite concentrate from a dredge operation at Bear Valley, Idaho, although at a reduced rate. The company contract with the Federal Government for delivery of 1,050,000 pounds of combined Cb and Ta pentoxides by June 1961 was far ahead of schedule; it will be completed early in 1960.

TABLE 1.—Salient statistics of columbium-tantalum concentrate

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Columbium-tantalum concentrate shipped from mines:[1]						
Pounds	11,001	12,954	216,606	370,483	428,347	189,263
Value	$21,488	$22,125	(2)	(2)	(2)	(2)
Imports for consumption:						
Columbium-mineral concentrate pounds	3,226,356	9,612,576	5,699,553	3,348,706	2,555,942	3,395,816
Tantalum-mineral concentrate pounds	527,464	1,907,686	1,312,865	828,265	1,035,588	652,839
Industrial consumption:[3]						
Contained metal tons	(2)	580	810	924	593	835
World: Production of columbium-tantalum concentrates pounds	5,220,700	11,540,000	8,940,000	6,840,000	4,990,000	6,170,000

[1] 1956–59 data are for columbite-tantalite concentrate plus columbium-tantalum oxide content of euxenite concentrate.

[2] Figure withheld to avoid disclosing individual company confidential data.

[3] Includes metal content of all raw materials consumed, including columbium-tantalum-bearing tin slags.

---

[1] Commodity specialist.

[2] National Research Council, Report of the Committee on Refractory Metals: Materials Advisory Board Rept. MAB–154–M(1), vol. 2, Oct. 15, 1959, pp. 59–110.

Production of columbium metal continued to increase. Leading producers were Wah Chang Corp., at Albany, Oreg.; E. I. du Pont de Nemours & Co., Inc., at Newport, Del.; and Union Carbide Metals Co., at Niagara Falls, N.Y., in that order. Production of tantalum was estimated at 122 tons. Fansteel Metallurgical Corp., with plants at North Chicago, Ill., and Muskogee, Okla., was the leading producer, followed by Kawecki Chemical Co., at Boyertown, Pa., and National Research Corp., at Cambridge, Mass.

E. I. du Pont de Nemours & Co., Inc., planned completion in 1960 of a metallurgical development plant in Baltimore. Processes for columbium reportedly will be based on development studies performed by Thompson-Ramo-Wooldridge, Inc. The Baltimore plant will contain equipment for melting and fabrication. The company also purchased a large pyrochlore deposit near Powderhorn, Colo., which is stated to contain over 100,000 tons of columbium pentoxide.

Early in 1959, National Research Corp., Cambridge, Mass., consolidated the tantalum production and marketing operations in a Metals Division. A contract was placed with the company by the Navy Bureau of Ordnance for research and development of tantalum and its alloys in solid-fuel rocket propulsion systems.

Wah Chang Corp. installed three electron-beam furnaces at Albany, Oreg., for refining refractory metals. Extensive fabricating facilities also were under construction.

Total production of ferroalloys was 542 tons, a 26-percent increase over 1958. Union Carbide Metals Co., Shieldalloy Corp., Molybdenum Corp. of America, and Vanadium Corp. of America were the principal producers. The last-named company marketed Thermocol, an exothermic ferrocolumbium.

The Wolverine Tube Division of Calumet & Hecla, Inc., Allen Park, Mich., announced commercial extrusion of columbium rod and tube and later in the year brought out a process for making inflatable tubing of a number of metals, including columbium and tantalum. Superior Tube Co., Norristown, Pa., announced commercial production of columbium and tantalum tubing. The Refractomet Division, Universal-Cyclops Steel Corp., Bridgeville, Pa., began producing columbium sheet.

CONSUMPTION AND USES

Domestic consumption of columbium-tantalum-bearing concentrates and slags, in terms of metal content, was 576 tons of columbium and 259 tons of tantalum.

A series of tantalum-tungsten alloys was developed. The most promising, containing 10 percent tungsten, is highly corrosion resistant, maintains good strength at high temperature, and can be fabricated and machined by standard methods. The alloy will be used for the throats of solid-fuel rocket engines, for missile structures, for electronic components, and for other applications at temperatures above 1650° C.

Fansteel Metallurgical Corp. developed two new alloys (Fansteel 80 and Fansteel 82). These are alloys of columbium-zirconium and columbium-tantalum-zirconium, respectively; are available as ingot, bar, rod, plate, and sheet; and are intended for high-temperature corrosion-resistant applications in missiles, rockets, and spacecraft. Crucible Steel Co. of America is developing alloys which are readily rolled into sheet for similar uses. A nickel-base, 1-percent-columbium alloy has been developed for use in spark-plug terminals. Union Carbide Metals Co., in its study of uranium carbide as a reactor fuel, will clad the elements in columbium metal.

Tantalum was used increasingly in the lining of chemical reaction vessels. The P. R. Mallory & Co., Inc., has introduced a line of tantalum capacitors, series XTL–125, with extended life at high temperatures. Tantalum is mentioned among the metal catalysts usable in making synthetic diamonds.

PRICES AND SPECIFICATIONS

Prices of the two grades of columbite opened and closed the year at $1.05 to $1.10 per pound of contained oxides in concentrate with a 10:1 Cb:Ta ratio, and $0.95 to $1.00 per pound in concentrate with an 8½:1 ratio. The higher ratio material was subject to small price fluctuations during the year. On the London exchange, tantalite containing 60 percent Ta_2O_5 opened the year at 800s. to 850s. per long-ton unit; declined to 650s. to 700s. on February 20; dropped to 550s. to 600s. on April 24; and returned to 650s. to 700s. on July 31, where it remained until the yearend.

Columbium metal, 99½ percent pure, was quoted throughout 1959 as follows: Roundels, $55 to $70 per pound, electrode segments, $60 to $75 per pound, and rough ingots, $65 to $80 per pound. Tantalum metal sold throughout 1959 at $128 per kilo for rod and $100 per kilo for sheet. The price of tantalum melting stock was cut from $60 to $35 per pound early in June. Tantalum powder was quoted on the London market at £12 to £15 per pound.

Closing prices for ferrotantalum-columbium and for ferrocolumbium were, respectively, $3.05 and $3.45 per pound of contained metal. Thermocol was quoted at $3.50 per pound of Cb, equivalent, on the basis of 53 percent metal, to $1.855 per pound of alloy.

TABLE 2.—Average grade of concentrates received by United States consumers and dealers in 1959, by country of origin, in percent of contained pentoxides

Country of origin	Columbite		Tantalite	
	Cb_2O_5	Ta_2O_5	Ta_2O_5	Cb_2O_5
Argentina	------	------	31	43
Australia	------	------	46	23
Belgian Congo	------	------	33	39
Brazil	40	29	53	19
British East Africa [1]	54	0	------	------
Madagascar	------	------	51	27
Malaya, Federation of	58	16	------	------
Mozambique	------	------	46	30
Nigeria	65	6	30	46
Norway [1]	51	1	------	------
Portugal	------	------	33	34
Rhodesia and Nyasaland, Federation of	------	------	63	7
Union of South Africa	------	------	45	29

[1] Pyrochlore concentrate.

FOREIGN TRADE [3]

Imports.—In addition to imports of ores and concentrates shown in tables 2 and 3, 1,565 pounds of columbium and tantalum metal valued at $32,548, was imported from West Germany.

Exports.—Exports were as follows:

	Pounds	*Value*
Ores and concentrates:		
Columbium	15, 060	$12, 730
Tantalum	10, 337	25, 021
Metals and alloys in crude form, also scrap	4, 235	42, 432
Metals and alloys in semifabricated forms	2, 260	182, 747
Tantalum powder	1, 988	75, 870

TABLE 3.—Columbium-mineral concentrates imported for consumption in the United States, by countries, in pounds

[Bureau of the Census]

Country	1950–54 (average)	1955	1956	1957	1958	1959
North America: Canada	----------	----------	----------	----------	----------	14, 000
South America:						
Argentina	2, 205	10, 800	----------	----------	2, 262	3, 591
Bolivia	6, 154	----------	3, 791	----------	----------	----------
Brazil	36, 245	233, 012	160, 462	54, 500	101, 992	137, 648
British Guiana	625	7, 033	----------	----------	----------	----------
Total	45, 229	250, 845	164, 253	54, 500	104, 254	141, 239
Europe:						
Germany, West	53, 591	849, 310	----------	1, 653	46, 628	11, 578
Netherlands [1]	----------	----------	----------	----------	----------	13, 000
Norway	76, 651	562, 759	521, 003	236, 147	310, 858	454, 535
Portugal	43, 791	168, 362	31, 024	72, 953	65, 461	38, 083
Spain	882	2, 525	----------	----------	----------	----------
Sweden	3, 343	----------	----------	----------	----------	----------
United Kingdom [1]	----------	----------	11, 200	29, 621	----------	----------
Total	178, 258	1, 582, 956	563, 227	340, 374	422, 947	517, 196
Asia:						
Aden	----------	----------	1, 350	----------	----------	----------
Japan [1]	6, 367	----------	----------	----------	----------	----------
Korea, Republic of	400	----------	----------	----------	----------	----------
Malaya, Federation of	60, 491	515, 688	521, 741	127, 524	709, 077	151, 881
Thailand	----------	----------	----------	----------	----------	13, 546
Total	67, 258	515, 688	523, 091	127, 524	709, 077	165, 427
Africa:						
Belgian Congo	497, 987	1, 247, 901	758, 919	905, 989	507, 725	519, 712
British West Africa	----------	14, 521	----------	----------	----------	----------
French Equatorial Africa	----------	4, 700	----------	----------	----------	----------
Madagascar	2, 212	36, 412	10, 621	3, 075	9, 920	11, 939
Mozambique	25, 473	64, 974	43, 124	81, 422	171, 164	85, 249
Nigeria	2, 362, 150	5, 739, 526	3, 593, 114	1, 804, 631	543, 925	1, 936, 296
Rhodesia and Nyasaland, Federation of	6, 449	13, 529	6, 652	----------	----------	----------
Uganda [2]	5, 792	24, 399	18, 780	----------	5, 771	2, 205
Union of South Africa	23, 443	55, 539	17, 772	31, 191	81, 159	----------
Total	2, 923, 506	7, 201, 501	4, 448, 982	2, 826, 308	1, 319, 664	2, 555, 401
Oceania: Australia	12, 105	61, 586	----------	----------	----------	2, 553
Grand total: Pounds	3, 226, 356	9, 612, 576	5, 699, 553	3, 348, 706	2, 555, 942	3, 395, 816
Value	$5, 113, 229	$19, 912, 381	$8, 386, 659	$3, 037, 706	$2, 345, 890	$2, 651, 783

[1] Presumably country of transshipment rather than original source.

[2] Classified by the Bureau of the Census as British East Africa.

---

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

The columbium ore was shipped to France and the tantalum ore to Japan and Austria. West Germany was the principal destination for the tantalum powder, and the metals were shipped to the United Kingdom and other countries.

TABLE 4.—Tantalum-mineral concentrates imported for consumption in the United States, by countries, in pounds

[Bureau of the Census]

Country	1950–54 (average)	1955	1956	1957	1958	1959
South America:						
Argentina	----------	6, 614	4, 409	----------	11, 635	1, 611
Brazil	72, 974	221, 834	140, 039	199, 205	159, 015	205, 898
French Guiana	7, 159	23, 085	14, 532	3, 075	----------	----------
Total	80, 133	251, 533	158, 980	202, 280	170, 650	207, 509
Europe:						
Belgium-Luxembourg [1]	21, 312	----------	----------	6, 391	10, 681	21, 871
Germany, West	12, 573	594, 030	----------	----------	135, 431	----------
Norway	----------	11, 729	----------	----------	----------	----------
Portugal	55, 206	6, 614	7, 054	5, 966	32, 513	27, 227
Spain	148	11, 276	----------	----------	----------	----------
Sweden	4, 699	----------	----------	----------	992	----------
United Kingdom [1]	----------	28, 533	----------	----------	----------	----------
Total	93, 938	652, 182	7, 054	12, 357	179, 617	49, 098
Asia:						
Japan [1]	2, 138	----------	----------	----------	----------	----------
Malaya, Federation of	1, 441	5, 853	----------	----------	6, 000	----------
Singapore, Colony of						----------
Thailand	----------	----------	----------	----------	----------	4, 515
Total	3, 579	5, 853	----------	----------	6, 000	4, 515
Africa:						
Belgian Congo	317, 276	539, 214	953, 092	491, 124	370, 120	166, 317
Madagascar	1, 235	10, 693	20, 165	6, 835	7, 716	9, 375
Mozambique	2, 179	57, 184	4, 409	24, 046	149, 777	68, 343
Nigeria	13, 107	303, 692	31, 174	16, 815	34, 537	50, 902
Rhodesia and Nyasaland, Federation of	2, 668	18, 326	22, 166	38, 975	77, 667	44, 720
Uganda [2]	841	8, 507	----------	----------	2, 034	2, 690
Union of South Africa	1, 303	14, 428	6, 511	6, 910	27, 368	24, 805
Total	338, 609	952, 044	1, 037, 517	584, 705	669, 219	367, 152
Oceania: Australia	11, 205	46, 074	109, 314	28, 923	10, 102	24, 565
Grand total: Pounds	527, 464	1, 907, 686	1, 312, 865	828, 265	1, 035, 588	652, 839
Value	$807, 058	$4, 820, 453	$1, 180, 118	$948, 638	$1, 838, 338	$1, 165, 536

[1] Presumably country of transshipment rather than original source.

[2] Classified by the Bureau of the Census as British East Africa.

TABLE 5.—World production of columbium and tantalum mineral concentrates,[1] by countries, in pounds[2]

[Compiled by Augusta W. Jann and Berenice B. Mitchell]

Country	1950-54 (average)		1955		1956		1957		1958		1959	
	Columbium	Tantalum	Columbium	Tantalum	Columbium	Tantalum	Columbium	Tantalum	Columbium	Tantalum	Columbium	Tantalum
North America:												
Canada	-----	-----	42	390	-----	-----	-----	-----	-----	-----	[3] 14,000	-----
United States (mine shipments)	11,001		12,954		216,606		370,483		428,347		189,263	
South America:												
Argentina	668		728		3,968		688		[3] 2,262	[3] 11,635	[3] 3,591	[3] 1,611
Bolivia (exports)	882	-----	2,350	-----	-----	-----	-----	-----	-----	-----	-----	-----
Brazil (exports	74,821	45,852	238,317	127,205	177,916	208,161	68,206	204,675	302,030		30,864	207,232
British Guiana	[4] 5,893	-----	6,720	-----	-----	-----	-----	-----	-----	-----	-----	-----
French Guiana	[5] 22,054		20,452		-----	14,916	-----	2,976	-----	-----	-----	-----
Europe:												
Germany, West (U.S. imports)	[6] 267,957	[6] 62,865	849,310	594,030	-----	-----	1,653	-----	46,628	135,431	11,578	-----
Norway	[5] 216,393	-----	675,930	-----	573,196	-----	425,488	-----	630,516	-----	756,178	-----
Portugal (U.S. imports)	43,791	55,206	168,362	6,614	31,024	7,054	72,953	5,966	65,461	32,513	38,083	27,227
Spain (U.S. imports)	[5] 2,205	[4] 247	2,525	11,276	-----	-----	-----	-----	-----	-----	-----	-----
Sweden (U.S. imports)	[5] 8,357	[5] 11,745	-----	-----	-----	-----	-----	-----	-----	992	-----	-----
Asia: Malaya, Federation of	108,864	-----	528,640	-----	619,136	-----	318,080	-----	356,160	-----	268,800	-----
Africa:												
Belgian Congo (including Ruanda-Urundi)[7]	465,964		967,819		932,546		524,695		553,355		535,718	
French Equatorial Africa	3,391		2,672		-----	-----	-----	-----	-----	-----	-----	-----
Madagascar	[8] 14,826		38,801		19,400		19,180		28,880		22,046	
Mozambique	40,747		82,884		56,580		288,503		378,916		320,004	
Nigeria	3,633,280	6,720	7,047,040	35,840	5,832,960	33,600	4,307,520	40,320	1,803,200	49,930	3,559,875	31,114
Rhodesia and Nyasaland, Federation of	[4] 8,093	10,934	12,240	4,660	5,080	29,320	760	76,960	-----	96,260	-----	116,820
Sierra Leone	[6] 8,960		8,960	-----	-----	-----	-----	-----	-----	-----	-----	-----
South West Africa	12,977		8,299	2,924	9,607	3,740	9,325	14,676	4,152	6,574	2,610	1,539
Swaziland (Yttrotantalite)	-----	-----	-----	-----	-----	-----	-----	32,920	-----	-----	-----	-----
Uganda [9]	21,945		34,003		3,494		4,054		6,384		5,264	
Union of South Africa	-----	20,400	-----	24,000	-----	2,900	-----	1,981	-----	37,920	-----	11,500
Oceania: Australia	34,732		27,139		159,655		50,038		13,507		[10] 18,000	
World total (estimate)[2]	5,220,700		11,540,000		8,940,000		6,840,000		4,990,000		6,170,000	

---

[1] Frequently the composition (Cb_2O_5–Ta_2O_5) of these concentrates lies in an intermediate position, neither Cb_2O_5 nor Ta_2O_5 being strongly predominant. In such cases the production figure has been centered.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] U.S. imports.

[4] Average for 1952–54.

[5] Average for 1953–54.

[6] Average for 1 year only, as 1954 was first year of commercial production.

[7] In addition, tin-columbium-tantalum concentrates were produced as follows: 1950–54 (average), 3,477,536 pounds; 1955, 5,456,385 pounds; 1956, 6,501,365 pounds; 1957, 4,360,699 pounds; 1958, 3,196,670 pounds; 1959 estimated 2,750,000 pounds; columbium-tantalum content averaging about 10 percent.

[8] Average for 1951–54.

[9] In addition, tin-columbium-tantalum concentrates were produced as follows: 1951–54 (average) 3,696 pounds; 1955, 515 pounds; no further production recorded.

[10] Estimate.

WORLD REVIEW

NORTH AMERICA

Canada.—St. Lawrence River Mines has completed drilling its pyrochlore deposit and that of its affiliate, Oka Uranium and Metals Co. A large columbium ore body was outlined. A 4-ton pilot mill was under construction at the end of 1959. Quebec Columbium, Ltd. (in which Kennecott Copper Corp. and Molybdenum Corp. of America have large interests), did extensive sampling and testing of its deposit in the same area. In Ontario, Nova Beaucage Mines, Ltd. (controlled by Consolidated Mining and Smelting Company of Canada, Ltd.), operated a pilot flotation mill on its pyrochlore property at North Bay. At Bernic Lake, Manitoba, Chemalloy Minerals, Ltd. (formerly Montgary Explorations), sampled the deposit with a view toward producing byproduct tantalum; the mineral has a Ta: Cb ratio of about 10:1.

SOUTH AMERICA

Brazil.—The Wah Chang Mining Co. at Araxá controls a pyrochlore deposit with an estimated Cb_2O_5 content of 4.6 million tons. Other large pyrochlore bodies have been discovered at Tapira and Serra Negra.[4] Brazilian regulations still prohibit free export of this material.

French Guiana.—The tantalite mine at Sursaut was shut down, and exploration has disclosed no promising new deposits.

EUROPE

Germany, East.—The VEB Elektrochemisches Kombinat at Bitterfeld has separated columbium and tantalum successfully on a pilot-plant scale.

Germany, West.—No production of columbium or tantalum metal was recorded.

Portugal.—Production of high-grade columbite and tantalite continued at a moderate rate.

Rumania.—A government-sponsored mine-development organization reports discovery of pegmatite desposits containing columbium and tantalum.

Switzerland.—CIBA, Ltd., was developing processes for extracting high-purity columbium and tantalum.

United Kingdom.—In February the Board of Trade applied export restrictions to various columbium alloys. Murex, Ltd., announced that a tantalum-columbium plant had been substantially completed and that operations had begun. This plant will produce metal, oxide, or salt and will cost about $1.1 million.

---

[4] Bureau of Mines, Mineral Trade Notes: Vol. 48, No. 6, June 1959, pp. 46–48.

ASIA

India.—Some interest was shown by both governmental agencies and private companies in extensive placer deposits containing some columbite-tantalite about 140 miles northwest of Calcutta.

AFRICA

Belgian Congo.—No columbium-tantalum-bearing tin slag was produced, but shipments were made to the United States from stocks.

British East Africa.—Preliminary investigation of the Mbeya, Tanganyika, pyrochlore deposit was completed. Output from a pilot mill was shipped to the plant of the parent company, N. V. Billiton Maatschappij in Holland.

In Uganda, Sukulu Mines, Ltd., continued to operate a pilot plant on its pyrochlore-phosphate deposit near Tororo.

Liberia.—Opening a columbite-tantalite deposit with an annual production of 100,000 pounds is being considered.

Mozambique.—Small quantities of columbite were reported moving from the Alto Ligonha beryl district; Monteminas, Ltd., and Empresa Mineira do Alto Ligonha are major factors in this area.

Nigeria.—Geochemical prospecting of the Jos Plateau formations for columbium and other elements was sponsored by the Nigerian Government.

Columbite production increased during the year; operating companies included Jantar Nigeria Co., Ltd., Tin and Associated Minerals, Ltd. (a subsidiary of Kennecott Copper Corp.), Gold & Base Metal Mines of Nigeria, Ltd., Bisichi Tin Co., United Tin Areas of Nigeria, and London Tin Corp., Ltd.

Rhodesia and Nyasaland, Federation of.—The discovery of pyrochlore at Ilomba Hill in 1958 has led to additional discoveries at Chilwa Island and Tundula Hill.

TECHNOLOGY

Several articles discussing the production, properties, and uses of columbium were published.[5] One article summarized in concise form the essential data for companies in the field.[6]

A process for flotation of columbium minerals was developed and patented.[7]

A patent on the extraction of columbium by chlorination with carbon tetrachloride was issued.[8]

---

[5] Mining World and Engineering Record, World-wide Research into the Nature and Uses of Niobium: Vol. 175, No. 4522, January 1959, pp. 14–17.

Sandor, J., Niobium (Columbium)—Its Future Prospects: Metallurgia, vol. 59, No. 354, April 1959, pp. 185–194.

Mining Journal (London), Columbite Returns to Favour: Vol. 253, No. 6482, Nov. 13, 1959, pp. 474–475.

[6] Chemical Week, New Push for Columbium and Tantalum: Vol. 85, No. 1, July 4, 1959, pp. 51, 56, 57.

[7] Last, A. W., and Marquardson, K. F. (assigned to Kennecott Copper Corp., New York, N.Y.), Process of Concentrating Columbium Minerals by Froth Flotation: U.S. Patent 2,875,896. Mar. 3, 1959.

[8] Cookston, Jack W. (assigned to Nova Beaucage Mines, Ltd. [NPL], North Bay, Ontario, Canada), Method of Separating Metals from Ores and Concentrates: U.S. Patent 2,905,545. Sept. 22, 1959.

Several papers dealing with the iodide (de Boer-van Arkel) process for producing pure columbium and tantalum were published.[9]

The electron-bombardment furnace, a recently developed tool for purification of columbium, was the subject of several articles.[10]

A survey of the field of vacuum metallurgy [11] included a section on tantalum.

Studies were published of alloys of tantalum with tungsten, cobalt, copper, nickel, and scandium and alloys of columbium with uranium, zirconium, tungsten, titanium, aluminum, and molybdenum.[12]

Further studies of columbium and tantalum oxides in oxide systems were published.[13]

The properties and applications of columbium, tantalum, and their alloys were surveyed in several discussions of refractory metals.[14]

---

[9] Loonam, A. C., Principles and Applications of the Iodide Process: Jour. Electrochem. Soc., vol. 106, No. 3, March 1959, pp. 238–244.

Rolsten, R. F., High-Purity Tantalum: Trans. AIME. Met. Soc., vol. 215, No. 3, June 1959, pp. 472–476.

Rolsten, R. F., Iodide Columbium: Trans. AIME Met. Soc., vol. 215, No. 3, June 1959, pp. 478–483.

Rolsten, R. F., A Study of the Iodide Niobium Process: Jour. Electrochem. Soc., vol. 106, No. 11, November 1959, pp. 975–980.

[10] Jones, F. O., Knapton, A. G., and Savill, J. Arc Furnace and Electron Bombardment Techniques Used in Studies of the Refractory Metals: Jour. Less-Common Metals, vol. 1, No. 1, February 1959, pp. 80–84.

Smith, H. R., Hunt, C. d'A., and Hanks, C. W., Electron Bombardment Melting: Jour. Metals, vol. 11, No. 2, February 1959, pp. 112–117.

Chemical Engineering, Electron Beams Break into Production: Vol. 66, No. 14, July 13, 1959, pp. 80, 82.

Iron Age, Electron-Beam Welding Process Operates in a Vacuum: Vol. 183, No. 13, Mar. 26, 1959, pp. 156–158.

[11] Darling, A. S., Low Pressure Metallurgy—A General Survey: Metallurgia, vol. 60, No. 360, October 1959, pp. 137–143.

[12] Reactor Core Materials, Fuel and Fertile Materials: Vol. 2, No. 1, February 1959, p. 9.

Reactor Core Materials, Fuel and Fertile Materials: Vol. 2, No. 2, May 1959, pp. 5–6.

Reactor Core Materials, uel and ertile Materials: Vol. 2, No. 3, August 1959, pp. 3, 4, 11, 12.

Kieffer, R., Sedlatschek, K., and Braun, H., Tungsten Alloys of High Melting Point: Jour. Less-Common Metals, vol. 1, No. 1, February 1959, pp. 26–33.

Suiter, J., Properties of Titanium-Aluminum-Niobium Alloys: Jour. Less-Common Metals, vol. 1, No. 3, June 1959, pp. 232–236.

Smith, C. S., Alloys of Copper, Nickel, and Tantalum: Trans. AIME Met. Soc., vol. 215, No. 6, December 1959, pp. 905–909.

Korchynsky, M., and Fountain, R. W., Precipitation Phenomena in Cobalt-Tantalum Alloys: Trans. AIME Met. Soc., vol. 215, No. 6, December 1959, pp. 1033–1042.

[13] Subbarao, E. C., and Shirane, G., Dielectric and Structural Studies in the Systems $Ba(Ti,Nb)O_3$ and $Ba(Ti,Ta)O_3$: Jour. Am. Ceram. Soc., vol. 42, No. 6, June 1959, pp. 279–284.

Subbarao, E. C., Nonstoichiometric $PbNb_2O_6$-Type Solid Solutions: Jour. Am. Ceram. Soc., vol. 42, No. 9, September 1959, p. 448.

Egerton, L., and Dillon, D. M., Piezoelectric and Dielectric Properties of Ceramics in the System Potassium-Sodium Niobate: Jour. Am. Ceram. Soc., vol. 42, No. 9, pp. 438–442.

Shafer, M. W., and Roy, R., Phase Equilibria in the System Na_2O-Nb_2O_5: Jour. Am. Ceram. Soc., vol. 42, No. 10, October 1959, pp. 483–486.

[14] Chemical Engineering, What Materials Beat High Nuclear Heat?: Vol. 66, No. 8, Apr. 20, 1959, pp. 202, 204, 206.

Chemical and Engineering News, Tantalum, Tungsten Fill Hot Needs: Vol. 37, No. 42, Oct 19, 1959, pp. 52, 55.

Chemical Engineering, Wanted: Better Refractory Alloys: Vol. 66, No. 24, Nov. 30, 1959, pp. 36, 38, 40.

Copper

By A. D. McMahon,[1] Gertrude N. Greenspoon [2] and Wilma F. Washington [2]

❖

Contents

ALTHOUGH copper production in the United States reached a record rate in the first 6 months of 1959, the year ended with the lowest annual total since 1949. Operations at most of the principal copper mines, smelters, and refineries were halted by the longest strike in history. As a result, mine output fell 16 percent and smelter and refinery production from domestic ores dropped 20 percent.

An upward trend in consumption of refined copper which had begun in the second half of 1958 continued through June 1959. Influenced by vacations at fabricators and lower output because of strikes, consumption in the last 6 months fell 19 percent below the first 6 months. For the entire year, however, consumption exceeded 1958 by 17 percent. Because of the high consumption and reduced domestic output, stocks of refined copper at the end of the year were 63 percent less than on January 1, and the lowest since before 1900; stocks of unrefined copper were 2 percent less.

The primary producers' annual price of electrolytic copper was the highest since 1956.

Imports of unmanufactured copper rose 19 percent; those of refined copper gained 67 percent and of unrefined 7 percent. Exports of refined copper—the principal export class—fell 59 percent and were the lowest since 1953.

World mine production was 6 percent higher than in 1958 and the highest ever achieved. All important copper-producing countries except the United States registered gains in production; increases of 16 percent in Canada, 17 in Chile, 19 in the Belgian Congo, 36 in

---

[1] Commodity specialist.
[2] Statistical assistant.

Northern Rhodesia, and 26 in Australia enabled those countries to establish new records. Among the smaller producers only Mexico and Peru had lower production.

Major developments in the copper industry included the authorization, on January 19, by the Export-Import Bank of a supplemental credit of $15 million to Southern Peru Copper Corp. for the development of the Toquepala project in Peru. An original credit authorization of $100 million had been approved in 1955. The project was completed about 5 months ahead of schedule and production of blister copper at the smelter was to begin January 1, 1960. The first copper ore was produced at the new El Salvador mine of The Anaconda Company in Chile during April. Operations at Kennecott Copper Corp.'s El Teniente mine, also in Chile, were adversely affected by a 3-day strike in March and a month-long strike in October. In Rhodesia, completion of the Kariba Dam on the Zambesi River assured that additional electric power would become available the beginning of January 1960.

LEGISLATION AND GOVERNMENT PROGRAMS

Under the Office of Minerals Exploration (OME), copper continued to be eligible for exploration assistance with 50-percent Government participation. One contract was executed on September 3, 1959, with Golden Copper Queen Mining Corp., for exploration of the Copper Queen prospect, Lemhi County, Idaho. The total amount of the contract was $40,270.

The 1.7-cent-a-pound excise tax on copper imports, effective July 1, 1958, was unchanged.

Effective February 20, the U.S. Department of Commerce reimposed controls on all copper exports; shippers were required to declare destinations of all shipments except those to Canada.

DOMESTIC PRODUCTION

PRIMARY COPPER

Copper production at mines, smelters, and refineries in the United States declined as a result of widespread strikes.

During the first half of the year, short-term strikes closed the new Kennecott Copper Corp.'s smelter at Ray, Ariz.; a railroad strike prevented ore shipments from The Anaconda Company's mines in Butte, Mont., to the smelter in Anaconda, Mont.; and an extended strike shut down operations at the Tacoma, Wash., plant of the American Smelting and Refining Co. from March 13 to June 17.

The 3-year labor contracts negotiated in June 1956 between principal producers and the unions expired in mid-1959 and by the middle of August strikes at producers' plants halted approximately 75 percent of the nation's output of copper. The Laurel Hill plant of Phelps Dodge Refining Corp. was closed on August 1; the four Western divisions of Kennecott Copper Corp. on August 10; Magma Copper Co. and San Manuel Copper Corp. on August 11; the Anaconda

TABLE 1.—Salient statistics of the copper industry, in short tons

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
New (primary) copper produced—						
From domestic ores, as reported by—						
Mines	904, 990	998, 570	1, 104, 156	1, 086, 859	979, 329	824, 846
Value thousand	$461, 545	$744, 933	$938, 532	$654, 289	$515, 127	$506, 455
Copper ore produced [1]	96, 949, 340	112, 549, 665	131, 775, 959	129, 715, 586	114, 824, 468	103, 715, 843
Average yield of copper, percent	.86	.83	.78	.77	.79	.74
Smelters	909, 452	1, 007, 311	1, 117, 580	1, 081, 055	992, 918	799, 329
Percent of world total	29	28	28	27	25	19
Refineries	913, 890	997, 499	1, 080, 207	1, 050, 496	1, 001, 645	796, 452
From foreign ores, matte, etc., refinery reports	312, 021	344, 960	362, 426	403, 680	350, 875	301, 795
Total new refined, domestic and foreign	1, 225, 911	1, 342, 459	1, 442, 633	1, 454, 176	1, 352, 520	1, 098, 247
Secondary copper recovered from old scrap only	438, 885	514, 585	468, 489	444, 492	411, 367	471, 007
Imports (unmanufactured) [2]	613, 867	594, 100	595, 747	594, 032	[3] 496, 301	590, 447
Refined	278, 498	202, 312	191, 745	162, 309	128, 464	214, 058
Exports of metallic copper [4]	210, 966	[5] 259, 942	[5] 280, 575	[5] 430, 446	[5 6] 428, 015	[5 6] 196, 012
Refined (ingots and bars)	155, 506	199, 819	223, 103	346, 025	384, 868	158, 938
Stocks at end of year (producers)	234, 000	235, 000	339, 000	383, 000	305, 000	271, 000
Refined copper	32, 000	34, 000	78, 000	109, 000	48, 000	18, 000
Blister and materials in solution	202, 000	201, 000	261, 000	274, 000	257, 000	253, 000
Withdrawals (apparent) from total supply on domestic account:						
Total primary copper	1, 356, 000	1, 336, 000	1, 367, 000	1, 239, 000	1, 157, 000	1, 183, 000
Total primary and old copper (old scrap only)	1, 795, 000	1, 851, 000	1, 835, 000	1, 683, 000	1, 568, 000	1, 654, 000
Price average cents per pound	25.5	[7] 37.3	[7] 42.5	[7] 30.1	[7] 26.3	[7] 30.7
World:						
Smelter production, new copper	3, 140, 000	3, 630, 000	4, 000, 000	[3] 4, 040, 000	[3] 3, 950, 000	4, 170, 000
Mine production	2, 970, 000	[3] 3, 420, 000	[3] 3, 790, 000	[3] 3, 890, 000	[3] 3, 780, 000	4, 020, 000

[1] Includes old tailings smelted or re-treated. Not comparable with mine production figure shown in that latter includes recoverable copper content of ores not classified as "copper."

[2] Data are "general" imports; that is, they include copper imported for immediate consumption plus material entering country under bond. Comprises copper in ingots, plates, and bars, ores and concentrates, regulus, blister, and scrap.

[3] Revised figure.

[4] Total exports of copper, exclusive of ore, concentrates, composition metal, and unrefined copper. Exclusive also of "Other manufactures of copper," for which quality figures are not recorded before 1953. (See table 40.)

[5] Due to changes in classification 1955–59 data are not strictly comparable to earlier years.

[6] Beginning Jan. 1, 1958, copper rods not separately classified; included in "other copper manufactures."

[7] Exclusive of copper produced abroad and delivered in the United States.

Company's Montana properties on August 19; the Phelps Dodge Corp.'s Arizona properties (except Ajo) and El Paso refinery of the Phelps Dodge Refining Corp., and the American Smelting and Refining Co. plants on August 20; and the White Pine Copper Co. in Michigan on October 28. The first settlements were reached when the A.S. & R. plants resumed operations on December 11. The San Manuel strike was settled December 15, and all Kennecott divisions, except Utah Copper, returned to work on December 31. All other operations remained strikebound beyond the end of the year.

Mine Production.—Production of copper by U.S. mines decreased 16 percent. At the beginning of the year output was at the highest monthly rate since May 1956 and 69 percent of the total 1959 output was produced in the first 6 months. Strikes which began in August, however, reduced the monthly output from September through December to the lowest rate since compilation of monthly data was begun in 1941, and the year ended with the lowest annual total since 1949.

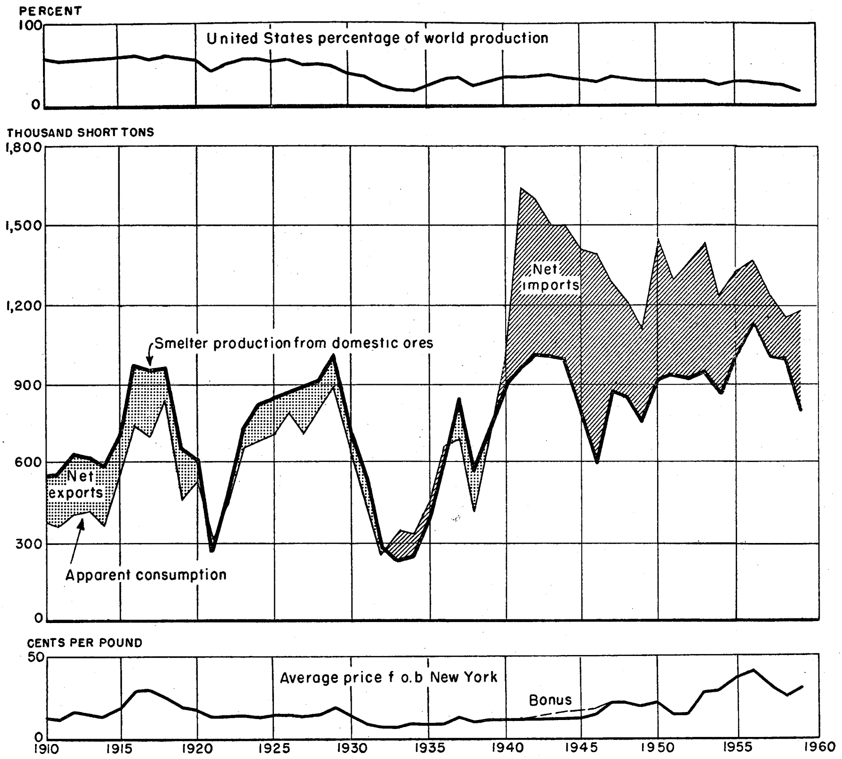

FIGURE 1.—Production, consumption, and price of copper in the United States, 1910–59

TABLE 2.—Copper produced from domestic ores, as reported by mines, smelters, and refineries, in short tons

Year	Mine	Smelter	Refinery	Year	Mine	Smelter	Refinery
1955	998, 570	1, 007, 311	997, 499	1958	979, 329	992, 918	1, 001, 645
1956	1, 104, 156	1, 117, 580	1, 080, 207	1959	824, 846	799, 329	796, 452
1957	1, 086, 859	1, 081, 055	1, 050, 496				

Arizona, by a wide margin, continued to lead all States in mine production of copper. The State supplied 52 percent of the domestic total, although its output was 11 percent less than in 1958 and 17 percent below the record established in 1957. In March, Duval Sulphur & Potash Co. began operations at the Esperanza open-pit copper mine and 12,000-ton-per-day mill in Pima County. After nearly 50 years of operation, underground mining at the Miami Copper Co. Miami mine ceased on June 26 and production came from in-place leaching.

Utah maintained its rank as the second largest copper-producing State but output was 24 percent below 1958, and its share of the total output fell from 19 to 18 percent. Montana was in third place with 8 percent; Nevada and Michigan each supplied 7 percent, but Nevada's output slightly exceeded that of Michigan, and the State continued to rank fourth. New Mexico furnished 5 percent of the total U.S. production, although its output fell 29 percent from 1958 and was the lowest since 1938.

Classification of production by mining method showed that approximately 74 percent of the recoverable copper and 79 percent of the copper ore came from open pits. Most domestic copper ore was treated by flotation at or near the mine of origin, and the resulting concentrate was shipped for smelting. Some copper ores were direct smelted, either because of their high grade or because of their fluxing qualities.

The first 5 mines in table 6 produced 49 percent of the U.S. total, the first 10 produced 73 percent, and the entire 25 furnished 97 percent.

TABLE 3.—Copper ore and recoverable copper produced by open-pit and underground methods, percent of total

Year	Open pit		Underground		Year	Open pit		Underground	
	Ore	Copper	Ore	Copper		Ore	Copper	Ore	Copper
1942	66	51	34	49	1951	84	74	16	26
1943	69	54	31	46	1952	85	77	15	23
1944	68	57	32	43	1953	83	75	17	25
1945	68	61	32	39	1954	83	79	17	21
1946	66	58	34	42	1955	83	77	17	23
1947	73	68	27	32	1956	78	73	22	27
1948	76	68	24	32	1957	77	72	23	28
1949	78	70	22	30	1958	76	71	24	29
1950	81	74	19	26	1959	79	74	21	26

TABLE 4.—Mine production of recoverable copper in the United States in 1959, by months [1]

Month	Short tons	Month	Short tons
January	95,804	August	54,729
February	86,787	September	26,879
March	96,868	October	28,943
April	99,496	November	25,291
May	100,500	December	29,489
June	93,307		
July	86,753	Total	824,846

[1] Monthly figures adjusted to final annual mine-production total.

TABLE 5.—Mine production of recoverable copper in the United States, with production of maximum year, and cumulative production from earliest record to end of 1959, by States, in short tons

State	Maximum production [1]		Production by years						Total production from earliest record to end of 1959
	Year	Quantity	1950–54 (average)	1955	1956	1957	1958	1959	
Western States:									
Alaska	1916	59,927	2	1	(2)	(2)	5	36	685,951
Arizona	1957	515,854	397,269	454,105	505,908	515,854	485,839	430,297	16,656,786
California	1909	28,644	622	613	859	945	749	663	636,301
Colorado	1938	14,171	3,485	4,323	4,228	5,115	4,193	2,940	295,784
Idaho	1958	9,846	3,089	5,618	6,656	7,912	9,846	8,713	166,678
Montana	1916	176,464	62,160	81,542	96,426	91,512	90,683	65,911	7,487,988
Nevada	1942	83,663	59,729	78,925	80,824	77,750	66,137	57,375	2,575,229
New Mexico	1942	80,100	69,801	66,417	74,345	67,472	55,540	39,688	2,192,946
Oregon	1916	1,791	9	4	7	23	10		12,468
South Dakota	1918	32							106
Texas	1928	224	4	1					1,384
Utah	1943	323,989	262,788	232,949	250,604	237,857	189,184	144,715	7,960,476
Washington	1940	9,612	4,176	3,958	2,926	1,700	52	49	121,670
Wyoming	1900	2,102			3	4	(2)		16,335
Total			863,134	928,456	1,022,786	1,006,144	902,238	750,387	38,810,102
West Central States: Missouri	1949	3,670	2,456	1,722	1,890	1,604	1,429	1,065	[3] 47,467
States east of the Mississippi:									
Alabama	1907	42							(4)
Georgia	1917	465							(4)
Maine	1918	383							(4)
Maryland	1917	146							(4)
Massachusetts	1906	5							(4)
Michigan	1916	136,846	23,995	50,066	61,526	58,400	58,005	55,300	5,294,230
New Hampshire	1908	[5] 94							(4)
North Carolina	1930	6,695		(6)	4,102	7,516	8,073	6,604	(4)
Pennsylvania	1942	6,410	3,844	4,110					(4)
South Carolina	(4)	(4)							(4)
Tennessee	1959	11,490	7,691	9,911	10,449	9,790	9,109	11,490	(4)
Vermont	1954	4,352	3,870	4,305	3,403	3,405	475		(4)
Virginia	1944	291							(4)
Wisconsin	1914	5							(4)
Total			39,400	68,392	79,480	79,111	75,662	73,394	[7] 6,073,532
Grand total	1956	1,104,156	904,990	998,570	1,104,156	1,086,859	979,329	824,846	[8] 44,931,101

---

[1] For Missouri and States east of the Mississippi, maximum since 1905.

[2] Less than 1 ton.

[3] Small quantity for Wisconsin included with Missouri.

[4] Data not available.

[5] The 1908 volume of Mineral Resources credits this figure to Massachusetts and New Hampshire; the 1909 volume credits it to New Hampshire alone.

[6] Less than 0.5 ton.

[7] For States other than Michigan, figures represent largely smelter output. Excludes small quantity, not separable, for Wisconsin shown with Missouri.

[8] Largely smelter production for States east of the Mississippi except Michigan.

TABLE 6.—Twenty-five leading copper-producing mines in the United States in 1959, in order of output

Rank	Mine	District	State	Operator	Source of copper
1	Utah Copper	West Mountain (Bingham)	Utah	Kennecott Copper Corp	Copper ore.
2	Morenci	Copper Mountain (Morenci)	Arizona	Phelps Dodge Corp	Copper, gold-silver ores.
3	New Cornelia	Ajo	do	do	Do.
4	Butte Mines (includes Kelley, Berkeley)	Summit Valley (Butte)	Montana	The Anaconda Co	Copper, silver-zinc ores.
5	San Manuel	Old Hat	Arizona	San Manuel Copper Corp	Copper ore.
6	Inspiration	Globe-Miami	do	Inspiration Consolidated Copper Co	Do.
7	Copper Queen-Lavender Pit	Warren (Bisbee)	do	Phelps Dodge Corp	Do.
8	Chino	Central	New Mexico	Kennecott Copper Corp	Do.
9	White Pine	Lake Superior	Michigan	White Pine Copper Co	Do.
10	Yerington	Yerington	Nevada	The Anaconda Co	Do.
11	Ray Pit	Mineral Creek (Ray)	Arizona	Kennecott Copper Corp	Do.
12	Liberty Pit	Robinson (Ely)	Nevada	do	Do.
13	Copper Cities	Globe-Miami	Arizona	Copper Cities Mining Co	Do.
14	Silver Bell	Silver Bell	do	American Smelting & Refining Co	Do.
15	Calumet & Hecla, Inc	Lake Superior	Michigan	Calumet & Hecla, Inc	Copper ore and tailings.
16	Esperanza	Pima	Arizona	Duval Sulphur & Potash Co	Copper ore.
17	Pima	do	do	Pima Mining Co	Do.
18	Magma	Pioneer (Superior)	do	Magma Copper Co	Do.
19	Bagdad	Eureka (Bagdad)	do	Bagdad Copper Corp	Do.
20	Burra-Boyd	Polk County	Tennessee	Tennessee Copper Co	Copper-zinc ore.
21	Miami	Globe-Miami	Arizona	Miami Copper Co	Copper ore.
22	Veteran Pit	Robinson (Ely)	Nevada	Kennecott Copper Corp	Do.
23	Blackbird	Blackbird	Idaho	Calera Mining Co	Do.
24	Ore Knob	Ashe County	North Carolina	Appalachian Sulfides, Inc	Do.
25	Cornwall	Lebanon County	Pennsylvania	Bethlehem Steel Co	Magnetite-pyrite-chalcopyrite ore.

TABLE 7.—Copper ore sold or treated in the United States in 1959, with copper, gold, and silver content in terms of recoverable metal [1]

State	Ore sold or treated (short tons)	Recoverable metal content				Value of gold and silver per ton of ore
		Copper		Gold (fine ounces)	Silver (fine ounces)	
		Pounds	Percent			
Alaska	53	72,217	68.13	----------	755	$12.89
Arizona	53,121,545	803,087,000	.76	96,153	2,724,701	.11
California	794	46,900	2.95	88	830	4.82
Colorado	17,378	1,179,700	3.39	2,357	383,912	24.74
Idaho	379,563	10,035,700	1.32	5,626	14,045	.55
Michigan [2]	7,606,988	110,600,000	.73	----------	----------	----------
Montana	8,069,191	125,937,235	.78	12,917	1,638,305	.24
Nevada	8,547,263	114,730,400	.67	23,858	173,399	.12
New Mexico	4,581,639	59,885,100	.65	1,688	41,876	.02
North Carolina	233,696	8,268,000	1.77	965	16,319	.21
Tennessee [3]	1,482,810	22,980,000	.77	99	59,739	.04
Utah	19,673,423	277,003,600	.70	223,658	1,784,672	.48
Washington	1,500	42,000	1.40	46	374	1.30
Total	103,715,843	1,533,867,852	.74	367,455	6,838,927	.18

[1] Excludes copper recovered from precipitates as follows: Arizona, 48,610,000 pounds; California, 88,700 pounds; Montana, 4,192,826 pounds; New Mexico, 18,593,700 pounds; Utah, 7,770,800 pounds.

[2] Includes tailings.

[3] Copper-zinc ore.

TABLE 8.—Copper ore concentrated in the United States in 1959, with content in terms of recoverable copper

State	Ore concentrated (short tons)	Recoverable copper content	
		Pounds	Percent
Arizona	[1] 52,741,920	769,530,600	.73
California	700	22,300	1.59
Colorado	325	11,400	1.75
Idaho	378,819	9,979,200	1.32
Michigan [2]	7,606,988	110,600,000	.73
Montana	8,068,111	125,904,535	.78
Nevada	[3] 8,517,212	[3] 113,325,700	.67
New Mexico	[4] 4,534,164	[5] 58,909,400	.65
North Carolina	233,696	8,268,000	1.77
Tennessee [6]	1,482,810	22,980,000	.77
Utah	19,673,200	276,935,100	.70
Washington	1,500	42,000	1.40
Total	103,239,445	1,496,508,235	.72

[1] Includes ore that was treated by leaching followed by concentration.

[2] Includes tailings.

[3] Includes ore treated by straight leaching, and copper precipitates recovered therefrom; Bureau of Mines not at liberty to publish.

[4] In addition 8,800 tons was treated by leaching.

[5] In addition 164,100 pounds of copper was recovered by leaching.

[6] Copper-zinc ore.

Smelter Production.—The recovery of copper from ores of domestic origin by smelters in the United States declined 20 percent to the lowest point since 1949. Copper production from foreign materials was the lowest since before these data were compiled in 1945, and from secondary sources, the lowest since 1955. Total output of the smelters fell 21 percent to the smallest amount since 1946.

Smelter-production data are based upon reports from domestic primary smelters handling copper-bearing materials. Blister copper is accounted for in terms of copper content. Production of furnace-refined copper in Michigan is included in smelter production, as well as in refinery output. Metallic and cement copper recovered from leaching solutions is included in smelter production.

TABLE 9.—Copper ore shipped to smelters in the United States in 1959, with content in terms of recoverable copper

State	Ore shipped to smelters			State	Ore shipped to smelters		
	Short tons	Recoverable copper content			Short tons	Recoverable copper content	
		Pounds	Percent			Pounds	Percent
Alaska	53	72,217	68.13	Nevada	30,051	1,404,700	2.34
Arizona	379,625	33,556,400	4.42	New Mexico	38,675	811,600	1.05
California	94	24,600	13.09	Utah	223	68,500	15.36
Colorado	17,053	1,168,300	3.43				
Idaho	744	56,500	3.80	Total	467,598	37,195,517	3.98
Montana	1,080	32,700	1.51				

TABLE 10.—Copper ores[1] produced in the United States, and average yield in copper, gold, and silver

Year	Smelting ores		Concentrating ores		Total				
	Short tons	Yield in copper (percent)	Short tons[2]	Yield in copper (percent)	Short tons[2 3]	Yield in copper (percent)	Yield per ton in gold (ounce)	Yield per ton in silver (ounce)	Value per ton in gold and silver
1950–54 (average)	818,983	3.56	92,549,949	0.86	96,949,340	0.86	0.0059	0.087	$0.28
1955	877,287	3.81	108,060,525	.81	112,549,665	.83	.0052	.102	.28
1956	906,319	4.11	127,251,488	.75	131,775,959	.78	.0044	.087	.23
1957	827,226	4.32	124,640,436	.76	129,715,586	.77	.0043	.086	.23
1958	631,714	4.78	114,027,754	.77	114,824,468	.79	.0040	.080	.21
1959	467,598	3.98	103,239,445	.72	103,715,843	.74	.0035	.066	.18

[1] Includes old tailings, smelted or re-treated, etc., for 1950–52.
[2] Includes some ore classed as copper-zinc ore.
[3] Includes copper ore leached.

TABLE 11.—Copper produced by primary smelters in the United States, in short tons

Year	Domestic	Foreign	Secondary	Total
1950–54 (average)	909,452	103,208	61,176	1,073,836
1955	1,007,311	99,215	53,554	1,160,080
1956	1,117,580	113,772	81,374	1,312,726
1957	1,081,055	97,090	75,931	1,254,076
1958	992,918	76,134	61,848	1,130,900
1959	799,329	42,466	54,895	896,690

On January 2, Kennecott Copper Corp. began operating the Garfield, Utah, smelter which had been purchased from the American Smelting and Refining Co. in 1958.

The quantity and value of copper produced from domestic ores by smelters in the United States were shown by years for 1845–1955 in Minerals Yearbook, 1955, volume I.

Refinery Production.—The refinery output of primary copper in the United States came from 15 plants; 9 employed the electrolytic method only, 3 used the furnace process on Lake Superior copper, and 2 used both electrolytic and furnace methods. One western smelter fire-refined part of its blister but shipped the remainder to electrolytic refineries. The leaching plant of the Inspiration Consolidated Copper Co. at Inspiration, Ariz., produced electrolytic copper directly from leaching solutions; a substantial part of this copper was shipped as cathodes to other refineries for melting and casting into commercial shapes.

These 15 plants constituted what commonly are termed "primary refineries." The electrolytic plants, exclusive of that at Inspiration, had a rated capacity of 1,912,000 tons of refined copper a year and produced at 69 percent of capacity.

Six large electrolytic refineries were located on the Atlantic seaboard; three lake refineries on the Great Lakes; and four electrolytic refineries west of the Great Lakes (one each at Great Falls, Mont.; Tacoma, Wash.; El Paso, Tex.; and Garfield, Utah). The El Paso plant of the Phelps Dodge Refining Corp. and the Carteret plant of the American Metal Climax, Inc., produced fire-refined copper, in addition to the electrolytic grade. The lake refinery of the Quincy Mining Co., which had closed in February 1958, resumed operations in July 1959.

The new electrolytic refinery of Kennecott Refining Corp., on the Patapsco River south of Baltimore, Anne Arundel County, Md., was completed in September. Test production in the tank house began in August, and it was expected that full capacity of 16,500 tons of electrolytic copper a month would be reached by July 1960.

TABLE 12.—Primary and secondary copper produced by primary refineries in the United States, in short tons

	1950–54 (average)	1955	1956	1957	1958	1959
Primary:						
From domestic ores, etc.:[1]						
Electrolytic	816,071	883,674	948,732	945,394	892,758	699,890
Lake	24,545	35,387	57,053	58,814	59,111	54,543
Casting	73,274	78,438	74,422	46,288	49,776	42,019
Total	913,890	997,499	1,080,207	1,050,496	1,001,645	796,452
From foreign ores, etc.:[1]						
Electrolytic	307,283	320,822	351,768	372,791	340,470	256,002
Casting and best select	4,738	24,138	10,658	30,889	10,405	45,793
Total refinery production of primary copper	1,225,911	1,342,459	1,442,633	1,454,176	1,352,520	1,098,247
Secondary:						
Electrolytic[2]	147,560	196,386	220,340	203,073	199,508	200,183
Casting	15,774	10,169	13,477	8,521	7,828	11,405
Total secondary	163,334	206,555	233,817	211,594	207,336	211,588
Grand total	1,389,245	1,549,014	1,676,450	1,665,770	1,559,856	1,309,835

[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 13.—Copper cast in forms at primary refineries in the United States

Form	1958		1959	
	Thousand short tons	Percent	Thousand short tons	Percent
Wirebars	950	61	776	59
Billets	161	10	152	12
Ingots and ingot bars	147	10	135	10
Cathodes	176	11	118	9
Cakes	107	7	112	9
Other forms	19	1	17	1
Total	1,560	100	1,310	100

Copper Sulfate.—Operations of the copper-sulfate-producing industry were adversely affected by the strikes at the copper plants and production declined 17 percent to the lowest since 1936. Shipments dropped 10 percent and stocks fell 52 percent. Of the total shipments of 42,100 tons (46,500 in 1958), producers' reports indicated that 19,400 tons (20,800) was for agricultural uses, 19,200 (18,100) for industrial uses, and 3,500 (7,600) for other purposes, chiefly for export.

TABLE 14.—Production, shipments, and stocks of copper sulfate, in short tons

Year	Production		Shipments (gross weight)	Stocks at end of year[1] (gross weight)
	Gross weight	Copper content		
1950-54 (average)	85,406	21,349	85,342	5,317
1955	78,088	19,522	79,112	4,852
1956	66,808	16,702	67,008	4,068
1957	70,680	17,670	70,256	3,828
1958	48,596	12,149	46,580	5,168
1959	40,292	10,073	42,100	2,500

[1] Some small quantities are purchased and used by producing companies, so that the figures given do not balance exactly.

SECONDARY COPPER AND BRASS[3]

Recovery of copper in unalloyed and alloyed form from nonferrous scrap in the United States totaled 931,000 short tons in 1959, 17 percent more than in 1958. The increase was achieved in spite of wide variation in monthly consumption of copper scrap, from which about 99 percent of secondary copper was produced. Unsettled business conditions, attributed chiefly to strikes at primary copper producers' plants, caused wide fluctuations in monthly scrap consumption by all major consuming groups, including brass mills, secondary smelters, and primary producers. The net effects for the year were increases in consumption over 1958 by brass mills and smelters and little change in the annual totals for primary producers.

---

[3] Prepared by Archie J. McDermid, commodity specialist, and Ivy C. Roberts, statistical assistant.

The rising trend in consumption of copper scrap which began in the latter part of 1958 continued through April for brass mills and secondary smelters and through May for primary producers. Some of the increase was caused by increases in stocks of smelter and brass-mill products by foundries and fabricators in anticipation of possible scarcity later. In the following 4 months the effect of the strikes was evident. Consumption of copper scrap at brass mills and smelters declined from 46,000 and 39,000 tons, respectively, in April to 26,000 and 27,000 tons in July. Scrap consumption at primary producers was reduced from 33,000 tons in May to 16,000 tons in August. For the remainder of the year a rising trend in scrap metal activity by all groups was evident.

The strikes affected the primary producers more than other groups although a few secondary copper smelters and brass mills in western States were closed late in the year. Brass mills in general fared better in regard to supplies of raw materials because, to a great extent, they could use refined copper interchangeably with unalloyed copper scrap.

Foundries increased their consumption of brass ingot 17 percent over 1958 but increased their use of purchased copper scrap 22 per-

TABLE 15.—Secondary copper produced in the United States, in short tons

	1950–54 (average)	1955	1956	1957	1958	1959
Copper recovered as unalloyed copper	215,233	246,928	273,060	248,015	255,121	261,588
Copper recovered in alloys [1]	706,985	742,076	657,604	593,872	542,267	668,982
Total secondary copper	922,218	989,004	930,664	841,887	797,388	930,570
Source:						
New scrap	483,333	474,419	462,175	397,395	386,021	459,563
Old scrap	438,885	514,585	468,489	444,492	411,367	471,007
Percentage equivalent of domestic mine output	102	99	84	77	81	113

[1] Includes copper in chemicals, as follows: 1950–54 (average), 19,062; 1955, 15,898; 1956, 14,739; 1957, 14,240; 1958, 9,491; 1959, 10,061.

TABLE 16.—Copper recovered from scrap processed in the United States, by kind of scrap and form of recovery, in short tons

Kind of scrap	1958	1959
New scrap:		
Copper-base	381,173	453,144
Aluminum-base	4,693	6,199
Nickel-base	125	175
Zinc-base	30	45
Total	386,021	459,563
Old scrap:		
Copper-base	408,149	467,161
Aluminum-base	2,538	3,156
Nickel-base	509	583
Tin-base	27	17
Zinc-base	144	90
Total	411,367	471,007
Grand total	797,388	930,570

Form of recovery	1958	1959
As unalloyed copper:		
At primary plants	207,336	211,588
At other plants	47,785	50,000
Total	255,121	261,588
In brass and bronze	517,680	637,387
In alloy iron and steel	2,272	3,289
In aluminum alloys	12,445	17,899
In other alloys	379	346
In chemical compounds	9,491	10,061
Total	542,267	668,982
Grand total	797,388	930,570

cent and of refined copper 48 percent. These plants, in general, bought only metallic scrap which could be remelted like brass ingot and refined copper. Skimmings generated were usually returned to brass ingot makers or to primary producers.

TABLE 17.—Copper recovered as refined copper, in alloys and in other forms, from copper-base scrap processed in the United States, in short tons

	From new scrap		From old scrap		Total	
	1958	1959	1958	1959	1958	1959
By secondary smelters	50, 480	58, 630	202, 222	223, 705	252, 702	282, 335
By primary copper producers	94, 431	96, 600	115, 415	116, 472	209, 846	213, 072
By brass mills	220, 968	277, 562	25, 008	48, 480	245, 976	326, 042
By foundries and manufacturers	14, 258	19, 019	60, 452	72, 233	74, 710	91, 252
By chemical plants	1, 036	1, 333	5, 052	6, 271	6, 088	7, 604
Total	381, 173	453, 144	408, 149	467, 161	789, 322	920, 305

TABLE 18.—Production of secondary copper and copper-alloy products in the United States, in short tons

Item produced from scrap	Gross weight produced	
	1958	1959
Unalloyed copper products:		
Refined copper by primary producers	207, 336	211, 588
Refined copper by secondary smelters	38, 672	38, 645
Copper powder	[1] 7, 768	9, 796
Copper castings	1, 345	1, 559
Total	255, 121	261, 588

Item produced from scrap	Nominal composition (percent)						
	Cu	Sn	Pb	Zn	Ni		
Brass and bronze ingots:							
Tin bronze	88	10	------	2	------	13, 874	15, 036
Leaded tin bronze	88	6	1. 5	4. 5	------	16, 050	16, 939
Leaded red bronze	85	5	5	5	------	83, 935	93, 590
Leaded semired brass	81	3	7	9	------	63, 195	73, 163
High-leaded tin bronze	80	10	10	------	------	13, 295	16, 872
Do	84	6	8	2	------	13, 279	15, 638
Do	75	5	20	------	------	3, 237	4, 438
Leaded yellow brass	66	1	3	30	------	14, 804	14, 754
Nickel silver	58	2	7	18	14	3, 020	3, 055
Do	65	4	3	5	22		
Low brass	80	------	------	20	------	2, 434	2, 503
Conductor bronze	94	2	2	2	------	535	539
Manganese bronze	60 Cu	40 Zn, ±Mn, Al, etc				12, 478	12, 665
Aluminum bronze	90 Cu	10 Al, ±Mn, Zn, Fe, etc				4, 881	6, 187
Silicon bronze	92 Cu	+Si, ±Zn, Fe, Al, Mn				4, 357	4, 290
Copper-base hardeners and special alloys						11, 948	13, 525
Total						261, 322	293, 194
Brass-mill products						319, 125	423, 789
Brass and bronze castings						74, 593	86, 439
Brass powder						971	1, 397
Copper in chemical products						9, 491	10, 061
Grand total						920, 623	1, 076, 468

---

[1] Includes black copper shipments.

TABLE 19.—Composition of secondary copper-alloy production, gross weight in short tons

Year	Copper	Tin	Lead	Zinc	Nickel	Aluminum	Total
BRASS AND BRONZE INGOT PRODUCTION [1]							
1958	205,536	12,265	16,643	26,395	418	65	261,322
1959	231,196	13,931	18,701	28,864	438	64	293,194
SECONDARY METAL CONTENT OF BRASS-MILL PRODUCTS							
1958	245,968	180	2,620	69,124	1,205	28	319,125
1959	326,040	132	3,595	92,598	1,412	12	423,789
SECONDARY METAL CONTENT OF BRASS AND BRONZE CASTINGS							
1958	57,552	3,047	8,191	5,694	30	79	74,593
1959	66,399	3,755	10,501	5,619	39	126	86,439

[1] About 95 percent from scrap and 5 percent from other than scrap.

TABLE 20.—Stocks and consumption of new and old copper scrap in the United States in 1959, gross weight in short tons

Class of consumer and type of scrap	Stocks, beginning of year	Receipts		Consumption				Stocks, end of year
		Purchased scrap	Machine-shop scrap	Purchased scrap			Machine-shop scrap	
				New	Old	Total		
Secondary smelters:								
No. 1 wire and heavy copper	2,656	41,256	--------	6,380	33,935	40,315	--------	3,597
No. 2 wire, mixed heavy, and light copper	3,050	63,633	--------	6,128	57,021	63,149	--------	3,534
Composition or red brass	5,698	94,976	--------	33,184	62,126	95,310	--------	5,364
Railroad-car boxes	174	865	--------	--------	924	924	--------	115
Yellow brass	6,839	63,632	--------	8,254	56,017	64,271	--------	6,200
Cartridge cases and brass	334	334	--------	1	543	544	--------	124
Auto radiators (unsweated)	5,375	44,096	--------	--------	44,519	44,519	--------	4,952
Bronze	2,447	30,767	--------	8,745	22,228	30,973	--------	2,241
Nickel silver	576	3,166	--------	527	2,531	3,058	--------	684
Low brass	500	2,054	--------	1,558	670	2,228	--------	326
Aluminum bronze	101	554	--------	45	330	375	--------	280
Low-grade scrap and residues	5,892	33,269	--------	23,000	11,040	34,040	--------	5,121
Total	33,642	378,602	--------	87,822	291,884	379,706	--------	32,538
Primary producers:								
No. 1 wire and heavy copper	1,286	44,318	--------	18,703	25,130	43,833	--------	1,771
No. 2 wire, mixed heavy, and light copper	[1] 5,164	120,242	--------	67,042	54,361	121,403	--------	4,003
Refinery brass	[1] 4,694	36,233	--------	7,815	25,611	33,426	--------	7,501
Low-grade scrap and residues	[1] 26,596	162,974	--------	42,203	86,341	128,544	--------	61,026
Total	[1] 37,740	363,767	--------	135,763	191,443	327,206	--------	74,301

See footnotes at end of table.

TABLE 20.—Stocks and consumption of new and old copper scrap in the United States in 1959, gross weight in short tons—Continued

Class of consumer and type of scrap	Stocks, beginning of year	Receipts		Consumption				Stocks, end of year
		Purchased scrap	Machine-shop scrap	Purchased scrap			Machine-shop scrap	
				New	Old	Total		
Brass mills: [2]								
No. 1 wire and heavy copper	6,638	89,892	--------	54,453	35,439	89,892	--------	5,113
No. 2 wire, mixed heavy, and light copper	2,750	39,862	--------	37,098	2,764	39,862	--------	7,932
Yellow brass	16,202	206,120	--------	206,120	--------	206,120	--------	16,322
Cartridge cases and brass	2,226	52,797	--------	37,376	15,421	52,797	--------	3,545
Bronze	1,016	2,386	--------	2,386	--------	2,386	--------	673
Nickel silver	2,411	7,777	--------	7,777	--------	7,777	--------	2,988
Low brass	2,298	25,493	--------	25,493	--------	25,493	--------	3,235
Aluminum bronze	121	104	--------	104	--------	104	--------	98
Mixed alloy scrap	9,863	6,280	--------	6,280	--------	6,280	--------	11,474
Total [2]	43,525	430,711	--------	377,087	53,624	430,711	--------	51,380
Foundries, chemical plants and other manufacturers:								
No. 1 wire and heavy copper	2,008	23,319	606	6,865	15,818	22,683	505	2,745
No. 2 wire, mixed heavy, and light copper	1,696	12,372	533	4,883	7,463	12,346	498	1,757
Composition or red brass	1,733	6,024	12,490	2,746	3,611	6,357	12,216	1,674
Railroad-car boxes	4,312	53,927	2,141	--------	55,750	55,750	2,104	2,526
Yellow brass	2,133	12,332	9,325	4,898	7,219	12,117	9,923	1,750
Auto radiators (unsweated)	306	7,048	--------	--------	7,042	7,042	--------	312
Bronze	1,325	2,895	2,322	1,100	1,698	2,798	2,343	1,401
Nickel silver	57	101	46	1	107	108	66	30
Low brass	207	932	2,164	34	905	939	2,127	237
Aluminum bronze	316	1,076	296	300	812	1,112	313	263
Low-grade scrap and residues	579	10,226	166	4,496	4,545	9,041	127	1,803
Total	14,672	130,252	30,089	[3] 25,323	[3] 104,970	[3] 130,293	30,222	14,498
Grand total: [4]								
No. 1 wire and heavy copper	12,588	198,785	606	86,401	110,322	196,723	505	13,226
No. 2 wire, mixed heavy, and light copper	[1] 12,660	236,109	533	115,151	121,609	236,760	498	17,226
Composition or red brass	7,431	101,000	12,490	35,930	65,737	101,667	12,216	7,038
Railroad-car boxes	4,486	54,792	2,141	--------	56,674	56,674	2,104	2,641
Yellow brass	25,174	282,084	9,325	219,272	63,236	282,508	9,923	24,272
Cartridge cases and brass	2,560	53,131	--------	37,377	15,964	53,341	--------	3,669
Auto radiators (unsweated)	5,681	51,144	--------	--------	51,561	51,561	--------	5,264
Bronze	4,788	36,048	2,322	12,231	23,926	36,157	2,343	4,315
Nickel silver	3,044	11,044	46	8,305	2,638	10,943	66	3,702
Low brass	3.005	28,479	2,164	27,085	1,575	28,660	2,127	3,798
Aluminum bronze	538	1,734	296	449	1,142	1,591	313	641
Low-grade scrap and residues [5]	[1] 37,761	242,702	166	77,514	127,537	205,051	127	75,451
Mixed alloy scrap	9,863	6,280	--------	6,280	--------	6,280	--------	11,474
Total [4]	[1] 129,579	1,303,332	30,089	625,995	641,921	1,267,916	30,222	172,717

[1] Revised figure.

[2] 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.

[3] Of the totals shown, chemical plants reported the following: Unalloyed copper scrap, 1,003 tons of new and 4,896 old; copper-base alloy scrap, 1,136 tons of new and 4,521 old.

[4] Includes machine-shop scrap receipts and consumption for foundries, chemical plants, and other manufacturers.

[5] Includes refinery brass.

TABLE 21.—Consumption of copper and brass materials in the United States, by principal consuming groups, in short tons

Item consumed	Primary producers	Brass mills	Wire mills	Foundries, chemical plants, and miscellaneous users	Secondary smelters	Total
1958						
Copper scrap	325,594	324,280	------------	108,174	351,431	1,109,479
Refined copper [1]	------------	479,510	740,270	23,715	7,182	1,250,677
Brass ingot	------------	4,906	160	[2] 254,039	------------	259,105
Slab zinc	------------	91,562	------------	3,122	6,691	101,375
Miscellaneous	------------	82	------------	200	8,177	8,459
1959						
Copper scrap	327,206	430,711	------------	130,293	379,706	1,267,916
Refined copper [1]	------------	584,100	836,177	34,643	8,111	1,463,031
Brass ingot	------------	7,062	166	[2] 283,102	------------	290,330
Slab zinc	------------	116,048	------------	3,536	9,694	129,278
Miscellaneous	------------	43	------------	275	6,669	6,987

[1] Detailed information on consumption of refined copper will be found in table 25.
[2] Shipments to foundries by smelters less increase in stocks at foundries.

TABLE 22.—Dealers' monthly average buying prices for copper scrap and consumers' alloy-ingot prices at New York in 1959, in cents per pound

[Metal Statistics, 1960]

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
No. 1 Heavy copper scrap	20.73	22.14	24.19	23.39	23.42	22.66	21.01	21.65	22.55	22.85	23.42	22.64	22.55
No. 1 Composition scrap	17.06	18.03	20.12	19.99	19.25	18.70	17.71	17.92	18.75	18.99	19.33	18.75	18.72
No. 1 Composition ingot	28.00	28.67	31.24	31.07	30.25	30.25	29.42	29.25	29.71	29.25	30.42	30.75	29.86

TABLE 23.—Foundry consumption of brass ingot, by type, in the United States, in short tons

	1950-54 (average)	1955	1956	1957	1958	1959
Tin bronze	16,143	13,862	15,012	15,408	10,272	11,257
Leaded tin bronze	35,393	27,331	30,272	23,118	20,591	24,868
Leaded red brass	154,899	172,472	150,532	138,289	138,183	162,798
High-leaded tin bronze	20,494	27,833	28,428	24,691	17,478	19,413
Leaded yellow brass	19,830	21,071	17,887	15,906	15,790	17,344
Manganese bronze	14,576	11,317	12,748	11,436	8,155	9,609
Hardeners	2,721	2,148	2,594	2,348	1,565	2,185
Nickel silver	2,586	3,466	4,333	2,967	2,428	2,921
Low brass	6,585	8,157	7,939	8,631	6,690	7,699
Total	273,227	287,657	269,745	242,794	221,152	258,094

CONSUMPTION

Apparent withdrawals of primary copper on domestic account increased 2 percent over 1958.

TABLE 24.—Primary refined copper withdrawn from total year's supply on domestic account, in short tons

	1950-54 (average)	1955	1956	1957	1958	1959
Production from domestic and foreign ores, etc.	1,225,911	1,342,459	1,442,633	1,454,176	1,352,520	1,098,247
Imports [1]	278,498	202,312	191,745	162,309	128,464	214,058
Stock at beginning of year [1]	39,000	25,000	34,000	78,000	109,000	48,000
Total available supply	1,543,409	1,569,771	1,668,378	1,694,485	1,589,984	1,360,305
Copper exported [1]	155,506	199,819	223,103	346,025	384,868	158,938
Stock at end of year [1]	32,000	34,000	78,000	109,000	48,000	18,000
Total	187,506	233,819	301,103	455,025	432,868	176,938
Apparent withdrawals on domestic account [2]	1,356,000	1,336,000	1,367,000	1,239,000	1,157,000	1,183,000

[1] May include some copper refined from scrap.

[2] Includes copper delivered by industry to the national strategic stockpile.

Actual consumption of refined copper rose 17 percent and was the largest since 1956. These data are based on reports from consumers of quantities entering processing, with no adjustment for stock changes of material in process. Unlike table 24, in which all but new copper is eliminated so far as possible, table 25 does not distinguish between new and old copper but includes all copper in refined form.

Distribution of actual consumption by principal consuming groups followed the usual pattern with wire mills consuming 57 percent and brass mills 40 percent of the total. Consumption in the first and second quarters of the year averaged 127,000 and 139,000 tons per month, respectively. The total for April (143,000 tons) was the largest for any month since May 1956. In July a downward trend began due to the annual vacation periods at consuming plants and later to curtailed production by labor strikes; as a result, consumption in the last 6 months averaged 108,000 tons.

TABLE 25.—Refined copper consumed, by classes of consumers, in short tons

Class of consumer	Cathodes	Wire bars	Ingots and ingot bars	Cakes and slabs	Billets	Other	Total
1958							
Wire mills	4,394	723,450	11,464	--------	--------	962	740,270
Brass mills	91,192	47,354	74,098	116,659	150,160	47	479,510
Chemical plants	--------	--------	407	--------	--------	490	897
Secondary smelters	4,080	--------	2,485	219	--------	398	7,182
Foundries	3,285	413	9,731	15	201	238	13,883
Miscellaneous [1]	779	40	1,012	111	501	6,492	8,935
Total	103,730	771,257	99,197	117,004	150,862	8,627	1,250,677
1959							
Wire mills	6,432	817,030	11,790	--------	--------	925	836,177
Brass mills	86,648	64,277	116,190	146,852	170,074	59	584,100
Chemical plants	--------	--------	310	--------	--------	484	794
Secondary smelters	5,320	--------	2,079	246	--------	466	8,111
Foundries	4,877	218	11,465	17	216	795	17,588
Miscellaneous [1]	1,298	4	4,064	6	295	10,594	16,261
Total	104,575	881,529	145,898	147,121	170,585	13,323	1,463,031

[1] Includes iron and steel plants, primary smelters producing alloys other than copper, consumers of copper powder and copper shot, and miscellaneous manufacturers.

STOCKS

High consumption throughout most of the year coupled with reduced domestic production caused stocks of refined copper in the United States to drop 63 percent to the lowest figure since before 1900. Unrefined copper stocks decreased 2 percent and were the lowest since 1955.

TABLE 26.—Stocks of copper at primary smelting and refining plants in the United States at end of year, in short tons

Year	Refined copper[1]	Blister and materials in process of refining[2]	Year	Refined copper[1]	Blister and materials in process of refining[2]
1950–54 (average)	32,000	202,000	1957	109,000	274,000
1955	34,000	201,000	1958	48,000	257,000
1956	78,000	261,000	1959	18,000	253,000

[1] May include some copper refined from scrap.
[2] Includes copper in transit from smelters in the United States to refineries therein.

According to the United States Copper Association, fabricators' stocks of refined metal (including in-process copper and primary fabricated shapes), were 414,800 tons at the end of 1959, 7 percent less than those on hand January 1. Working stocks (see table 27) were 340,300 (a 4-percent increase over those on hand January 1). After unfilled sales of metal were taken into account, copper classed as "available for sale" was less than 2,000 tons.

TABLE 27.—Stocks of copper in fabricators' hands at end of year, in short tons

[United States Copper Association]

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)
1955	389,974	139,094	314,145	293,264	−78,341
1956	437,187	117,601	336,217	183,834	34,737
1957	430,171	75,627	347,465	138,631	19,702
1958	446,358	90,401	326,438	177,869	32,452
1959	414,757	130,324	340,349	202,775	1,957

[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) equals column (5).

PRICES

Reports from copper-selling agencies indicated that 929,000 tons of domestic refined copper was delivered to purchasers at an average price of 30.7 cents a pound. The average price of foreign copper delivered in the United States was 31.6 cents a pound.

The price for electrolytic copper quoted by primary producers was 29 cents a pound, delivered, at the beginning of the year. Increases in early February brought the price to 30 cents and after another increase in March producers were quoting 31.5 cents. About mid-July producers reduced the price to 30 cents. On September 9 some of the operating companies raised the price to 31.5 cents. Other producers had made no change in the price and the market was quoted at a range of 30–31.5 cents. On November 6 the price was raised to a range of 30–33 cents; by November 12 it was quoted at a flat 33-cent level, and this price held until the end of the year.

The custom smelters' price of 29 cents at the beginning of the year was increased gradually until it reached 34 cents on March 16. It dropped thereafter until it was again quoted at 29 cents on July 13. On August 31 a custom smelter posted a 33-cent price but on October 23 the price was withdrawn because of the strikes. On December 23, a custom smelter was quoting 35 cents for electrolytic copper for February 1960 shipment.

TABLE 28.—Average weighted prices of copper deliveries,[1] consumers' plants, in cents per pound

Year	Domestic copper	Foreign copper	Year	Domestic copper	Foreign copper
1955	37.3	37.5	1958	26.3	25.0
1956	42.5	43.2	1959	30.7	31.6
1957	30.1	29.6			

[1] Covers copper produced in the United States and delivered here and abroad and copper produced abroad and delivered in the United States; excludes copper both produced and delivered abroad, whether or not handled by United States selling agencies.

London Price.—Quotations on the London Metal Exchange were trending upward at the beginning of the year. The monthly average price of cash copper for March of £248 10s. 3d. per long ton (equivalent to 31.20 cents a pound) was the highest since January

TABLE 29.—Average monthly quoted prices of electrolytic copper for domestic and export shipments, f.o.b. refineries, in the United States and for spot copper at London, in cents per pound

Month	1958				1959			
	Domestic, f.o.b. refinery[1]	Domestic, f.o.b. refinery[2]	Export, f.o.b. refinery[2]	London spot[3] [4]	Domestic, f.o.b. refinery[1]	Domestic, f.o.b. refinery[2]	Export, f.o.b. refinery[2]	London, spot[3] [4]
January	25.46	25.114	21.253	21.52	28.82	28.636	27.927	28.83
February	24.82	24.397	20.079	20.48	29.80	29.617	28.726	29.62
March	24.82	24.018	20.738	21.38	30.97	31.031	30.271	31.20
April	24.82	24.253	21.631	22.08	31.32	31.300	29.397	30.18
May	24.82	24.298	21.944	22.47	31.32	31.155	28.814	29.68
June	25.18	24.689	23.670	24.42	31.32	31.102	28.114	28.88
July	25.95	25.674	24.397	25.01	30.44	30.077	26.732	27.72
August	26.32	26.088	25.179	25.77	29.82	29.893	28.270	29.20
September	26.32	26.081	25.489	26.19	30.40	31.018	28.015	28.83
October	27.40	27.310	28.573	29.61	30.57	32.576	29.150	30.31
November	28.82	28.665	29.476	30.43	32.20	34.060	30.481	31.35
December	28.82	28.583	26.041	27.66	32.82	33.724	30.801	31.91
Average	26.13	25.764	24.123	24.79	30.82	31.182	28.892	29.80

[1] American Metal Market.
[2] E&MJ Metal and Mineral Markets.
[3] Metal Bulletin (London).
[4] Based on average monthly rates of exchange by Federal Reserve Board.

1957 (£265 17s. 11d. or 33.19 cents). Prices moved downward and were the lowest of the year in July. In the last 3 months of 1959 quotations advanced and the average for December was £255 8s. 10d (31.91 cents). The annual average was 20 percent more than 1958.

FOREIGN TRADE[4]

Imports.—Imports of unmanufactured copper rose 19 percent over 1958. As usual, Chile was the chief source of copper from abroad, supplying 44 percent of the total—29 percent more than in 1958. Canada was second with 19 percent of the total and 50 percent more than in 1958. More copper also was received from the Union of South Africa, whereas decreases were registered in receipts from Mexico, Peru, the Philippines, and the Federation of Rhodesia and Nyasaland.

TABLE 30.—Copper (unmanufactured) imported into the United States, in short tons in terms of copper content[1]

[Bureau of the Census]

	Ore	Concentrates	Regulus, black, or coarse copper, and cement copper	Unrefined, black, blister, and converter copper, in pigs or converter bars	Refined, in ingots, plates, or bars	Old and scrap copper, fit only for remanufacture, and scale and clippings	Total
1950–54 (average)[2]	4, 034	102, 783	4, 600	211, 686	278, 498	12, 266	613, 867
1955	8, 132	109, 497	7, 898	253, 693	202, 312	12, 568	594, 100
1956	17, 459	97, 404	7, 311	276, 085	191, 745	5, 743	595, 747
1957	18, 838	99, 755	6, 196	301, 136	162, 309	5, 798	594, 032
1958							
North America:							
Canada	326	6, 301	1, 248	-----	62, 849	4, 089	74, 813
Cuba	335	13, 657	-----	-----	-----	472	14, 464
Mexico	162	2, 796	2, 712	40, 030	4, 235	88	50. 023
Other North America	-----	-----	3	-----	-----	450	453
Total	823	22, 754	3, 963	40, 030	67, 084	5, 099	139, 753
South America:							
Bolivia	581	2, 814	-----	-----	-----	-----	3. 395
Chile	207	16, 174	-----	183, 051	713	-----	200. 145
Peru	[3] 2, 015	6, 835	1, 095	9, 132	11, 349	-----	[3] 30, 426
Other South America	50	370	113	5	1	424	963
Total	[3] 2, 853	26, 193	1, 208	192, 188	12, 063	424	[3] 234, 929
Europe:							
Germany, West	-----	-----	-----	-----	4, 158	15	4, 173
Malta, Gozo, and Cyprus	-----	6, 384	-----	-----	527	-----	6, 911
Sweden	-----	-----	-----	-----	1, 063	-----	1, 063
United Kingdom	-----	-----	-----	-----	6, 958	227	7. 185
Other Europe	-----	-----	-----	-----	448	1, 208	1, 656
Total	-----	6, 384	-----	-----	13, 154	1, 450	20, 988

See footnotes at end of table.

---

[4] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 30.—Copper (unmanufactured) imported into the United States, in short tons, in terms of copper content—Continued

	Ore	Concentrates	Regulus, black, or coarse copper, and cement copper	Unrefined, black, blister, and converter copper, in pigs or converter bars	Refined, in ingots, plates, or bars	Old and scrap copper, fit only for remanufacture, and scale and clippings	Total
Asia:							
Philippines	4	14, 515	3	----------	----------	61	14, 583
Turkey	----------	----------	----------	1, 094	----------	----------	1, 094
Other Asia	14	----------	----------	----------	----------	26	40
Total	18	14, 515	3	1, 094	----------	87	15, 717
Africa:							
Belgian Congo	----------	----------	----------	----------	15, 515	----------	15, 515
Rhodesia and Nyasaland, Federation of	----------	336	4	16, 777	18, 052	----------	35, 169
Union of South Africa	3, 900	9, 018	----------	13, 655	2, 596	----------	29. 169
Total	3, 900	9, 354	4	30, 432	36, 163	----------	79, 853
Ocean: Australia	[3] 623	----------	----------	4, 438	----------	----------	[3] 5, 061
Grand total	[3] 8, 217	79, 200	5, 178	268, 182	128, 464	7, 060	[3] 496, 301
1959							
North America:							
Canada	318	5, 306	926	149	103, 237	2, 370	112, 306
Cuba	----------	9, 942	----------	----------	----------	865	10, 807
Mexico	9	445	1, 120	21, 215	6, 575	129	29, 493
Other North America	----------	----------	2	----------	----------	410	412
Total	327	15, 693	2, 048	21, 364	109, 812	3, 774	153, 018
South America:							
Chile	176	16, 718	----------	227, 095	14, 172	----------	258, 161
Peru	1, 946	5, 620	930	3, 052	17, 205	----------	28, 753
Other South America	347	1, 611	7	17	----------	272	2, 254
Total	2, 469	23, 949	937	230, 164	31, 377	272	289, 168
Europe:							
Belgium-Luxembourg	----------	----------	----------	----------	8, 504	----------	8, 504
Germany, West	----------	----------	----------	----------	24, 305	37	24, 342
Malta, Gozo, and Cyprus	----------	3, 524	----------	----------	----------	----------	3, 524
Sweden	----------	----------	----------	----------	3, 428	----------	3, 428
United Kingdom	----------	----------	----------	----------	13, 366	70	13, 436
Other Europe	----------	----------	----------	----------	774	1, 129	1, 903
Total	----------	3, 524	----------	----------	50, 377	1, 236	55, 137
Asia:							
Philippines	1	12, 881	5	----------	----------	872	13, 759
Other Asia	----------	----------	----------	1, 094	----------	41	1, 135
Total	1	12, 881	5	1, 094	----------	913	14, 894
Africa:							
Rhodesia and Nyasaland, Federation of	----------	----------	35	16, 191	16, 396	----------	32, 622
Union of South Africa	4. 049	7. 638	5, 924	14, 432	1, 712	----------	33, 755
Other Africa	----------	----------	----------	----------	4, 384	----------	4, 384
Total	4, 049	7, 638	5, 959	30, 623	22, 492	----------	70, 761
Oceania: Australia	497	2, 551	----------	4, 421	----------	----------	7, 469
Grand total	7, 343	66, 236	8, 949	287, 666	214, 058	6, 195	590, 447

---

[1] Data are "general" imports; that is, they include copper imported for immediate consumption plus material entering the country under bond.

[2] Some copper in "Ore" and "Other" from the Philippines is not separately classified and is included with "Concentrates."

[3] Revised figure.

Imports of refined copper rose 67 percent with Canada the chief supplier for the fifth successive year. Canadian shipments to the United States accounted for 48 percent of the total and were 64 percent more than in 1958. Receipts from Chile and Peru rose over those in 1958, but Rhodesia and the Belgian Congo shipped smaller quantities.

Of the unrefined class which rose 7 percent, Chile supplied 79 percent of the total and shipped 24 percent more than in 1958; Mexico

TABLE 31.—Copper (unmanufactured) imported into the United States by countries, in short tons, in terms of copper content[1]

[Bureau of the Census]

Country	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada	83,238	107,034	120,489	120,224	74,813	112,306
Cuba	20,323	21,122	16,345	17,435	14,464	10,807
Mexico	55,734	49,642	52,835	47,746	50,023	29,493
Other North America	542	693	671	543	453	412
Total	159,837	178,491	190,340	185,948	139,753	153,018
South America:						
Bolivia	4,130	3,301	4,500	4,463	3,395	1,790
Chile	294,177	226,772	236,623	236,016	200,145	258,161
Peru	19,769	31,119	42,841	41,636	[2] 30,426	28,753
Other South America	345	20	772	986	963	464
Total	318,421	261,212	284,736	283,101	[2] 234,929	289,168
Europe:						
Belgium-Luxembourg	1,491	383	800	447	56	8,504
France	2,188	2,128	991	660	1,188	1,125
Germany[3]	2,525	3,582	2,744	2,552	4,173	24,342
Malta, Gozo, and Cyprus	4,242	4,388	6,945	8,937	6,911	3,524
Netherlands	123	2,291	11	22	392	727
Norway	2,838	149	5,969	----------	20	50
Sweden	455	1,024	254	2,689	1,063	3,428
United Kingdom	640	11,650	3,356	2,415	7,185	13,436
Yugoslavia	8,743	2,149	138	----------	----------	----------
Other Europe	111	----------	----------	----------	----------	1
Total	23,356	27,744	21,208	17,722	20,988	55,137
Asia:						
Philippines	14,097	13,321	10,911	13,067	14,583	13,759
Turkey	4,321	547	5,586	3,496	1,094	1,094
Other Asia	11,557	245	811	22	40	41
Total	29,975	14,113	17,308	16,585	15,717	14,894
Africa:						
Belgian Congo	4,288	14,160	12,764	10,221	15,515	4,335
Rhodesia and Nyasaland, Federation of[4]	61,934	73,464	27,562	45,430	35,169	32,622
Union of South Africa	9,392	13,089	21,291	19,945	29,169	33,755
Other Africa	12	----------	1,085	----------	----------	49
Total	75,626	100,713	62,702	75,596	79,853	70,761
Oceania:						
Australia	6,569	11,827	19,453	15,075	[2] 5,061	7,469
Other Oceania	83	----------	----------	5	----------	----------
Total	6,652	11,827	19,453	15,080	[2] 5,061	7,469
Grand total	613,867	594,100	595,747	594,032	[2] 496,301	590,447

---

[1] Data are "general" imports; that is, they include copper imported for immediate consumption plus material entering the country under bond.

[2] Revised figure.

[3] Beginning Jan. 1, 1952, classified as West Germany.

[4] Prior to July 1, 1954, classified as Southern and Northern Rhodesia.

supplied 7 percent of the total but 47 percent less; Federation of Rhodesia and Nyasaland 6 percent and 3 percent less; and the Union of South Africa 5 percent and 6 percent more.

Although the Union of South Africa and Chile supplied larger quantities of ores, concentrates, and regulus or coarse copper in 1959, smaller receipts from the Philippines, Cuba, and Peru resulted in an 11-percent decrease in the total for these classes.

TABLE 32.—Old brass and clippings from brass or Dutch metal[1] imported for consumption in the United States

[Bureau of the Census]

Year	Short tons		Value
	Gross weight	Copper content	
1950–54 (average)	13,866	10,263	$3,823,723
1955	11,758	8,295	5,170,383
1956	6,519	4,310	[2] 3,002,940
1957	7,911	4,643	[2] $2,393,405
1958	6,763	4,201	1,851,560
1959	2,054	1,257	698,257

[1] For remanufacture.

[2] Data known to be not comparable with other years.

TABLE 33.—Copper imported for consumption in the United States, by classes[1]

(Quantity in terms of copper content)

[Bureau of the Census]

Year	Ore		Concentrates		Regulus, black, or coarse copper, and cement copper	
	Short tons	Value	Short tons	Value	Short tons	Value
1950–54 (average) [2]	3,866	$1,995,750	93,968	$47,512,903	3,772	$2,218,871
1955 [2]	7,476	4,948,251	105,045	68,405,687	6,386	4,515,264
1956	6,089	4,048,965	74,651	54,514,496	5,198	4,395,456
1957	20,951	12,216,626	62,361	34,258,232	5,361	3,212,609
1958	5.926	2,357,336	84,871	37,968,199	4,925	2,172,363
1959	113	34,302	9,299	5,505,362	7,113	4,260,263

Year	Unrefined, black, blister, and converter copper, in pigs or converter bars		Refined, in ingots, plates, or bars		Old and scrap copper, fit only for remanufacture, and scale and clippings		Total value
	Short tons	Value	Short tons	Value	Short tons	Value	
1950–54 (average) [2]	191,993	$108,360,900	280,298	$158,607,221	11,748	$4,617,205	$323,312,850
1955 [2]	253,693	182,073,314	202,312	154,137,270	12,577	[3] 9,030,398	[3] 423,110,184
1956	276,085	[3] 225,931,796	191,812	157,943,985	5,410	[3] 3,463,270	[3] 450,297,968
1957	301,136	179,440,276	162,309	97,024,574	5,843	[3] 3,048,969	[3] 329,201,286
1958	138,633	66,320,458	124,629	61,139,201	5,849	2,676,350	172,633,907
1959	203	125,878	237,304	146,478,443	2,984	1,634,487	158,038,735

[1] Excludes imports for manufacture in bond and export, which are classified as "imports for consumption" by the Bureau of the Census.

[2] Some copper in "Ore" and "Other" from the Philippines is not separately classified and is included with "Concentrates."

[3] Data known to be not comparable with other years.

Exports.—Refined copper continued as the principal class of exports but shipments dropped 59 percent to the lowest since 1953. Although 87 percent of the total exported went to European countries, all of the purchasers took substantially smaller quantities than in 1958. Shipments of other classes of copper also were lower, except insulated wire and cable, which rose 51 percent to the largest volume since 1949.

TABLE 34.—Copper exported from the United States, in short tons

[Bureau of the Census]

	Ore, concentrates, matte, and other unrefined copper (copper content)	Refined in cathodes, billets, ingots, wire bars, and other crude forms	Rods [1]	Old and scrap	Pipes and tubes	Plates and sheets	Wire and cable, bare [2]	Wire and cable, insulated	Other copper manufactures [3]
1950-54 (average)	872	155, 506	2, 639	27, 281	1, 912	475	7, 203	15, 950	(3)
1955	12, 897	199, 819	202	31, 137	1, 292	542	6, 976	19, 974	234
1956	13, 717	223, 103	366	25, 681	1, 550	337	11, 104	18, 434	185
1957	15, 656	346, 025	1, 659	48, 989	1, 354	265	11, 119	21, 035	238
1958	11, 475	384, 868	(1)	21, 861	1, 608	166	5, 030	14, 482	2, 302
1959									
North America:									
Canada	4	3, 313	--------	1, 283	135	122	360	6, 931	323
Cuba	--------	5	--------	31	57	15	47	513	1, 283
Mexico	115	27	--------	--------	24	10	132	429	26
Other North America	--------	4	--------	4	153	19	225	1, 228	6
Total	119	3, 349	--------	1, 318	369	166	764	9, 101	1, 638
South America:									
Argentina	21	4, 268	--------	1, 536	4	--------	4	62	(4)
Brazil	--------	4, 972	--------	--------	5	4	15	132	24
Other South America	--------	87	--------	--------	129	21	842	2, 270	2, 673
Total	21	9, 327	--------	1, 536	138	25	861	2, 464	2, 697
Europe:									
Belgium-Luxembourg	--------	270	--------	10	2	(4)	--------	82	--------
France	--------	42, 567	--------	59	(4)	9	1	583	2
Germany, West	1, 171	38, 524	--------	2, 826	(4)	36	29	44	--------
Italy	1, 281	15, 234	--------	482	--------	(4)	(4)	402	--------
Netherlands	--------	7, 131	--------	50	1	8	6	63	--------
Norway	--------	1, 820	--------	--------	1	1	--------	5	--------
Spain	--------	--------	--------	50	94	1	644	30	--------
Sweden	--------	1, 320	--------	--------	1	2	7	64	--------
Switzerland	--------	1, 870	--------	--------	(4)	(4)	1	10	--------
United Kingdom	56	26, 300	--------	--------	--------	48	5	4, 561	1
Yugoslavia	--------	2, 257	--------	880	--------	--------	--------	1	--------
Other Europe	--------	1, 534	--------	619	15	2	39	185	--------
Total	2, 508	138, 827	--------	4, 976	114	107	732	6, 030	3
Asia:									
India	--------	922	--------	997	16	--------	119	47	2
Japan	334	5, 333	--------	1, 834	3	6	1	444	--------
Other Asia	--------	69	--------	60	146	8	475	3, 571	9
Total	334	6, 324	--------	2, 891	165	14	595	4, 062	11
Africa	--------	--------	--------	--------	13	--------	425	169	3
Oceania	--------	1, 111	--------	--------	--------	1	1	37	(4)
Grand total	2, 982	158, 938	(1)	10, 721	799	313	3, 378	21, 863	4, 352

[1] Beginning Jan. 1, 1958, not separately classified; included in Other copper manufactures."
[2] Owing to changes in classifications, 1952–59 data not strictly comparable with earlier years.
[3] Weight not recorded before 1953; 1953, 294 tons; 1954, 250 tons.
[4] Less than 1 ton.

TABLE 35.—Copper exported from the United States

[Bureau of the Census]

Year	Ore, concentrates, composition metal, and unrefined copper (copper content)		Refined copper and semimanufactures [1]		Other copper manufactures [1]		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1950-54 (average)	872	$498,277	210,966	$130,786,633	(2)	$871,226	211,838	$132,156,136
1955	12,897	9,478,941	259,942	207,741,551	234	308,792	273,073	217,529,284
1956	13,717	11,648,348	280,575	253,614,925	185	290,552	294,477	265,553,825
1957	15,656	9,963,640	430,446	288,936,283	238	321,237	446,340	299,221,160
1958	11,475	5,864,534	[3] 428,015	[3] 229,534,839	[3] 2,302	[3] 1,567,100	441,792	236,966,473
1959	2,982	1,808,289	[3] 196,012	[3] 128,577,107	[3] 4,352	[3] 3,280,116	203,346	133,665,512

[1] Owing to changes in classifications 1952-59 data not strictly comparable with earlier years.

[2] Weight not recorded before 1953; 1953, 294 tons ($352,124); 1954, 250 tons ($307,848).

[3] Beginning Jan. 1, 1958, copper rods not separately classified; included in "Other copper manufactures."

TABLE 36.—Copper-base alloys (including brass and bronze) exported from the United States, by classes

[Bureau of the Census]

Class	1958		1959	
	Short tons	Value	Short tons	Value
Ingots	276	$505,235	383	$898,218
Scrap and other forms	28,502	10,456,481	29,406	12,497,070
Bars, rods, and shapes	565	772,424	515	803,736
Plates, sheets, and strips	555	951,029	573	1,172,252
Pipes and tubes	1,198	1,594,892	1,273	1,848,775
Pipe fittings	1,528	3,454,384	1,691	3,850,983
Plumbers' brass goods	2,670	6,997,664	2,453	6,693,763
Welding rods and wire	709	1,382,330	724	1,413,958
Castings and forgings	245	442,462	136	260,137
Powder	283	273,065	391	402,044
Semifabricated forms, not elsewhere classified	34	76,400	62	160,973
Total	36,565	26,906,366	37,607	30,001,909

TABLE 37.—Unfabricated copper-base alloy[1] ingots, bars, rods, shapes, plates, sheets, and strips exported from the United States

[Bureau of the Census]

Year	Short tons	Value	Year	Short tons	Value
1950-54 [2] (average)	3,923	$3,312,770	1957 [2]	1,747	$2,943,557
1955 [2]	2,175	3,200,780	1958 [2]	1,396	2,228,688
1956 [2]	2,233	3,844,261	1959 [2]	1,471	2,874,206

[1] Includes brass and bronze.

[2] Owing to changes in classifications, data 1953-59 not strictly comparable with earlier years.

TABLE 38.—Copper sulfate (blue vitriol) exported from the United States

[Bureau of the Census]

Year	Short tons	Value	Year	Short tons	Value
1950-54 (average)	35,824	$6,683,740	1957	33,644	$6,534,037
1955	37,382	8,381,815	1958	7,248	1,175,944
1956	30,177	8,036,233	1959	2,672	674,522

TABLE 39.—Brass and copper scrap imported into and exported from the United States, in short tons

[Bureau of the Census]

	1950-54 (average)	1955	1956	1957	1958	1959
Imports for consumption:						
Brass scrap (gross weight)	13,866	11,758	6,519	7,911	6,763	2,054
Copper scrap (copper content)	11,748	12,577	5,410	5,843	5,849	2,984
Exports:						
Brass scrap [1]	29,565	45,260	50,485	69,996	28,502	29,406
Copper scrap	27,281	31,137	25,681	48,989	21,861	10,721

[1] Beginning Jan. 1, 1952, classified as copper-base-alloy scrap (new and old).

TABLE 40.—Copper scrap imported into and exported from the United States, 1959, by countries, in short tons

[Bureau of the Census]

Country	Exports		Imports	
	Unalloyed copper scrap	Copper-alloy scrap	Unalloyed copper scrap (copper content)	Copper-alloy scrap (gross weight)
North America:				
Canada	1,283	55	1,568	1,276
Cuba	31	---	820	531
Other North America	4	12	348	205
Total	1,318	67	2,736	2,012
South America	1,536	114	5	---
Europe:				
Germany, West	2,826	3,571	37	---
Italy	482	523	---	---
Netherlands	50	951	3	---
Portugal	374	16	---	---
Yugoslavia	880	---	---	---
Other Europe	364	547	162	14
Total	4,976	5,608	202	14
Asia:				
Hong Kong	---	1,213	---	---
India	997	1,029	---	---
Japan	1,834	21,172	41	14
Other Asia	60	192	---	14
Total	2,891	23,606	41	28
Oceania: Australia	---	11	---	---
Grand total	10,721	29,406	2,984	2,054

Tariff.—The price of copper remained above 24 cents a pound and the 1.7-cent-a-pound excise tax, effective July 1, 1958, was applicable to imported copper. If the price were to drop below 24 cents, the tariff would be 2 cents a pound.

WORLD REVIEW

NORTH AMERICA

Canada.—Output of the International Nickel Co. of Canada, Ltd., was near capacity following resumption of operations at Ontario properties closed by a 3-month strike in the latter part of 1958. Ore mined in the Sudbury district totaled 15.3 million tons (9.5 million in 1958), of which 13.8 million tons (8.9 million) was from underground operations and 1.5 million (0.6 million) from open pit. The company delivered 126,300 tons of copper compared with 105,300 tons in 1958, most of which went to Canada and the United Kingdom. Shipments of ore from the Murray mine, suspended in July 1958, were resumed in January; development of the Crean Hill mine, suspended in February 1958, was started again in August; and the Levack concentrator began operations on June 1.

Falconbridge Nickel Mines, Ltd., the other important copper-producing company in Ontario, established a record output for the tenth successive year. Ore deliveries from company mines totaled 2.2 million tons compared with 2 million in 1958. The Fecunis mine which began production in the latter half of the year accounted for a large part of the increased output. For the first time, production from the northern area mines (Hardy, Longvack, and Fecunis) exceeded that of the southern area mines (Falconbridge, East, and McKim). Output from the Norduna mines, in which Falconbridge has a 50-percent interest, was sold to Falconbridge under contract and totaled 141,100 tons compared with 64,300 tons in 1958. The company delivered 16,400 tons of copper to customers, 6 percent more than in 1958.

TABLE 41.—World mine production of copper, by countries, in short tons [1] [2]

[Compiled by Augusta W. Jann and Berenice B. Mitchell]

Country	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada	269, 640	325, 994	354, 860	359, 109	345, 114	399, 362
Cuba	19, 864	20, 800	18, 200	18, 000	14, 343	9, 942
Mexico	66, 682	60, 269	60, 478	66, 800	71, 609	63, 134
United States	904, 990	998, 570	1, 104, 156	1, 086, 859	979, 329	824, 846
Total	1, 261, 176	1, 405, 633	1, 537, 694	1, 530, 768	1, 410, 395	1, 297, 284
South America:						
Bolivia (exports)	4, 933	3, 855	4, 896	4, 320	3, 168	2, 461
Brazil [3]	--------	730	880	1, 400	1, 400	800
Chile	414, 258	477, 873	539, 844	535, 306	514, 925	602, 256
Peru	36, 729	47, 844	50, 966	63, 023	59, 105	53, 147
Total	455, 920	530, 302	596, 586	604, 049	578, 598	658, 664
Europe:						
Austria	2, 681	2, 841	2, 579	2, 574	2, 695	2, 726
Bulgaria [3]	2, 888	6, 900	5, 800	7, 700	8, 800	12, 000
Finland	21, 164	23, 700	23, 150	28, 700	31, 800	32, 400
France [4]	534	580	450	410	794	674
Germany:						
East [3]	14, 200	23, 100	23, 100	24, 250	24, 250	27, 100
West	2, 163	1, 335	1, 076	1, 203	1, 156	1, 584
Ireland	--------	--------	--------	--------	[3] 5, 300	[3] 5, 300
Italy	211	365	373	310	660	600
Norway	15, 405	15, 419	16, 488	16, 787	17, 501	16, 100
Poland	3, 350	6, 100	8, 000	8, 300	[3] 8, 800	[3] 9, 900

See footnotes at end of table.

TABLE 41.—World production of copper, by countries, in short tons—Continued

Country	1950–54 (average)	1955	1956	1957	1958	1959
Europe—Continued						
Portugal	618	600	1,066	619	819	[3] 800
Spain [5]	8,478	6,726	7,525	11,077	8,230	12,137
Sweden	16,132	17,275	18,436	19,924	17,964	19,977
U.S.S.R.[3] [6] [7]	306,000	385,000	430,000	450,000	470,000	480,000
Yugoslavia	[7] 36,684	32,098	35,088	36,883	38,840	42,556
Total [3] [6]	430,500	522,000	573,000	609,000	638,000	664,000
Asia:						
Burma [3]	64	165	165	143	143	165
China [3]	7,100	11,000	13,000	16,500	33,000	[8] 33,000
Cyprus (exports)	26,878	26,179	39,497	43,676	36,614	39,978
India	7,365	8,500	8,800	9,000	9,150	8,900
Japan	57,519	80,466	86,497	90,066	89,837	92,912
Korea, Republic of	537	1,760	970	710	590	449
Philippines	13,977	19,247	29,722	44,513	51,842	54,587
Taiwan	829	1,100	1,593	1,840	1,702	1,793
Turkey	[7] 21,199	26,740	30,544	28,871	27,744	30,551
Total [3] [6]	135,500	175,200	210,800	235,300	250,600	262,300
Africa:						
Algeria	133	74	209	476	435	57
Angola	1,793	2,011	3,154	3,735	3,273	3,715
Belgian Congo [7]	222,359	259,161	275,538	267,028	261,867	310,955
Morocco: Southern zone	618	823	852	694	1,216	1,572
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	378,535	395,308	445,466	480,313	441,073	598,835
Southern Rhodesia	170	1,179	1,931	3,226	8,430	12,016
South-West Africa	14,037	23,588	28,980	29,910	30,975	34,436
Tanganyika [9]	299	650	1,276	1,178	1,770	1,220
Uganda	----------	----------	3,230	11,723	[7] 12,130	[7] 13,376
Union of South Africa	39,965	49,239	51,252	50,959	54,615	55,696
Total	657,909	732,033	811,888	849,242	815,784	1,031,878
Oceania: Australia	28,885	50,956	59,406	64,034	82,269	103,504
World total (estimate)	2,970,000	3,420,000	3,790,000	3,890,000	3,780,000	4,020,000

[1] Albania, Czechoslovakia, Hungary and Iran also produce copper but production data are not available. No estimates for these countries are included in the total. Ecuador and Israel are now producing a small amount of copper.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Estimate.

[4] Includes Cu content of auriferous ores.

[5] According to Yearbook of American Bureau of Metal Statistics. These data do not include content of iron pyrites, the copper content of which may or may not be recovered.

[6] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.

[7] Smelter production.

[8] Data represents estimate of 1958 production; however, 1959 production was probably greater.

[9] Copper content of exports and local sales.

Geco Mines, Ltd., Manitouwadge area, milled 1.3 million tons of ore averaging 2.10 percent copper, 2.38 percent zinc, and some gold and silver. Copper content of the concentrate produced totaled 25,900 tons. The copper concentrate was shipped to the Noranda smelter and most of the zinc concentrate went to a U.S. plant for treatment.

At the Horne mine of Noranda Mines, Ltd., Quebec, 1.4 million tons of ore was mined; the smelter treated 1.5 million tons of ore and concentrate, of which 0.8 million tons was smelted for other companies. Copper produced totaled 135,500 tons—26,500 tons from the Horne mine and 109,000 tons from others.

The copper was recovered at the electrolytic refinery of Noranda's subsidiary, Canadian Copper Refiners, Ltd., Montreal East. Output of refined copper totaled 232,500 tons compared with 239,000 tons in

1958. The tank house capacity of the refinery was being increased to 270,000 tons of copper annually and was expected to reach capacity by June 1960. The refining contract with Hudson Bay Mining & Smelting Co., Ltd., was extended to 1971.

TABLE 42.—World smelter production of copper, by countries, in short tons [1]

[Compiled by Augusta W. Jann and Berenice B. Mitchell]

Country	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada	234, 064	288, 997	328, 458	323, 540	329, 239	365, 433
Mexico	56, 260	49, 730	52, 089	62, 061	67, 109	61, 105
United States [2]	1, 012, 660	1, 106, 526	1, 231, 352	1, 178, 145	1, 069, 052	841, 795
Total	1, 302, 984	1, 445, 253	1, 611, 899	1, 563, 746	1, 465, 400	1, 268, 333
South America:						
Chile	388, 961	447, 292	506, 256	496, 736	484, 678	571, 555
Peru	26, 006	34, 862	35, 005	46, 137	42, 403	38, 024
Total	414, 967	482, 154	541, 261	542, 873	527, 081	609, 579
Europe:						
Austria	8, 152	10, 720	11, 088	8, 806	10, 525	11, 601
Bulgaria [3]	1, 650	4, 000	5, 000	5, 600	6, 748	6, 000
Finland	20, 039	24, 583	24, 767	28, 469	33, 873	35, 941
Germany:						
East [3]	23, 100	30, 000	33, 000	33, 000	33, 000	33, 000
West [4]	229, 462	286, 306	279, 463	279, 313	295, 609	310, 729
Italy	143	1, 024	373	310	[3] 660	[3] 660
Norway	11, 617	15, 142	17, 013	17, 357	19, 365	21, 033
Poland	[4] 13, 200	17, 331	22, 396	21, 966	19, 146	19, 127
Spain	5, 798	6, 477	6, 940	6, 600	5, 556	7, 686
Sweden	17, 487	19, 159	18, 673	21, 472	22, 268	27, 921
U.S.S.R. [3] [5]	306, 000	385, 000	430, 000	450, 000	470, 000	480, 000
Yugoslavia	36, 684	31, 151	32, 390	37, 186	37, 117	38, 858
Total [3] [5] [6]	673, 300	831, 000	881, 000	911, 000	954, 000	993, 000
Asia:						
China [3]	7, 100	11, 000	13, 000	16, 500	[7] 33, 000	[7] 33, 000
India	7, 136	8, 155	8, 543	8, 790	8, 782	8, 459
Japan	57, 932	89, 353	101, 946	120, 013	113, 979	173, 196
Korea, Republic of	162	362	1, 000	874	886	824
Taiwan	683	1, 295	1, 659	1, 883	1, 833	1, 986
Turkey	21, 199	26, 234	27, 297	26, 897	24, 835	27, 599
Total [3] [5]	94, 200	136, 400	153, 400	175, 000	183, 300	245, 100
Africa:						
Angola	1, 430	861	1, 425	1, 791	1, 533	1, 564
Belgian Congo	222, 359	259, 161	275, 538	267, 028	261, 867	310, 955
Rhodesia and Nyasaland, Federation of: Northern Rhodesia	366, 968	384, 357	429, 503	466, 157	420, 936	593, 756
Uganda	----------	----------	168	8, 361	12, 130	13, 376
Union of South Africa	38, 895	47, 480	48, 681	48, 229	53, 406	53, 843
Total	629, 652	691, 859	755, 315	791, 566	749, 872	973, 494
Oceania: Australia	27, 524	41, 932	54, 914	56, 440	72, 360	76, 692
World total (estimate)	3, 140, 000	3, 630, 000	4, 000, 000	4, 040, 000	3, 950, 000	4, 170, 000

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[2] Smelter output from domestic and foreign ores, exclusive of scrap. Production from domestic ores only, exclusive of scrap, was as follows: 1950–54 (average), 909,453 short tons; 1955, 1,007,311; 1956, 1,117,580; 1957, 1,081,055; 1958, 992,918; and 1959, 799,329.

[3] Estimate.

[4] Includes scrap.

[5] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.

[6] Belgium reports a large output of refined copper which is believed to be produced principally from crude copper from Belgian Congo; it is not shown here, as that would duplicate output reported under latter country.

[7] Data represents estimated 1958 mine production; however, 1959 production was probably greater.

Gaspé Copper Mines, Ltd., subsidiary of Noranda, mined 2.4 million tons of ore averaging 1.44 percent copper. A total of 2.3 million tons was milled and 117,200 tons of concentrate was produced. The smelter treated 274,400 tons of concentrate and fluxing ore, of which 62,900 tons was custom concentrate. Copper produced totaled 45,000 tons including 11,600 tons of custom copper.

The Quemont Mining Corp., Ltd., which adjoins the Horne mine, treated 850,000 tons of ore averaging 1.33 percent copper. Copper concentrate totaling 60,700 tons and containing 10,400 tons of copper was smelted at the Noranda smelter.

The Waite Amulet Mines, Ltd., subsidiary of Noranda, treated 311,400 tons of ore and produced concentrate containing 12,800 tons of copper. The West Macdonald mine supplied 13,800 tons of ore before shipments ceased in February.

The Normetal Mining Corp., Ltd., milled 376,400 tons of ore averaging 3.2 percent copper. The copper concentrate was smelted at Noranda and yielded 11,300 tons of copper.

East Sullivan Mines, Ltd., mined and milled 957,000 tons of ore averaging 0.83 percent copper compared with 896,000 tons averaging 1 percent in 1958; copper production totaled 7,200 tons.

Opemiska Copper Mines milled 443,000 tons of ore averaging 3.36 percent copper compared with 353,000 tons averaging 3.95 percent in 1958. Copper production totaled 14,000 tons (13,000 in 1958). Capacity of the mill was expanded to 2,000 tons of ore per day in late December.

TABLE 43.—Copper produced (mine output) in Canada, by Provinces, in short tons[1]

Province	1950–54 (average)	1955	1956	1957	1958	1959 (preliminary)
British Columbia	22,608	22,127	21,682	15,411	6,010	6,124
Manitoba	13,543	19,380	17,973	18,551	12,601	12,872
New Brunswick	-------	35	6	5,738	328	-------
Newfoundland	3,075	3,052	3,108	4,535	14,751	15,777
Northwest Territories	1	-------	-------	165	434	438
Nova Scotia	432	1,027	404	-------	-------	-------
Ontario	128,544	146,407	156,271	171,703	142,035	186,747
Quebec	69,891	101,021	122,300	112,409	131,445	136,839
Saskatchewan	31,546	32,945	33,116	30,597	37,510	36,096
Total	269,640	325,994	354,860	359,109	345,114	394,893

[1] Dominion Bureau of Statistics, Department of Trade and Commerce, Government of Canada, Preliminary Report on Mineral Production, 1959.

In the 1958–59 fiscal year, Campbell Chibougamau Mines, Ltd., milled 683,000 tons of ore averaging 2 percent copper, compared with 592,000 tons averaging 2.07 percent in the 1957–58 period. Copper production totaled 12,600 tons compared with 11,500 tons.

Saskatchewan and Manitoba together accounted for 12 percent of Canadian copper output in 1959. The Hudson Bay Mining and Smelting Co., Ltd., and Sherritt Gordon Mines, Ltd., were the largest producers.

The Hudson Bay Mining and Smelting Co., Ltd., mined and hoisted 1.7 million tons of ore from three mines; 1.5 million tons came from the Flin Flon mine and 100,000 tons each from the Birch Lake and

Schist Lake mines. The mill treated 1.7 million tons from the mines and 9,700 tons of Birch Lake and Flin Flon ore was smelted without milling. Copper concentrate produced totaled 326,000 tons averaging 13.53 percent copper. The smelter treated 434,900 tons of Hudson Bay concentrate, residue, and direct smelting ores, and shipped 44,100 tons of blister copper to the refinery. Refined copper production totaled 43,900 tons compared with 45,500 tons in 1958.

Development continued at the Coronation mine in Saskatchewan and the Chisel Lake mine in Manitoba; production at the Coronation mine was to begin in early 1960 and at the Chisel Lake mine in the latter part of 1960.

Sherritt Gordon Mines, Ltd., mined and milled 988,500 tons of nickel-copper ore. Copper content of the concentrate totaled 5,200 tons compared with 4,900 tons in 1958. The mill-expansion program was completed in the fourth quarter of 1959.

At the Phoenix Copper Co., Ltd., subsidiary of Granby Mining Co., Ltd., British Columbia, plant construction and installation of equipment were completed and production began in April. The mill treated 175,900 tons of ore containing 0.8 percent copper. Production of copper totaled 1,150 tons. Much of the equipment at the company's Copper Mountain property, which closed in April 1957, had been installed at Phoenix. In 1959 the capacity of the mill was increased from 700 tons per day to 1,000 tons.

Production at the Britannia copper-zinc mine, of the Howe Sound Co., British Columbia, was resumed in March, and output thereafter was at a monthly rate of approximately 27,000 tons of ore.

Production of refined copper was 365,000 tons compared with 330,000 tons in 1958. Consumption of refined copper totaled 130,000 and 123,000 tons, respectively in the 2 years. Imports totaled 105 tons in 1959, compared with 1 ton in the previous year.

Exports of copper in ore, matte, and regulus totaled 32,000 (30,300 in 1958) tons; Norway was the destination of 17,000 (14,900), the United States 7,300 (10,700), Japan 6,000 (2,200), and the remainder went (in smaller quantities) to the United Kingdom, Belgium, and West Germany. Exports of ingots, bars, and billets, in short tons, were as follows:

Destination:	*1958*	*1959*
United States	63, 865	101, 501
United Kingdom	90, 927	83, 487
France	20, 806	10, 038
Germany, West	14, 051	9, 510
India	11, 652	7, 619
Belgium	1, 008	3, 738
Netherlands	9, 089	2, 939
Italy	6, 137	1, 400
Brazil	1, 994	334
Switzerland	2, 380	-------
Other	2, 729	1, 871
Total	224, 638	222, 437

In addition, 16,900 (14,400) tons of rods, strips, sheet, and tubing were shipped, of which 6,400 (4,000) went to the United States, 3,800 (4,000) to Switzerland, and 2,100 (3,300) to United Kingdom. Copper-scrap slag skimmings totaling 6,200 (11,100) tons also were exported.

Western Copper Mills, Ltd., the first copper-fabricating plant in western Canada, began operations in January.[5] Annual output was expected to be about 18,000 tons of copper and copper-alloy products.

SOUTH AMERICA

Chile.—At the El Teniente mine of the Braden Copper Co., a subsidiary of Kennecott Copper Corp., 11.1 million tons of ore was mined and milled and 182,000 tons of copper was produced compared with 11.3 million tons and 191,600 tons, respectively, in 1958. Operations were affected by a strike from October 2 to November 1. All of the Braden fire-refined copper and most of the blister copper continued to be sold in Europe. The remainder of the blister copper was shipped to the United States for electrolytic refining and subsequent shipment to European customers.

Copper production at the Chuquicamata mine of the Chile Exploration Co., a subsidiary of The Anaconda Company, totaled 306,500 tons, a record output. The installation of additional ball mills and regrinding equipment increased capacity of the concentrator; conversion of the electrolytic tankhouse for refining blister was continued. Capacity of 5,000 tons a month was attained and the conversion would continue until 7,000-ton capacity is reached by mid-1960.

In April, the El Salvador mine of the Andes Copper Mining Co., another Anaconda subsidiary, began production. The last ore from Potrerillos was received at the treatment plant on June 10. Since production began at the Potrerillos mine in 1927 more than 200 million tons of ore was mined that yielded about 1.75 million tons of copper. With the start of production from the El Salvador mine, copper output of the company increased from about 3,500 tons monthly, a rate that had been maintained for more than 6 years, to nearly 7,500 tons a month during the last quarter. Capacity of the concentrator was increased to 24,000 tons of ore daily by the construction of four grinding and flotation units. The rebuilding of the large reverberatory furnace at the smelter in Potrerillos was completed and crane facilities were enlarged to handle increased production from El Salvador.

Copper production of the Andes Copper Mining Co. totaled 60,300 tons, of which 18,000 tons came from Potrerillos and 42,300 tons from El Salvador.

Production of La Africana mine of the Santiago Mining Co., subsidiary of Anaconda, totaled 11,700 tons of concentrate averaging 30.4 percent copper. Operation was interrupted by an 18-day strike, and shipment of concentrate to the United States for smelting and refining was halted twice by work stoppages at U.S. smelters.

The Cerro de Pasco Corp. continued development at the Rio Blanco property, Aconcagua and Santiago Provinces. The ore reserve was increased to 121 million tons averaging 1.58 percent copper, of which 87 million was considered proved ore.

---

[5] Bureau of Mines, Mineral Trade Notes: Vol. 48, No. 4, April 1959, p. 5.

The Paipote smelter, operated by the Government's Empresa Nacional de Fundiciones, produced 22,600 tons of blister copper. Output of Chile's small- and medium-sized copper mines totaled 30,700 tons of copper in ores, concentrates, and cement copper.

TABLE 44.—Principal types of copper exported from Chile, in short tons

Destination	1958				1959			
	Refined		Standard (blister)	Total	Refined		Standard (blister)	Total
	Electrolytic	Fire-refined			Electrolytic	Fire-refined		
Belgium	----------	----------	----------	----------	2,326	----------	----------	2,326
France	----------	----------	----------	----------	6,671	----------	----------	6,671
Germany, West	31,099	6,467	45,393	82,959	32,667	9,055	42,159	83,881
Italy	11,172	3,829	4,491	19,492	16,905	12,076	1,291	30,272
Netherlands	38,901	----------	----------	38,901	58,554	1,755	56	60,365
Spain	----------	----------	9,285	9,285	----------	----------	3,426	3,426
Sweden	8,778	----------	----------	8,778	11,823	----------	----------	11,823
Switzerland	132	3,877	----------	4,009	----------	1,597	----------	1,597
United Kingdom	23,427	43,774	16,672	83,873	23,057	50,128	33,690	106,875
United States	61	250	200,116	200,427	13,993	2,804	201,417	218,214
Other countries	117	112	----------	229	144	944	----------	1,088
Total	113,687	58,309	275,957	447,953	166,140	78,359	282,039	526,538

In addition to the exports shown in table 44, 30,200 (27,100 in 1958) tons of ore and concentrate was shipped, of which 15,300 (11,700) tons went to the United States, 9,900 (3,200) to Japan, 4,400 (11,500) to West Germany, 300 (300) to Belgium, and 200 (200) to Sweden.

Peru.—A 14-day strike from February 18 to March 2 and curtailment of production at properties of Cerro de Pasco Corp. resulted in a 10-percent decrease in output. Cerro de Pasco's copper production totaled 36,900 tons of which 26,700 was from corporation and leased ores.

Development of the open-pit mine and construction of mill, smelter, and related facilities of the Toquepala project of Southern Peru Copper Corp., which began in 1955, were completed about 5 months ahead of schedule. Production of blister copper at the Ilo smelter began January 1, 1960. It was expected that annual capacity of 140,000 tons of blister would be attained within a few months.

EUROPE

United Kingdom.—Consumption of primary and secondary copper in the United Kingdom (the free world's second largest copper-consuming country) decreased for the first time since 1953—536,300 tons was consumed in 1959 compared with 598,800 in 1958. Consumption of copper in scrap, however, rose from about 150,000 tons to 173,000 tons. Of the total, 517,000 tons of refined copper and 107,400 tons in scrap were consumed for semimanufactured products, and 19,300 tons of refined copper and 65,500 tons in scrap were for castings, copper sulfate, and miscellaneous products. Inventories of blister and refined copper, exclusive of government stocks, dropped from 66,200 tons at the end of 1958 to 61,600 tons at the end of 1959.

Production of copper sulfate rose from 31,400 tons in 1958 to 35,300 tons in 1959.

On January 7 the British Board of Trade announced it would offer 7,250 tons of government stockpile copper for delivery in equal installments over a 5-month period beginning in January; on May 21, 6,000 tons (the last of the Board's stocks) of copper was offered for delivery from July to November.

Effective February 16, the Board of Trade removed controls on exports of copper ores and concentrates to the Soviet bloc and Chinese mainland.

According to the British Bureau of Nonferrous Metal Statistics, imports of copper into the United Kingdom are shown in table 45.

TABLE 45.—Copper imported into the United Kingdom, by country of origin, in short tons

Country	1958			1959		
	Blister	Electrolytic	Fire-refined	Blister	Electrolytic	Fire-refined
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	90,583	120,400		74,744	182,143	
Chile	16,072	24,211	49,842	32,422	23,228	46,984
Canada		89,200			81,576	
United States		105,944	6,858		31,057	1,959
Union of South Africa			840		280	5,683
Belgian Congo		3,920			4,541	
Norway		1,858			3,455	
Peru		2,875			588	
Belgium		1,339			452	
Japan		140				
Other countries	729	579		5	633	
Total	107,384	350,466	57,540	107,171	327,953	54,626

Exports and reexports of refined copper were 111,400 tons (65,800 in 1958), of which 26,700 (4,100) went to the U.S.S.R., 17,600 (9,000) to the United States, 11,600 (18,300) to West Germany, 11,500 (1,200) to Poland, 10,100 (945) to Czechoslovakia, 8,700 (3,100) to China, 4,000 (3,200) to India, 3,500 (2,500) to Hungary, 3,300 (3,400) to the Netherlands, 3,100 (1,700) to France, 2,000 (6,200) to Argentina, and the remainder in lots of less than 2,000 tons each to other countries. No blister copper was reexported in 1959 or 1958.

ASIA

Philippines.—Production of copper continued its upward trend for the sixth successive year and exceeded 1958 by 5 percent. Five copper mines accounted for most of the output; the remainder came from gold mining operations.

The Atlas Consolidated Mining & Development Corp. mined and milled 3.9 million tons (3.5 million in 1958) of ore averaging 0.62 percent copper at its Toledo mine. Copper concentrate produced contained 21,300 tons of copper compared with 20,800 tons in 1958.

The Lepanto Consolidated Mining Co. milled 455,100 tons of ore averaging 3.33 percent copper compared with 453,300 tons averaging

3.33 percent in 1958 and produced 14,400 tons of copper in both years.

Elsewhere in the Philippines copper was produced by Marinduque Iron Mines Agents, Inc., at its Sipalay and Bagacay properties, and by the Philex Mining Corp., at its Santo Tomás group of mines. Production of 9,000 tons of copper at the Sipalay mine was slightly less than in 1958 (9,100 tons), but that at Bagacay dropped 23 percent due to depletion of direct smelting ore. Milling-grade ore was treated in the company's 400-ton concentrator, which began operating in May, and total output was 4,300 tons compared with 5,500 in 1958. At the 2,000-ton mill at the Santo Tomás group, Philex treated 558,000 tons of copper ore and produced 2,900 tons of copper.

Turkey.—All of Turkey's production came from the Murgul and Ergani mines; a rise of 10 percent in output to 30,600 tons was mainly due to an increase from 4,900 tons to more than 8,800 at the Government-owned Murgul mine. A $1.5-million Export-Import Bank credit was granted to the Ergani mine to develop new production facilities. It was reported[6] that the ore reserve totaled 13 million tons of ore averaging 2.65 percent copper. The high-grade ore, which had been supplying production and was almost depleted, averaged over 7 percent copper.

AFRICA

Belgian Congo.—Production of copper by the Union Minière du Haut Katanga, the only producer, established a new record; output of 309,100 tons exceeded the previous record of 1956 by 13 percent. Most of the output continued to come from mines in the Western Group and the Prince Leopold mine in the Southern Group. Of the total of 7.4 million tons of ore mined, 2.4 million came from the Kamoto mine, 1.9 million from Musonoi, 1.2 million from Ruwe, and 74,000 tons from Kolwezi. The Prince Leopold mine produced 1.1 million tons, and the remainder consisted of uranium-radium ore from Shinkolobwe and ore from other properties.

The Kolwezi concentrator treated 4.2 million tons of copper and mixed ores from the Kamoto and Musonoi mines; it produced 558,000 tons of concentrate containing 24.74 percent copper and 175,000 tons containing 30.02 percent copper. The Kipushi concentrator treated 1.2 million tons, of which 1 million came from the Prince Leopold mine. The Ruwe concentrator treated 1.1 million tons, and the remainder was treated at the Shinkolobwe and Ruashi plants.

Copper production came from the following plants:

	Short tons
Lubumbashi (blast furnaces and converters)	132, 936
Jadotville-Shituru (leaching, electrolysis, and refining)	[1] 174, 669
Jadotville-Panda electric smelter (recoverable copper in white cobalt alloy)	945
Recoverable copper contained in zinc concentrates	541
	309, 091

[1] Included 2,784 tons of recoverable copper in cathodes exported.

---

[6] Mining World Catalog, Survey and Directory Number, 1960: Vol. 22, No. 5, Apr. 25, 1960, p. 132.

Construction of the Kambove concentrator, which had been halted in 1958, was resumed and it was expected that operations would begin in early 1961. Work was speeded up on the Luilu electrolytic plant and the first stage was to begin producing 55,000 tons per year in April 1960. Completion of the second stage was expected in the first quarter of 1961.

Rhodesia and Nyasaland, Federation of.—In Northern Rhodesia, Roan Antelope Copper Mines, Ltd., mined and milled 5.5 million tons of ore averaging 1.97 percent copper during the fiscal year ended June 30, 1959. Concentrate produced contained 88,700 tons of recoverable copper. A total of 90,600 tons of molten blister was produced, of which 47,400 tons was of fire-refinable grade and 43,200 tons went to the Ndola plant for electrolytic refining. In addition, the Roan smelter produced 1,000 tons of copper for Nchanga.

A total of 4.1 million tons of ore averaging 2.65 percent copper was mined by Mulfulira Copper Mines, Ltd., in the fiscal year ended June 30, 1959, compared with 4.4 million tons averaging 2.67 percent in the preceding fiscal period. Decreased output was due to voluntary curtailment of production begun in 1958. After settlement of the strike in November, the production rate was increased and 98,600 tons of ore was produced compared with 104,100 tons in the fiscal year ended June 30, 1958. Development continued on the Mufulira West project, and the completion date remained at mid-1962.

Chibuluma Mines, Ltd., mined 513,000 tons of ore averaging 4.67 percent copper in the fiscal year ended June 30, 1959. Copper production totaled 21,500 tons compared with 30,400 tons in the preceding fiscal year. The latter figure, however, included 10,100 tons from concentrate stockpiled in previous years.

In its first year of operation the electrolytic refinery of Ndola Copper Refineries, Ltd., produced 38,000 tons of cathode copper. The casting plant converted 25,000 tons of cathode copper into 23,000 tons of wirebars. Completion of the second stage of the refinery was expected early in 1960 but it was not planned to use the additional capacity for the first year or two.

The Rhokana Corp., Ltd., mined 4.2 million tons of ore and treated 4.1 million tons averaging 2.49 percent copper in the fiscal year ended June 30, 1959. Production of concentrate totaled 246,900 tons, averaging 32.37 percent copper and 0.81 percent cobalt. Copper production totaled 86,200 tons, of which 29,200 tons was blister and 57,000 tons was electrolytic. The smelter produced 206,100 tons of blister and anode copper, virtually unchanged from the preceding fiscal year (206,200 tons). Of the total smelter output, 29,200 tons was blister and 57,700 tons anode for Rhokana, 36,200 blister and 68,600 anode for Nchanga, 13,600 blister for Bancroft, and 800 blister for others.

Bancroft Mines, Ltd., resumed operations on April 1 and 13,600 tons of blister copper was produced at the Rhokana smelter April–June 1959.

Operations at mines of Nchanga Consolidated Copper Mines, Ltd., were at a record high rate in the fiscal year that ended March 31, 1959. A total of 3.7 million tons of ore was mined, of which 2.8 million was from Nchanga West ore body, 0.7 million from Nchanga open pit, and 0.2 million from Chingola open pit. Ore milled totaled 3.6 million tons averaging 5.12 percent copper, and 162,600 tons of copper in concentrate was produced. Production of copper totaled 156,200 tons—38,400 tons of blister and 117,800 tons of electrolytic.

TABLE 46.—Copper exported from Federation of Rhodesia and Nyasaland in 1959, in short tons

Destination	Ore and concentrates	Blister	Electrolytic			Copper slimes
			Bar and ingot	Cathodes	Wirebars	
Argentina	----------	----------	224	----------	4,532	----------
Australia	----------	----------	----------	----------	1,122	----------
Belgium	10,009	6,720	----------	112	3,612	----------
Brazil	----------	----------	----------	----------	3,371	----------
China	----------	----------	----------	1,120	----------	----------
France	----------	402	1,456	784	18,781	----------
Germany, West	----------	49,438	448	11,285	18,873	----------
India	----------	8,715	1,883	----------	19,298	----------
Italy	----------	6,048	----------	454	20,643	----------
Japan	18,505	----------	18	4,377	7,857	----------
Netherlands	----------	5,057	784	4,411	11,984	----------
Norway	----------	----------	----------	----------	1,176	----------
Spain	----------	2,489	----------	----------	402	----------
Sweden	48	----------	----------	----------	26,072	----------
Switzerland	----------	224	112	616	3,613	----------
Union of South Africa	6,756	194	779	----------	7,848	----------
U.S.S.R.	----------	5,972	----------	4,760	12,040	----------
United Kingdom	----------	78,770	8,154	16,023	163,982	----------
United States	----------	14,554	----------	2,294	11,166	544
Other countries	----------	816	2	----------	243	----------
Total	35,318	179,399	13,860	46,236	336,615	544

Despite work stoppages, production of the refinery of Rhodesia Copper Refineries, Ltd., was maintained at a higher rate in the fiscal year that ended June 30, 1959, than in the period that ended June 30, 1958. Output of refined copper rose from 180,600 tons to 186,600 tons. Of the total, 170,600 tons was refined-copper shapes and 16,000 tons was cathode copper.

Production in Southern Rhodesia rose from 8,400 tons in 1958 to 12,000 tons in 1959. In the fiscal year ended September 30, 736,400 tons of ore from the Mangula mine, operated by a subsidiary of Messina (Transvaal) Development Co., Ltd., was milled; and 16,400 tons of concentrate yielding 8,400 tons of copper was produced. At the Umkondo mine, operated by another subsidiary of Messina, 72,800 tons was milled and yielded 6,400 tons of copper concentrate. It was reported[7] that operations would begin soon at the Sanyati property (formerly Copper Queen), and that work was proceeding on the Alaska mine and smelter. The smelter was expected to begin operations in October 1960.

South-West Africa.—Production of copper continued its upward trend for the sixth successive year and rose 11 percent over 1958. The Tsumeb Corp., Ltd., milled 625,500 tons of ore averaging 6.13 percent copper in the fiscal year ended June 30, 1959, compared with 666,000 tons of ore averaging 5.66 percent copper in fiscal 1958. About 29,000 tons of copper was sold in each fiscal year. A copper smelter to be

---

[7] Work cited in footnote 6, p. 152.

built at Tsumeb was expected to begin operations in 1962 with an annual output of 20,000 tons of blister copper.

Uganda.—Kilembe Mines, Ltd., subsidiary of Frobisher, Ltd., treated 703,000 tons of ore from the Kilembe mine, of which 11,000 tons was direct smelting ore. The ore milled totaled 692,000 tons compared with 522,000 in 1958 and reflected the first full year's operation of the 500-ton concentrator for treating high-grade oxide ore. Blister-copper production totaled 13,400 tons (12,100 tons in 1958). The sulfide concentrating plant was enlarged and will have a capacity of 62,000 tons of ore monthly by the end of 1960. The combined capacities of the sulfide and oxide plants will total 77,000 tons of ore per month. Capacity of the roasting plant at Kasese was increased by installing more drying and filtering equipment. The addition of a third converter raised capacity of the smelter at Jinja to 18,000 tons of blister copper annually.

Union of South Africa.—Output in the Union rose slightly to 56,000 tons and established a new peak. Production of copper by O'okiep Copper Co., Ltd., rose for the second year as output of blister in the fiscal year ended June 30, 1959 totaled 38,100 tons compared with 34,900 tons in fiscal 1958. Ore milled totaled 1.7 million tons averaging 2.46 percent copper. The Carolusberg ore body was being prepared to replace output from older mines in the O'okiep area. Production was scheduled to begin in 1963 at a rate of 75,000 tons of ore a month.

OCEANIA

Australia.—Mount Isa Mines, Ltd., Queensland, subsidiary of American Smelting and Refining Co., milled 2.5 million tons of ore, of which 1.5 million tons was copper ore and 1 million was silver-lead-zinc ore, in the fiscal year ended June 30, 1959. The copper ore averaged 4.1 percent copper compared with 3.9 percent in the preceding fiscal year. Blister-copper production totaled 47,000 tons, 35 percent more than in 1958, and 43,300 tons of copper concentrate containing 11,000 tons of copper was exported for treatment. Installation of new plant and equipment under the expansion program accounted for the increased production. The history and expansion program of Mount Isa was described.[8]

The electrolytic refinery of Copper Refineries Pty., Ltd., subsidiary of Mount Isa, was completed and began operating in late June; capacity will be increased from 50,000 to 67,000 tons of copper a year. Construction also was started on a mill for rolling wire rods and a plant for drawing and stranding copper wire.

Production of copper by Mount Lyell Mining & Railway Co., Ltd., Tasmania, totaled 11,200 tons in the 1959 fiscal year. At the Mount Morgan mine of Mount Morgan, Ltd., Queensland, 4.6 million tons of ore was mined and 925,500 tons was milled. Copper production totaled 8,800 tons. Peko Mines, N.L., treated 131,700 tons of ore averaging 6.11 percent copper, and produced concentrate containing 7,300 tons of copper.

---

[8] Chemical Engineering and Mining Review (Melbourne), Mount Isa Mine of the North: Vol. 51, No. 10, July 15, 1959, pp. 35–39.

TECHNOLOGY

The Bureau of Mines,[9] published information on results of investigations at copper deposits.

The Geological Survey[10] published information on deposits in Colorado.

Rhodesian Copperbelt orebodies were considered to be of hydrothermal origin, derived from an unexposed magmatic source.[11] Conclusions were based on geochemical, mineralogical, textural and regional considerations. Examination of stratigraphic sections in the Mokambo and Mufulira areas showed mineralization to have been localized by carbonaceous quartzites which formed as channel deposits. In these, biotite and chlorite are absent where sulfides are present, and in the higher grades of mineralization there is extensive replacement of feldspar by sericitic aggregates. A low soda content is characteristic of all rock types containing significant copper mineralization.

The ore horizon of the Bancroft mine, in Northern Rhodesia, appears to be a continuation of the River lode extension of the main Nchanga orebody.[12] The orebodies occupy similar positions in the stratigraphic succession. However, lateral changes in rock type, both in the ore zone and in the footwall and hanging-wall beds, make precise correlation difficult.

The geologic structural framework of the Southwest was studied for evidence of four principal trends of lineament tectonics.[13] Their intersections were classified and the positions of those trends that appear most favorable were compared with the positions of known mining districts. In southeastern Arizona and southwestern New Mexico, the ore-bearing veins, fissures, and dikes have a preferred northeast trend.[14] Northwest and north trends are less common, and, except near the Mexican border, east-west trends are rare. Whether or not the concentration of orogenic trends and intersections in this copper province is unique and favorable to copper precipitation had been debated for a long time.

---

[9] Everett, F. D., Sinking Methods and Costs at the Burgin Shaft, Bear Creek Mining Co., East Tintic Project, Utah County, Utah: Bureau of Mines Inf. Circ. 7879, 1959, 26 pp.

McWilliams, John R., Mining Methods and Costs at the Anaconda Company Berkeley Pit, Butte, Mont.: Bureau of Mines Inf. Circ. 7888, 1959, 46 pp.

Hardwick, W. R., Block-Caving Mining Methods and Costs, Bagdad Copper Corp., Yavapai County, Ariz.: Bureau of Mines Inf. Circ. 7890. 1959, 28 pp.

King, E. G., and Kelley, K. K., Low-Temperature Heat Capacities of Copper Ferrites (With a Summary of Entropies at 298.15° K. of Spinel Minerals): Bureau of Mines Rept. of Investigations 5502, 1959, 6 pp.

Rampacek, Carl, McKinney, W. A., and Waddleton, P. T., Treating Oxidized and Mixed Oxide-Sulfide Copper Ores by the Segregation Process: Bureau of Mines Rept. of Investigations 5501, 1959, 28 pp.

Hardwick, W. R., Open-Pit Copper Mining Methods, Morenci Branch, Phelps Dodge Corp., Greenlee County, Ariz.: Bureau of Mines Inf. Circ. 7911, 1959, 67 pp.

Hardwick, W. R., and Jones, E. L., III, Open-Pit Copper Mining Methods and Costs at the Bagdad Mine, Bagdad Copper Corp., Yavapai County, Ariz.: Bureau of Mines Inf. Circ. 7929, 1959, 30 pp.

[10] Harrison, J. E., and Wells, J. D., Geology and Ore Deposits of the Chicago Creek Area, Clear Creek County, Colo.: Geol. Survey Prof. Paper 319, 1959, 92 pp.

Wilmarth, V. R., Geology of the Garo Uranium-Vanadium-Copper Deposit, Park County, Colo.: Geol. Survey Bull. 1087–A, 1959, 21 pp.

[11] Darnley, H. G., Petrology of Some Rhodesian Copperbelt Orebodies and Associated Rocks: Bull. Inst. Min. and Met., vol. 61, No. 638, January 1960, pp. 137–173.

[12] Armstrong, D., The Geology of Bancroft Mine: Rhodesian Min. and Eng., vol. 24, No. 13, December 1959, pp. 37–42.

[13] Mayo, Evans B., Lineament Tectonics and Some Ore Districts of The Southwest: Min. Eng., vol. 10, No. 11, November 1958, pp. 1169–1175.

[14] Schmitt, Harrison A., The Copper Province of the Southwest: Min. Eng., vol. 11, No. 6, June 1959, pp. 597–600.

In the Portage Lake lava series of the Keweenaw Peninsula, Michigan, three overlapping amygdule mineral zones—prehnite, epidote, and quartz zones, respectively—can be distinguished.[15] Higher stratigraphic horizons typically lie within the prehnite zone and lower horizons within the epidote and quartz zones. Copper concentrations are commonly near the quartz zones, but may lie well within the quartz zone where quartz is not abundant.

The distribution of elements in sulfide orebodies suggests that copper, zinc, and lead are deposited simultaneously in relatively constant proportions rather than successively in a paragenetic sequence.[16] Zoning may be due to different ratios of metals being deposited under changing temperature, pressure, and chemical environment or may be the result of other processes.

Geco Mines, Ltd., carried out a master development pattern which permitted recovery of ore in both the A and B zones.[17] Vertical attitude, width, rake, and competent country rock suggested a system of blasthole stopes, undercut with scram drifts and connected by a transfer raise system to a crusher on the 1,250 foot level. A 42-inch conveyor on this level transferred the ore about 1,200 feet to a loading pocket at the No. 1 shaft.

Three ore bodies were mined by Gaspé Copper Mines Ltd. The A (open pit) and B (underground) orebodies, and the top half of the C (underground) ore body, are roughly superimposed.[18] The geology, mineralogy, and mining techniques for the B and C orebodies are described. Experimental stoping established that mining widths of 50 feet, with roof bolts on a 4 x 4 foot pattern, could be maintained.

The testing and use of ammonium nitrate for blasting different types of rock at Nevada Mines Division, Kennecott Copper Corp., was described.[19] The porphyries and rhyolites were easy to fragment, the limestones varied from easy to hard, and the jasperoid was extremely hard to fragment.

The low cost of Cananea Consolidated Copper Co's. new haulage level resulted from modification of original layout to take advantage of self-supporting rock as predicted by analysis of certain diamond drill core data.[20] Core-segment length and modulus of rupture appeared to be two criteria by which drill-core could be used to predict the ground support needed in a given mining area.

The Anaconda Co's. Berkeley Pit at Butte, Mont., was the subject of four articles on history and geology, mining plan and operations, crushing and conveying system, and servicing of mobile equipment.[21]

---

[15] Stoiber, Richard E., and Davidson, Edward S., Amygdule Mineral Zoning in the Portage Lake Lava Series, Michigan Copper District: Econ. Geol., vol. 54, No. 7, November 1959, pp. 1250–1277.

[16] Wilson, H. D. B., and Anderson, D. T., The Composition of Canadian Sulphide Ore Deposits: Canadian Min. and Met. Bull., vol. 52, No. 570, October 1959, pp. 619–631.

[17] Dayton, Stanley H., This Mine Was Designed to Eliminate Tramming—These Are The Results: Min. World, vol. 21, No. 7, June 1959, pp. 40–45.

[18] Brissenden, William G., Mining at Gaspé Copper: Min. Eng., vol. 11, No. 9, September 1959, pp. 899–903.

[19] Quilici, Frank, Ammonium Nitrate-Blasting Copper Ore In Nevada: Min. Cong. Jour., vol. 45, No. 5, May 1959, pp. 54, 56–57.

[20] Ruff, Arthur W., and Parkinson, Lute J., How Cananea Uses Drill-Core Data To Aid Ground Control Planning: Eng. Min. Jour., vol. 160, No. 9, September 1959, pp. 88–91.

[21] Mining Engineering, Anaconda's Berkeley Pit, A Four-part Report on Open Pit Mining Operations: Vol. 11, No. 3, March 1959, pp. 289–300D. Goddard, C. C., Jr., History and Geology: Min. Eng., vol. 11, No. 3, March 1959, pp. 290–292; Bonner, E. O., Mining Plan and Operations: Pp. 293–297; Ralph F., Crushing and Conveying System: Pp. 298–300A; Young, P. M., Servicing Mobile Equipment: Pp. 300B–300D.

Mining tough porphyry wall rocks of the Rio Tinto orebodies by open sublevel stopes resulted in coarse fragmentation.[22] The problems associated with the hoisting and handling of the broken ore were solved by a system incorporating large detachable containers with some original laborsaving devices giving automatic sequence control.

The trend in drilling equipment was toward increased mobility and larger units at western open-pit copper mines. Rubber-tired units were replacing crawlers in many applications to facilitate moving between job areas.[23]

Important elements of long range open-pit planning are: Types of ore, pit limits, grade cutoff, stripping ratio, and rate of production. These factors must be resolved to obtain the lowest unit operating cost.[24]

Increases in the size of open-pit haulage trucks meant not only reduced haulage costs but also made possible the use of larger shovels and higher benches, with a corresponding reduction in overall mining costs.[25]

The increased tonnage mined by The Anaconda Co. from the Kelley mine and the Berkeley pit in Butte, Mont., necessitated additional crushing, grinding, and flotation equipment at the concentrator in Anaconda, Mont.[26] In expanding capacity from 12,000 to 38,000 tons per day, various process-control devices were installed to increase efficiency and decrease costs.

Designing a tailing dam is a major step toward a fully integrated mill operation.[27] In the case of large concentrators considerable planning is necessary and the site of the tailing disposal area may dictate the location of the concentrator.

Interaction of sulfide minerals and native metals with reagents in flotation is largely determined by particle-surface changes resulting from action of the medium and dissolved gases.[28]

Bureau of Mines research showed that the segregation process, developed about 1923, had merit for treating oxidized and mixed oxide-sulfide copper ores commonly occurring in the Southwest.[29] This process was to be used commercially for the first time by Transarizona Resources, Inc., in concentrating ores from the Lake Shore group of claims.

Ray Mines Division of Kennecott Copper Corp. completed a modernization program at Hayden, Ariz., that included new leach-precipitation-flotation (LPF) facilities and a new smelter. Mill expansion

---

[22] Rich, Edward, Rock Hoisting and Handling in Detachable Containers as Developed at the Rio Tinto Mines, Spain: Bull. Inst. Min. and Met. (London), vol. 68, pt. II, No. 633, August 1959, pp. 493–518.

[23] Soderberg, Adolph, Western Practices In The Use of Rotary Air Drills: Skillings' Min. Review, vol. 48, No. 18, Aug. 1, 1959, pp. 1, 4–5, 29.

[24] Soderberg, Adolph, Elements of Long Range Open Pit Planning: Min. Cong. Jour., vol. 45, No. 4, April 1959, pp. 54–57, 62.

[25] Van de Water, J. C., Truck Haulage Improvements: Min. Cong. Jour., vol. 45, No. 9, September 1959, pp. 38, 40, 41.

[26] Moore, John R., Automation at the Anaconda Mill: Min. Cong. Jour., vol. 45, No. 11, November 1959, pp. 64–65, 71.

[27] Given, E. V., Designing for Tailing Disposal In The Southwest: Min. Eng., vol. 11, No. 7, July 1959, pp. 691–693.

[28] Plaksin, Igor, Interaction of Minerals With Gases and Reagents In Flotation: Min. Eng., vol. 11, No. 3, March 1959, pp. 319–324.

[29] Mining World, Segregation Process To Be Used at New Copper Project: Vol. 21, No. 13, December 1959, p. 19.

was planned to increase capacity from the present 15,500 tons per day to 22,500 tons per day.[30]

Plant experience showed that burned chrome-magnesite brick and burned magnesite brick give excellent service in copper converters.[31] A study confirmed that experience showing that, chemically and mineralogically, both are well suited for this service.

Eight papers on applying the fluidizing reactor to the mineral industry were presented at a University of Arizona symposium.[32] Three of the papers dealt with operating practice at copper properties in the Southwest.

The modern design features of Kennecott Copper Corp's. new smelter at Hayden, Ariz. were described.[33] One central building housed the reverberatory furnace, a powerhouse annex, three converters, two anode furnaces, one anode-casting wheel, a brick-storage area, an air-preheating installation, and various offices, lunch rooms, and storage areas for the reverberatory and converted departments. In addition there was space for a second reverberatory furnace and two more converters.

Direct smelting of copper ores and concentrates to blister copper in converters using oxygen-enriched air was accomplished by the Nippon Mining Co., Ltd., at the Hitachi mine smelter.[34] Sulfuric acid was made from the converter gases and the converter slag was treated by flotation and separated into a concentrate (copper) and a tailing which became a raw material for iron.

One of the investigations at the Central Laboratory of Bolidens Gruvaktiebolag in Sweden concerned copper electrolysis at high current densities.[35] Increasing the current density will decrease certain costs, increase others, and some will remain unchanged. Apparently, there is a definite current density for which the sum of these current-density-dependent costs have a minimum. Considerable evidence points to the fact that this value lies high above current densities used at present.

A copper billet and slab casting machine was developed for the continuous casting of copper in all its forms.[36] The basic design of this equipment lends itself to the casting of brasses, bronzes, aluminum and magnesium alloys.

---

[30] Mining World, Ray Mines Closes Ore to Metal Cycle: Vol. 21, No. 1, January 1959, pp. 44–46.

Mining World, Tailor Metallurgy to Ore at Hayden: Vol. 21, No. 7, June 1959, pp. 30–39.

Franz, M. W., Leach-Precipitation-Flotation Process: Jour. Metals, vol. 11, No. 6, June 1959, pp. 352–355.

Franz, H. W., Pyrite Treated in Kennecott Reactor: Min. World, vol. 21, No. 4, April 1959, pp. 30–33.

[31] Clark, C. Burton, and McDowell, J. Spotts, Basic Brick in Copper Converters: Jour. Metals, vol. 11, No. 2, February 1959, pp. 119–124.

[32] Mining Engineering, University Session on Fluidizing Reactors: Vol. 11, No. 4, April 1959, pp. 414–420.

[33] Johnson, R. K., The New Hayden Smelter: Jour. Metals, vol. 11, No. 6, June 1959, pp. 376–381.

[34] Tsurumoto, Tamon, Investigation of Copper Smelting by Converter Using Oxygen-Enriched Air: Jour. Met. Inst. of Japan, vol. 75, No. 858, December 1959, pp. 27–34.

Tsurumoto, Tamon, Smelting of Copper Ores and Concentrates by Converter using Oxygen-Enriched Air at Hitachi Mine: Jour. Min. Met. Inst. of Japan, vol. 76, No. 861, March 1960, pp. 35–51.

[35] Wallden, S. J., Hendricksson, S. T., Arbstedt, P. G., and Miöen, Th., Electrolytic Copper Refining at High Current Densities: Jour. Metals, vol. 11, No. 8, August 1959, pp. 528–534.

[36] Metal Industry (London), Continuous Casting Copper Billets: Vol. 95, No. 15, Nov. 20, 1959, pp. 321–323.

Diatomite

By L. M. Otis[1] and James M. Foley[2]

◆

PRODUCTION of diatomite in the United States resumed an upward trend in 1959 after declining in 1958 for the first year since 1952.

DOMESTIC PRODUCTION

California continued as the leading diatomite-producing State, having held this position since 1910. Nevada was second, followed by Oregon and Washington.

The average production in 1957–59 was 22 percent higher than in 1954–56. The number of producing plants in 1959 was 13, operated by 10 companies, compared with 11 plants, operated by 9 companies, in 1958.

TABLE 1.—Diatomite sold or used in the United States by producers, 3-year totals

	1942–44	1945–47	1948–50	1951–53	1954–56	1957–59
Domestic production (sales)__short tons__	524, 872	640, 764	722, 670	908, 448	1, 105, 279	1, 349, 340
Average value per ton____________________	$18. 85	$20. 17	$25. 55	$29. 97	$39. 21	$45. 73

Exploration was reported in western Kern County, Calif., and Elko County, Nev.

CONSUMPTION AND USES

There was little change in uses of diatomite. It remained by far the most widely used filter medium, although there was increasing competition from expanded perlite. Filtering consumed more diatomite than any other use.

As a filler or extender, the second largest market, diatomite was in demand for many products, including paper, paint, varnish, brick, tile, ceramics, oilcloth, linoleum, plastics, soap, detergents, welding-rod coatings, belt dressing, crayons, and phonograph records.

The third most important use was as insulation against sound or temperature changes. Such applications included acoustical plaster, cast panels for sound deadening in walls, floors, and ceilings; and

---

[1] Commodity specialist.
[2] Supervisory statistical assistant.

insulation for ovens, kilns, safes, refrigerators, driers, evaporators, cold-storage houses, pipes, flues, furnaces, retorts, stacks, stills, stoves, and tanks.

Miscellaneous uses included abrasives, absorbents, carriers for catalysts, herbicides, pesticides, fungicides, glazes, enamels, flatting agents for paints, and manufacturing sodium and calcium silicates.

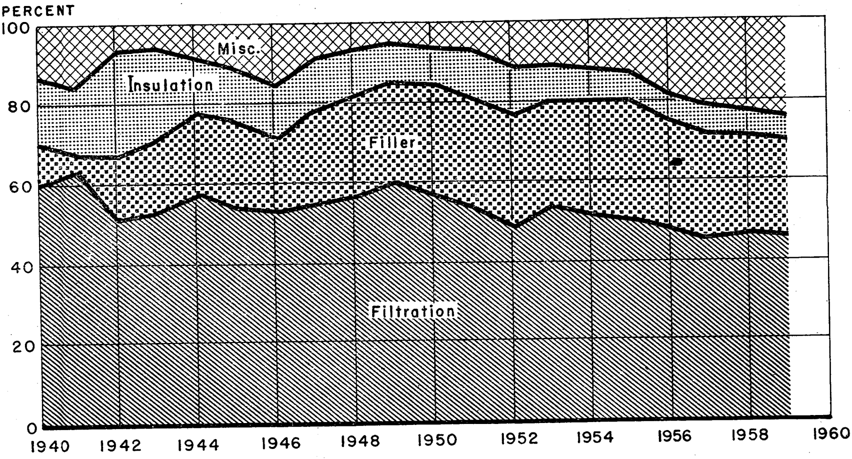

FIGURE 1.—Relative quantity of diatomite consumed in the United States for each principal class of use, 1940–59.

PRICES

Prices advanced in 1959. They varied according to purity; particle-size range; color; whether uncalcined, calcined, or calcined with fluxes; whether delivered in bulk or bagged; and type of bag used.

The average increase in price of diatomite in 1959 was 3 percent over 1958.

TABLE 2.—Average annual value of diatomite per ton, by uses

Use	1958	1959	Use	1958	1959
Filtration	$56.91	$57.59	Fillers	$45.23	$49.39
Insulation	41.43	41.08	Miscellaneous	26.18	28.11
Abrasives	137.00	137.31	Weighted average	46.18	47.59

FOREIGN TRADE

Processed diatomite, principally of filter quality, continued to enjoy a substantial market abroad.

WORLD REVIEW

Algeria.—Diatomite production increased substantially in 1958 but was still far below the output of 39,000 tons in 1954 before political conditions caused curtailment. Principal Algerian markets were France, Great Britain, the Netherlands, and Belgium.

Canada.—An estimated 27 tons of diatomite was produced in British Columbia in 1958. It was dried, ground, and screened in Vancouver and sold locally for fillers, concrete admixture, and insulating brick. Imports in 1958 increased 12 percent over 1957 to 27,258 short tons; all came from the United States except 33 tons from Denmark. Consumption for 1956, in short tons, was estimated as follows: Coating fertilizer, 8,650; filtration, 8,000; fillers, 3,000; insulation, 175; and miscellaneous, 100. Prices, f.o.b. Toronto and Montreal, in 1958, bagged and in carlots, ranged from Can $56 to Can $160 a ton.[3]

Nicaragua.—The Geological Service of the Ministry of Economy reported discovery of a deposit of diatomite during the last quarter of 1958 in the Jinotega area. Reserves were estimated at 10 million cubic meters. Exploitation concessions were granted by the Department of Natural Resources, Ministry of Economy, but no production was reported in 1959.

United Kingdom.—The Inverness County Council made efforts to have production resumed at the diatomite deposits in Skye, Scotland.[4] A new processing plant with improved techniques was planned.

TECHNOLOGY

A new vacuum filter for clarifying water claims a filter rate of 2 g.p.m. per square foot of diatomite filter cake.[5]

A reversible flow filter with a diatomite filter cake on both sides of the filter membrane for purifying water was described.[6]

The use of ceramic "sponges," composed largely of diatomite for disposal of radioactive wastes, was outlined.[7]

The role played by diatomite in uranium extraction was covered in an article.[8]

Advantages of using diatomite in cementing casings in oil and gas wells were discussed in a trade journal.[9]

Filtration rates of different varieties of diatomite were outlined in a German publication.[10]

---

[3] Ross, J. S., Diatomite (Canada), 1958: Dept. Mines and Tech. Surveys, Ottawa, Canada, Rev. 34, October 1959, 3 pp.

[4] Chemical Age (London), Move to Restart Work at Skye Diatomite Deposit: Vol. 82, No. 2110, Dec. 19, 1959, p. 898; No. 2096, Sept. 12, 1959, p. 302.

[5] Chemical Engineering, Diatomaceous Filter Cleans Large Volumes of Water: Vol. 66, No. 19, Sept. 21, 1959, p. 201.

[6] Brown, J. G., Reversible Diatomite Filtration: Jour. Appl. Chem. (London), vol. 9, May 1959, p. i 440.

[7] Chemical Age (London), U.S. Study on Radioactive Wastes Disposal Using Ceramic Sponges: Vol. 81, No. 2077, May 2, 1959, p. 741.

[8] Chemical Trade Journal and Chemical Engineer (London), Uranium Extraction: Vol. 144, No. 3738, Jan. 23, 1959, pp. 175–176.

[9] Willis, A. J., and Wynne, R. A., Diatomaceous Earth Cures Lost Circulation in Cementing Casing; Oil Gas Jour., vol. 57, No. 32, Aug. 3, 1959, pp. 78–84.

[10] Krämer, W., Brauwissenschaft, No. 11, 1958, p. 34; abstracted in Journal Appl. Chem. (London), vol. 8, No. 7, 1958, pp. ii–45.

TABLE 3.—World production of diatomite, by countries,[1] in short tons [2]

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country [1]	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada	55	16	2	120	27	-------
Costa Rica	456	3,000	6,737	[3] 1,800	2,205	[3] 2,200
Guatemala	[3] 11,700	[3] 16,500	[3] 16,600	20,600	21,190	-------
United States	303,600	[4] 368,426	[4] 368,426	[5] 449,780	[5] 449,780	[5] 449,780
South America:						
Argentina	2,586	6,988	2,682	4,084	4,457	[3] 4,400
Chile	49	551	-------	-------	-------	-------
Peru	[6] 1	1	34	39	117	254
Europe:						
Austria	3,836	4,445	5,490	3,823	4,086	4,497
Denmark:						
Diatomite	[7] 22,238	39,103	31,331	33,859	[3] 33,000	[3] 33,000
Moler [8]	[3] 47,400	39,442	40,080	41,074	[3] 165,000	[3] 165,000
Finland	1,440	2,059	2,535	1,874	2,315	[3] 2,200
France [9]	66,236	70,025	69,546	86,240	111,884	[3] 110,000
Germany, West [9]	49,310	62,575	67,416	71,918	115,319	[3] 112,000
Iceland	-------	-------	-------	-------	882	[3] 880
Italy	11,226	10,635	9,651	29,707	49,828	[3] 50,000
Portugal [9]	1,355	2,499	1,985	1,613	1,159	[3] 1,100
Spain [9]	8,447	15,927	13,048	13,856	12,858	[3] 13,000
Sweden	1,649	1,625	1,243	1,317	1,067	[3] 1,100
United Kingdom:						
Great Britain	11,656	24,656	19,361	18,706	[3] 11,000	[3] 11,000
Northern Ireland	7,909	7,293	6,577	6,842	7,206	[3] 7,700
Yugoslavia	[10] 3,530	4,490	[3] 4,400	[3] 4,400	[3] 4,400	[3] 5,000
Asia: Korea, Republic of	349	3,393	3,912	1,472	518	[3] 2,000
Africa:						
Algeria	25,412	30,384	26,360	10,360	29,762	24,222
Egypt	1,102	220	320	708	285	[3] 300
Kenya	4,560	3,304	5,418	4,737	3,892	4,111
Mozambique	[10] 19	-------	-------	-------	61	[3] 60
Rhodesia and Nyasaland, Fed. of:						
Southern Rhodesia [9]	-------	-------	-------	-------	-------	148
Union of South Africa	586	850	635	606	359	397
Oceania:						
Australia	6,988	5,647	6,484	6,968	4,749	[3] 5,500
New Zealand	160	623	152	3,537	6,336	[3] 6,600
World total (estimate) [1] [2]	640,000	765,000	760,000	860,000	1,090,000	1,060,000

[1] Diatomaceous earth is believed to be also produced in Brazil, Hungary, Japan, Rumania, and U.S.S.R. but complete data not available; estimates by senior author of chapter included in total.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding, where estimated figures are included in the detail.

[3] Estimate.

[4] Average annual production 1954–56.

[5] Average annual production 1957–59.

[6] Average 1953–54.

[7] Average annual production 1947–55.

[8] A clay-contaminated diatomite used principally for lightweight building brick.

[9] Includes tripoli.

[10] Average 1952–54.

Diatomite may be used with ground marble and silica sand for various applications, including plaster, stucco, brick mortar, and caulking material.[11]

A patent was issued for a granulated fertilizer made by mixing diatomite or calcined gypsum with dry urea and ground limestone.[12]

A patented stabilizer soil composition is composed of 5 to 25 percent diatomite, fly ash or pumicite, 35 to 75 percent plastic soil, 20 to 50 percent aggregate, and 2 to 9 percent brine.[13]

---

[11] Newell, W. J., and Lewis, T. W. (assigned to Waterproofing Materials, Inc., Fort Worth, Tex.), Cementitious Structural Material: U.S. Patent 2,901,368, Aug. 25, 1959.

[12] Parmella, R., and Owen, B.D.R., British Patent 822, 939, Nov. 4, 1959.

[13] Havelin, J. E., and Kahn, F. (assigned to G. & W. H. Corson, Inc.), Canadian Patent 585, 628, Oct. 20, 1959.

A road stabilizing compound was patented which comprises lime, soil, water, and a pozzolan such as calcined diatomite, pumicite, or fly ash.[14]

A patent was issued for using diatomite in a rubber-like cashew nut oil-phenol formaldehyde resin composition for such items as silent gears, tumbling barrels, and caster wheels.[15]

A method of making a colloidal bulking agent for use as a paper filler was patented. Diatomite is suspended in water with ground dolomite and sodium sulfide and the mixture heated in an autoclave.[16]

An apparatus was patented for making low-density-temperature insulating block from a mixture of calcium hydroxide, asbestos fiber, and diatomite or other siliceous material.[17]

A method was patented for accelerating the lime-silica reaction in a mixture of diatomite, lime hydrate, and asbestos fiber.[18]

A method of decolorizing diatomite containing iron oxides was patented. A water suspension of the material is treated with a mixture of H_2SO_4, NaHS, and $NaHSO_4$, after which zinc dust is added and the diatomite dried.[19]

A patented method for improving the porosity of diatomite calls for mixing it with charcoal, pitch coke, and H_3BO_3, As_2O_5, or As_2O_3, then baking it at 900° C. to 1,200° C.[20]

A patented process for making insulating refractories covers a mixture of expanded perlite, diatomite, bentonite, $CaCl_2$ and water glass, which are kneaded, molded, dried, heated, cooled rapidly to 600° C., then cooled slowly to room temperature.[21]

Improving the pozzolanic properties of diatomite or bentonite is outlined in a patent which covers drying at 300° C. or heating for 15 to 30 minutes at 700° C., then adding 10 to 80 percent kaolin.[22]

A method was patented for manufacturing rigid thermal insulation products comprising lime and diatomite mixed in water, ground to 150-mesh, and added to asbestos and exfoliated vermiculite or expanded perlite. Bentonite may be added to the mixing water as a dispersant and the final moulded product autoclaved.[23]

A method was patented for making fireproof acoustic tile, using diatomite, sawdust, and an aqueous dispersion of a glazing frit. After forming, the tile is fired at 1,700° to 2,200° F.[24]

---

[14] Havelin, J. E., and Kahn, F. (assigned to G. & W. H. Corson, Inc.), Canadian Patent 584, 502, Oct. 6, 1959.

[15] Newman, F. E. (assigned to Dominion Rubber Co.), Canadian Patent 583, 541, Sept. 22, 1959.

[16] Takahashi, K., Japanese Patent 2206, Apr. 9, 1959.

[17] Muehleck, E., Kinney, H. C., and Lanz, R. L., Jr. (assigned to Keasbey and Mattison Co., Ambler, Pa.), Apparatus for Molding Articles from Materials in Slurry Form: U.S. Patent 2,901,808, Sept. 1, 1959.

[18] Hoops, H. P., Weber, H. L., and Neal, J. R., Jr. (assigned to Fiberboard Paper Products, Corp., San Francisco, Calif.), Method of Calcareous-Siliceous Insulating Material: U.S. Patent 2,904,444, Sept. 15, 1959.

[19] Nishimura, Y. (assigned to Oita Prefecture), Japanese Patent 4414, June 5, 1958.

[20] Nishimura, Y. (assigned to Oita Prefecture), Japanese Patent 4413, June 5, 1958.

[21] Hamano, T. (assigned to Bureau of Industrial Technics), Japanese Patent 9875, Nov. 26, 1957.

[22] Ferrari, F., Italian Patent 525,990, May 12, 1955.

[23] Smith, E. C. W., and Blakeley, J. D. (assigned to Colchester Mineral Products, Ltd), Canadian Patent 572,338, Mar. 17, 1959.

[24] Heine, H. W., Manufacture of Acoustic Fireproofing Tiles: U.S. Patent 2,877,532, Mar. 17, 1959.

A number of other patents mentioned diatomite as a suitable material in processes or products in the fields of building plaster, silicates, road surfacing, foundry cores, oil-well cementing, retorting diatomaceous shale, plasterboard, and dentistry.[25]

---

[25] Apparatus for Cooling Finely Divided Material: U.S. Patent 2,913,237. Plaster Composition: U.S. Patent 2,905,566. Process for Producing Finely-divided Silica: U.S. Patent 2,886,414. Road Surfacing Composition and a Process for Preparing Same: U.S. Patent 2,877,127. Hydrous Calcium Silicates: U.S. Patent 2,875,075. Method of Making Foundry Core Drier Supports: U.S. Patent 2,873,480. Cement Composition and Process of Cementing Wells: U.S. Patent 2,880,096. Shale Retorting Process: U.S. Patent 2,881,117. Pozzolan Plaster Board: U.S. Patent 2,882,175. Dental Impression Material: U.S. Patent 2,878,129.

Feldspar, Nepheline Syenite, and Aplite

By Taber de Polo[1] and Gertrude E. Tucker[2]

⁂

FELDSPAR

INCREASED demand from the glass, pottery, and enamel industries resulted in the largest domestic production of crude feldspar and flotation concentrate since 1956. Exploitation of new deposits and processing of previously wasted material, coupled with the construction of additional mills by old and new companies, resulted in increased productive capacity and an additional drop in the price of Glass-grade feldspar from $9.80 to $9 per short ton, f.o.b. producers' plants in North Carolina. The marketing of feldspar-silica mixtures continued to be a factor in total production.

TABLE 1.—Salient feldspar statistics

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Crude feldspar:						
Domestic sales: [1]						
Long tons	491, 110	550, 861	560, 074	498, 057	469, 738	548, 390
Value, thousands	$3, 913	$4, 528	$5, 829	$4, 935	$4, 278	$5, 213
Average per long ton	$7. 97	$8. 22	$10. 41	$9. 91	$9. 11	$9. 51
Imports:						
Long tons	8, 210	105	258	72	73	45
Value, thousands	$69	$9	$9	$7	$5	$5
Average per long ton	$8. 46	$89. 01	$36. 09	$92. 03	$63. 82	$100. 49
Ground feldspar:						
Sales by merchant mills: [2]						
Short tons	537, 124	596, 158	608, 661	503, 170	469, 602	560, 105
Value, thousands	$7, 268	$8, 584	$8, 957	$7, 062	$6, 540	$7, 542
Average per short ton	$13. 53	$14. 40	$14. 72	$14. 04	$13. 93	$13. 47
Apparent domestic consumption: Long tons	499, 320	550, 966	560, 332	498, 129	469, 811	548, 435
World: Production: Long tons	860, 000	1, 050, 000	1, 100, 000	1, 070, 000	1, 050, 000	1, 150, 000

[1] See table 2 for distribution of feldspar by derivation.
[2] See table 4 for distribution of feldspar by derivation.

DOMESTIC PRODUCTION

Crude Feldspar.—Production of crude feldspar increased 17 percent. More than 50 percent of the output came from North Carolina, and California ranked second in production. The quantity of feldspar

---

[1] Commodity specialist.
[2] Statistical assistant.

produced by flotation in Georgia and North Carolina continued to increase and constituted almost 85 percent of the feldspar production from the two States.

Crude feldspar figures include hand-cobbed feldspar, flotation concentrate, and the feldspar content of feldspar-silica mixtures.

The feldspar mine and plants of Whitehall Co., Inc., suppliers of feldspar to Bon Ami Co., were sold.

International Minerals & Chemical Corp. began shipping feldspar from its new dry-process grinding mill at Custer, S. Dak., recently completed to replace one destroyed by fire in July 1958.

The Feldspar Corp. began constructing a feldspar flotation plant in Middletown, Conn. The new mill, expected to be in operation in 1960, will process both Glass- and Pottery-grade feldspars. Mica and silica will be sold as byproducts.

Golding-Keene Co. discontinued hand cobbing and began concentrating feldspar by an electrostatic process at its Keene, N.H., plant. The company produced high-potash feldspar and byproduct Sandspar, a mixture of quartz and feldspar.

Paco Products Corp. constructed a flotation plant at Pacolet, S.C., to treat the screenings from a granite quarry and produce feldspar, ground silica, and Paco Sand, a silica-feldspar mixture.

TABLE 2.—Crude feldspar sold or used by producers in the United States

Year	Derivation of feldspar [1]							
	Hand-sorted		Flotation concentrate		Feldspar-silica mixtures [2]		Total	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)
1950–54 (average)	(3)	(3)	418,563	$3,431	[4] 72,547	[4] $482	491,110	$3,913
1955	246,667	$1,836	218,711	1,965	85,483	727	550,861	4,528
1956	234,993	1,729	250,307	3,441	74,774	659	560,074	5,829
1957	227,826	1,958	208,984	2,449	61,247	528	498,057	4,935
1958	198,460	1,346	218,178	2,450	53,100	482	469,738	4,278
1959	169,473	1,508	293,356	3,072	85,561	633	548,390	5,213

[1] Partly estimated, 1952–59.
[2] Includes feldspar content only.
[3] Included with flotation concentrate.
[4] Average for 1952–54.

Ground Feldspar.—Ground feldspar sold by merchant mills in the United States increased 19 percent in quantity and 15 percent in value. Ground feldspar was produced in 26 mills in 14 States. North Carolina, California, Georgia, South Dakota, and Colorado were the leading producers in that order, and South Carolina reported production for the first time. Five Southeastern States (Georgia, North Carolina, South Carolina, Tennessee, and Virginia) produced almost 65 percent of the ground feldspar. Ground feldspar figures include flotation concentrate and the feldspar content of feldspar-silica mixtures. Tabular data show the origin of the feldspar (hand-cobbed, flotation concentration, and feldspathic sands and rocks).

TABLE 3.—Ground feldspar sold by merchant mills [1] in the United States

Year	Active mills	Domestic feldspar		Canadian feldspar		Total	
		Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1950–54 (average)	24	527, 017	$7, 025	10, 107	$243	537, 124	$7, 268
1955	24	596, 158	8, 584			596, 158	8, 584
1956	25	608, 661	8, 957			608, 661	8, 957
1957	23	503, 170	7, 062			503, 170	7, 062
1958	24	469, 602	6, 540	(2)	(2)	469, 602	6, 540
1959	26	560, 105	7, 542	(2)	(2)	560, 105	7, 542

[1] Excludes potters and others who grind for consumption in their own plants.
[2] Included with domestic feldspar.

CONSUMPTION AND USES

Crude Feldspar.—Virtually all crude feldspar was either ground by the producing company or sold to merchant grinders. Some pottery, enamel, and soap manufacturers purchased crude feldspar for all or part of their requirements and ground it to company specifications in their own mills.

TABLE 4.—Ground feldspar sold by merchant mills in the United States, in short tons, by derivation [1] and uses

Year	Hand-sorted					Flotation concentrate				
	Glass	Pottery	Enamel	Other	Total	Glass	Pottery	Enamel	Other	Total
1950–54 (average)	(2)	(2)	(2)	(2)	(2)	233, 438	191, 340	21, 819	9, 274	455, 871
1955	61, 554	146, 960	25, 919	24, 729	259, 162	143, 203	77, 202		20, 850	241, 255
1956	65, 357	136, 144	24, 732	23, 356	249, 589	183, 267	62, 451		29, 607	275, 325
1957	54, 283	109, 910	26, 052	16, 742	206, 987	166, 933	58, 131		6, 170	231, 234
1958	48, 376	93, 805	21, 734	13, 519	177, 434	171, 002	53, 205		8, 489	232, 696
1959	40, 365	88, 233	36, 929	24, 662	190, 189	219, 139	72, 496		10, 558	302, 193

Year	Feldspar-silica mixtures					Grand total				
	Glass	Pottery	Enamel	Other	Total	Glass	Pottery	Enamel	Other [4]	Total
1950–54 (average) [3]	80, 272	981			81, 253	313, 710	192, 321	21, 819	9, 274	537, 124
1955	88, 583	1, 004		6, 154	95, 741	293, 340	225, 166	25, 919	51, 733	596, 158
1956	74, 900			8, 847	83, 747	323, 524	198, 595	24, 732	61, 810	608, 661
1957	58, 643			6, 306	64, 949	279, 859	168, 041	26, 052	29, 218	503, 170
1958	49, 003	4, 767		5, 702	59, 472	268, 381	151, 777	21, 734	27, 710	469, 602
1959	55, 809	5, 323		6, 591	67, 723	315, 313	166, 052	36, 929	41, 811	560, 105

[1] Partly estimated, 1952–59.
[2] Included with flotation concentrate.
[3] Includes data for 1952–54 only, for feldspar content of feldspathic sands.
[4] Includes other ceramic uses, soaps, and abrasives.

Ground Feldspar.—Most feldspar consumers bought material already ground, sized, and ready for use in their manufactured products. The glass, pottery, and enamel industries consumed 93 percent of the ground feldspar sold by merchant mills.

TABLE 5.—Ground feldspar shipped, by States of destination, from merchant mills in the United States, in short tons

Destination	1955	1956	1957	1958	1959
California	128, 366	120, 941	75, 012	77, 407	87, 332
Illinois	37, 305	73, 067	56, 853	48, 385	57, 952
Indiana	(1)	(1)	(1)	16, 353	34, 212
Maryland	15, 016	18, 835	15, 930	14, 000	17, 572
Massachusetts	5, 539	5, 647	4, 746	3, 738	4, 229
New Jersey	38, 125	41, 144	29, 358	24, 306	28, 577
New York	22, 242	23, 169	21, 849	20, 883	16, 463
Ohio	102, 273	79, 757	61, 834	56, 367	71, 293
Pennsylvania	62, 072	69, 506	64, 302	60, 322	56, 332
Tennessee	(1)	(1)	(1)	(1)	12, 644
West Virginia	36, 677	(1)	44, 893	(1)	51, 965
Wisconsin	10, 674	10, 813	9, 822	8, 664	10, 823
Other destinations[2]	137, 869	165, 782	118, 571	139, 177	110, 711
Total	596, 158	608, 661	503, 170	469, 602	560. 105

[1] Included with "Other destinations."

[2] Includes Arkansas, Colorado, Connecticut (1956 and 1958–59), Kansas (1958), Kentucky, Louisiana, Maine (1957–59), Michigan, Minnesota, Mississippi, Missouri, New Hampshire (1956), New Mexico (1955), North Dakota (1956), Oklahoma, Rhode Island, Texas, Washington (1955–57 and 1959), shipments that cannot be separated by States, and shipments to States indicated by footnote 1. Also includes exports to Canada, Cuba (1959), England, Mexico, Panama (1957–59), Puerto Rico, Venezuela (1955–57 and 1959), West Germany (1957–58), and small quantities to unspecified countries.

TABLE 6.—Crude feldspar sold or used by producers in the United States, imports, and apparent domestic consumption

Year	Production		Imports		Apparent domestic consumption	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)
1950–54 (average)	491, 110	$3, 913	8, 210	$69	499, 320	$3, 982
1955	550, 861	4, 528	105	9	550, 966	4, 537
1956	560, 074	5, 829	258	9	560, 332	5, 838
1957	498, 057	4, 935	72	7	498, 129	4, 942
1958	469, 738	4, 278	73	5	469, 811	4, 283
1959	548, 390	5, 213	45	5	548, 435	5, 218

PRICES

Prices of crude feldspar do not appear in the trade publications. The average value, computed from producers' reports to the Bureau of Mines, was $9.51 per long ton, compared with $9.11 in 1958.

The average selling price of ground feldspar was $13.47 per short ton, a decrease of 3 percent from 1958.

The following producing States had the highest selling price per short ton: Illinois, $25; New Jersey, $23.13; Connecticut, $21.19; Arizona, $20.75; Tennessee, $20.56; and Maine, $19.88.

The highest average value by uses, $24.15 per short ton, was reported for soaps and abrasives. Of the larger uses, enamel had the more highest average value, $19.64.

Quotations on ground feldspar in E&MJ Metal and Mineral Markets for December 1959 were as follows: North Carolina, bulk carlots, 200-mesh, $20.50–$21; 325-mesh, $20.50–$23.50; 40-mesh, Glass grade, $13.50; and 20-mesh semigranular, $9.

FOREIGN TRADE [3]

According to reports from grinders, ground-feldspar exports increased 95 percent. The major destinations were Canada, Cuba, England, Mexico, Panama, Puerto Rico, and Venezuela.

Cornwall Stone.—Imports for consumption of ground cornwall stone (from England) decreased from 40 long tons in 1958 to 35 in 1959.

TABLE 7.—Feldspar imported (all from Canada) for consumption in the United States

[Bureau of the Census]

Year	Crude		Ground		Year	Crude		Ground	
	Long tons	Value	Long tons	Value		Long tons	Value	Long tons	Value
1950–54 (average)	8,210	$69,515	199	$5,043	1957	72	$6,626	3,969	$66,548
1955	105	9,346	1,254	31,737	1958	73	4,659	6,584	100,564
1956	258	9,311	1,374	33,589	1959	45	4,522	5,160	81,849

WORLD REVIEW

Estimated free world production increased 10 percent, and the United States furnished 48 percent of the output. Distribution of production by countries remained virtually the same.

---

[3] Figures on imports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 8.—World production of feldspar by countries,[1] in long tons [2]

[Compiled by Liela S. Price and Berenice B. Mitchell]

Country [1]	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada (shipments)	23,911	16,207	16,208	18,259	18,203	15,859
United States (sold or used)	491,109	550,861	560,074	498,057	469,738	548,390
Total	515,020	567,068	576,282	516,316	487,941	564,249
South America:						
Argentina	9,032	4,501	7,999	4,271	3,621	[3] 3,900
Brazil	[3] 12,400	(4)	(4)	(4)	(4)	(4)
Chile	1,200	821	826	369	[3] 400	[3] 400
Colombia	----------	----------	----------	----------	3,937	[3] 9,800
Peru	26	----------	----------	----------	----------	----------
Uruguay	744	381	----------	168	267	352
Total [3]	23,400	18,000	22,000	18,000	21,000	27,000
Europe:						
Austria	2,708	2,510	2,677	2,612	2,613	3,445
Finland	9,364	12,529	8,799	9,055	13,188	8,191
France	57,970	71,847	75,966	65,224	81,104	[3] 83,700
Germany, West	98,449	163,599	164,166	188,269	187,504	186,011
Italy	24,102	52,097	50,479	63,969	55,198	60,443
Norway	25,791	39,434	52,437	55,423	64,800	[3] 64,000
Portugal	242	592	912	1,161	544	[3] 590
Spain	9,568	5,041	3,524	4,472	5,199	[3] 4,900
Sweden	41,890	50,639	52,500	52,968	43,709	[3] 44,000
Yugoslavia	----------	----------	5,476	9,608	12,466	19,309
Total [1] [3]	275,000	405,000	420,000	460,000	470,000	480,000
Asia:						
Hong Kong	----------	120	60	1,156	1,653	1,716
India	3,507	5,230	3,263	7,872	8,432	9,740
Japan [5]	24,242	30,587	48,665	43,417	44,507	[3] 44.000
Philippines	----------	----------	----------	49	74	1,684
Viet-Nam, South	[6] 1,663	1,880	[3] 2,000	[3] 2,000	[3] 2,000	[3] 2,000
Total	29,412	37,817	53,988	54,494	56,666	[3] 59,000
Africa:						
Eritrea	2	12	12	394	413	[3] 400
Kenya	----------	----------	----------	120	26	----------
Madagascar	5	----------	203	----------	----------	----------
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	919	----------	----------	----------	447	----------
Union of South Africa	5,113	4,621	9,730	11,381	7,708	10,447
Total	6,039	4,633	9,945	11,895	8,594	10,847
Oceania: Australia [7]	12,953	20,833	18,629	8,820	7,016	[3] 5,700
World total (estimate) [1] [2]	860,000	1,050,000	1,100,000	1,070,000	1,050,000	1,150,000

[1] Feldspar is produced in China, Czechoslovakia, Rumania, and U.S.S.R., but data are not available; no estimates included in total except for Czechoslovakia.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Estimate.

[4] Data not available: estimate by senior author of chapter included in total.

[5] In addition, the following tonnages of aplite and other feldspathic rock were produced: 1950–54 (average), 64,059; 1955, 66,291; 1956, 63,723; 1957, 82,670; 1958, 76,856; 1959, 91,559.

[6] Average for 1 year only, as 1954 was first year of commercial production.

[7] Includes some china stone.

TECHNOLOGY

The geology of a nepheline syenite and feldspar deposit in India was described.[4]

---

[4] Bagchi, T. C., and Chatterjee, A. [The Occurrence and Origin of Nepheline and Feldspar Metacrysts in Limestone, Along the Contact of Nepheline Syenite]: Geol. Min. Met. Soc. (India), vol. 30, 1958, pp. 73–76; Chem. Abs., vol. 53, No. 3, Feb. 10, 1959, col. 2015.

The theory was advanced that the whiteness of some china clays is attributed to the peculiar crystal structure of feldspar which iron compounds cannot penetrate easily.[5]

Articles on the genesis and mineralogy of feldspar were published.[6]

Optical, X-ray, and flame photometer studies were conducted on feldspars.[7]

A rapid graphical method for determining the quartz content of feldspar was presented.[8]

Work was done on the dielectric properties of feldspar.[9]

The relationship of the structure of plagioclase feldspar to optical properties was studied.[10]

Data were presented to show that the quantity of trace lead in potash feldspars can be correlated with the lead ore deposits associated with igneous rocks.[11]

It was shown that fine grinding of quartz sand and feldspar reduced the absorption in semiporcelain bodies 50 percent and increased the mechanical strength 25 to 40 percent.[12]

Studies were made on properties of fired bodies containing feldspar.[13]

Some patents issued during the year dealt with processes for concentrating feldspar ores,[14] a method and apparatus for producing a finely divided mineral concentrate by wet grinding,[15] a method of removing iron-bearing minerals from feldspar,[16] and an apparatus reported to be especially adapted to cleaning and sorting feldspar.[17]

---

[5] Cardew, Michael, Genesis of China Clay: Pottery Quarterly, vol. 16, No. 4, 1957, pp. 147–152; Ceram. Abs., vol. 42, No. 1, January 1959, p. 28i.

[6] Smith, J. V., and MacKenzie, W. S., The Alkali Feldspars: V. The Nature of Orthoclase and Microcline Perthites and Observations Concerning the Polymorphism of Potassium Feldspars: Am. Mineral., vol. 44, No. 11–12, November–December 1959, pp. 1169–1186; Emeleus, C. H., The Alkali Feldspars: VI. Sanidine and Orthoclase Perthites From the Slieve Gullion Area, Northern Ireland: pp. 1187–1209.

Shimazer, Mitsuo [Potassium Feldspar in Some Metamorphic Rock]: Ganseki Kobutsu Kosho Gakkaishi, vol. 43, 1959, pp. 185–193; Chem. Abs., vol. 53, No. 20, Oct. 25, 1959, col. 18767i.

[7] Hewlett, C. G., Optical Properties of Potassic Feldspars: Bull. Geol. Soc. Am., vol. 70, 1959, pp. 511–538; Chem. Abs., vol. 53, No. 19, Oct. 10, 1959, col. 17778i.

Kern, R., and Gendt, R. [Regular Intergrowths of Potassic Feldspar and Plagioclases]: Bull. Soc. Franc. Miner. et Crist, vol. 81, 1958, pp. 263–266.

Emerson, Donaldo, Correlation Between X-ray Emission and Flame Photometer Determination of K_2O Content of Potash Feldspars: Am. Mineral., vol. 44, No. 5–6, May–June 1959, pp. 661–663.

[8] Kupfer, S. M. [Rational Method of Determining the Quartz Content in Ceramic Feldspar Raw Materials]: Steklo i Keramika (U.S.S.R.), No. 4, 1959, pp. 35–36.

[9] Ioffe, V. A., and Khvostenko, G. I. [The Anomalous Dispersion of the Dielectric Constant in Feldspars]: Doklady Akad. Nauk S.S.S.R. (U.S.S.R.), vol. 118, No. 4, 1958, pp. 709–711.

[10] Marfunin, A. S. [A New Diagram of the Optical Orientation of Acid and Medium Plagioclase]: Doklady Akad. Nauk S.S.S.R. (U.S.S.R.), vol. 118, No. 6, 1958, pp. 1183–1186.

[11] Slawson, W. F., and Nackowski, M. P., Trace Lead in Potash Feldspars Associated With Ore Deposits: Econ. Geol., vol. 54, No. 8, December 1959, pp. 1543–1555.

[12] Smirnova, K. A. [Influence of Finely Ground Quartz Sand and Feldspar Upon the Properties of Semiporcelain]: Steklo i Keram., vol. 15, No. 9, 1958, pp. 31–35; Ceram. Abs., vol. 42, No. 1, January 1959, p. 16c.

[13] Shiraki, Yoichi, and Matsumato, Tetsuo [Fired Properties of Sericite-Feldspar System]: Yogyo Kyokai Shi, vol. 67, 1959, pp. 75–79; Ceram. Abs., vol. 42, No. 11, November 1959, p. 287.

Kopeikin, A. A. [Effect of Fluxing Additions on the Structure and Properties of Semiporcelain]: Steklo i Keram., vol. 15, No. 10, 1958, pp. 18–22; Ceram. Abs., vol. 42, No. 2, February 1959, p. 50j.

[14] Le Baron, I. M. (assigned to International Minerals & Chemical Corp.), Beneficiation of Minerals: U.S. Patent 2,889,042, June 2, 1959.

[15] Paull, P. L. (assigned to Texaco Development Corp.): Canadian Patent 581,553, Aug. 18, 1959.

[16] McWaught, R. P., Metallic Ore-Collecting Member With a Plurality of Magnetized Surface Areas: U.S. Patent 2,918,170, Dec. 22, 1959.

[17] Windolph, E. W., Ore Separating Apparatus: U.S. Patent 2,883,050, Apr. 21, 1959.

Other patents issued during the year were for the use of feldspar in manufacturing cellular silica,[18] in compositions for forming electrical insulators,[19] in making lightweight silicate products,[20] and in a compound for polishing aluminum surfaces.[21]

NEPHELINE SYENITE

Domestic Consumption.—Domestic consumption of nepheline syenite imported from Canada in the glass and ceramic industries increased 12 percent in 1959 after a small decrease in 1958. Nepheline syenite unsuitable for the glass and ceramic industries was mined in Arkansas for use as roofing granules, and production statistics are included in the Stone chapter.

TABLE 9.—Nepheline syenite imported for consumption in the United States

[Bureau of the Census]

Year	Crude		Ground	
	Short tons	Value	Short tons	Value
1950–54 (average)	1,830	$7,447	74,678	[1]$1,073,539
1955	--------	--------	111,863	1,856,062
1956	--------	--------	140,306	[1]2,136,092
1957	--------	--------	166,989	[1]$2,505,248
1958	160	$2,696	164,814	2,253,062
1959	808	18,652	184,464	2,403,079

[1] Data known to be not comparable with other years.

Prices.[22]—Prices of processed nepheline syenite per short ton were quoted as follows, f.o.b. works, bags, carlots: Glass grade (30-mesh), $15; Pottery grade (200- to 325-mesh), $21.50 to $28; Byproduct grade (100-mesh), $10 (add $3 per short ton to bulk quotations for bags and bagging).

Foreign Trade.—Imports of ground nepheline syenite from Canada, mostly for use in the glass industry, increased 12 percent in quantity and 7 percent in value. About 800 short tons, of crude nepheline syenite was imported from Canada. A small quantity of nepheline syenite also was imported from Belgium-Luxembourg.

World Review.—Canada, with a substantial increase in production, continued to be the major producer of nepheline syenite for the ceramic industries.

An Oslo, Norway, firm announced plans to develop an extensive deposit of nepheline syenite in Sljernioy, northern Norway.

The U.S.S.R. planned to expand production of nepheline syenite as a source of raw material for the alumina industry. Two newly discovered shallow deposits were reported in central Kazakhstan.

---

[18] Ford, W. D. (assigned to Pittsburgh Corning Corp.), Method of Making Cellular Silica: U.S. Patent 2,890,126, 2,890,127, 2,890,173, June 9, 1959.

[19] Selsing, J. (assigned to Ohio Brass Co.), Ceramic Products: U.S. Patent 2,898,217, Aug. 4, 1959.

[20] Schraul, R., and Frey, A. (assigned to Deutsche Gold-und Silber-Scheideanstalt, Vormals Roessler): Canadian Patent 581,749, Aug. 18, 1959.

[21] Berkeley, B., and Peterson, R. (assigned to Commonwealth Products, Inc.), Aluminum Cleaning Composition: U.S. Patent 2,907,649, Oct. 6, 1959.

[22] Reeves, J. E., Nepheline Syenite: Canada Dept. of Mines and Tech. Surveys, Ottawa, No. 44, April 1959, p. 5.

Belgium-Luxembourg exported small quantities of nepheline syenite.

Deposits occur in Finland, India, and Korea, but no production has been reported.

Technology.—Nepheline syenite deposits in Ontario, Canada, were mapped.[23]

An article was published describing the use of nepheline syenite as a raw material for a glass to trap radioactive wastes,[24] and a patent was issued for the use of nepheline syenite in electric insulators.[25]

Experiments were conducted on growing nepheline crystals for piezoelectric measurements.[26]

It was reported that the U.S.S.R. planned to produce fertilizer potash from nepheline.[27] The weathering processes of nepheline syenite deposits in the U.S.S.R. were studied.[28]

China was reported to be using nepheline in producing a high-quality hydraulic cement.[29]

A patent was issued for a colored glazing composition for clay building brick.[30]

APLITE

Production of crude aplite, primarily used for making amber glass and window glass, increased over 85 percent. The glass industry consumed more than 70 percent of the ground aplite sold, and the tonnage used in glass increased almost 40 percent. Other uses of aplite were for brick, roofing granules, and crushed stone.

Buffalo Mines, Inc., Piney River, Va., was a new producer. The only other aplite producers were Riverton Lime & Stone Co. Division, Chadbourn Gotham, Inc., in Amherst County, and Consolidated Feldspar Department, International Minerals & Chemical Corp., in Nelson County, both near Piney River, Va.

Metal & Thermit Corp. of New York announced plans to expand mineral mining operations at a company-owned tract in Hanover County, Va., and to produce aplite as a byproduct. First shipments were expected to be made in the summer of 1960.

---

[23] Canadian Mining Journal (Quebec), Progress and Developments: Vol. 81, No. 3, March 1960, p. 147.

[24] Chemical and Engineering News, Research-Fission Wastes Trapped in Glass: Vol. 37, No. 23, June 8, 1959, p. 38.

[25] Selsing, J., Ceramic Products: U.S. Patent 2,898,217, Aug. 4, 1959.

[26] U.S. Government Research Reports, Investigation of Nepheline and Related Substances With Particular Emphasis on Growing Crystals for Piezoelectric Measurements: Vol. 32, No. 3, Sept. 11, 1959, p. 386.

[27] Mining Journal (London), Mining Miscellany: Vol. 253, No. 6474, Sept. 18, 1959, p. 265.

[28] Dorfman, M. D. [Geochemical Characteristics of Weathering Processes in Nepheline Syenites of the Khibina Tundia]: Geokhimiya, No. 5, 1958, pp. 424–434; Chem. Abs., vol. 53, No. 4, Feb. 25, 1959, col. 2972e.

[29] Engineering News Record, Research and Development—Chinese Produce Cement With a Different Recipe: Vol. 163, No. 8, Aug. 20, 1959, p. 64.

[30] Hummel, F. A. (assigned to Glen-Grey Shale Brick Corp.), Glazing Composition for Structural Clay Products and Process for Making Same: U.S. Patent 2,871,132, Jan. 27, 1959.

Ferroalloys

By H. Austin Tucker,[1] Gertrude C. Schwab,[2] and Hilda V. Heidrich [2]

◆

PRODUCTION of ferroalloys increased 13 percent, shipments 19 percent, and total value 14 percent. The ferroalloy industry smelted and shipped nearly 2 million tons of products.

(The ferroalloy chapter has been traditionally concerned with compounds and chemical elements that have little in common other than their use in producing iron and steel. In recent years, the scope of the chapter has been expanded to include a growing number of compounds and elements processed mostly by the producers of ferroalloys but used to make silicones and other chemicals and to alloy aluminum, copper, titanium, and other nonferrous metals. These newer alloying and chemical materials are discussed in the text, and identified in the footnotes and indicated in the column headings of tables. All other commodity aspects of the chemical entities described in this chapter are reported in separate chapters in this volume. Four new tables have been added to this chapter, largely as a result of a survey form sent to ferroalloy consumers for the first time.)

DOMESTIC PRODUCTION AND SHIPMENTS

In 1959, the ferroalloy industry produced 1.9 million tons of ferroalloys in 59 plants, of which 41 were electric-furnace, 11 blast-furnace, and 7 aluminothermic. The industry was active in 18 States. Ohio was the leading producing State, with 533,311 short tons, and Pennsylvania was next with 376,905 tons. Producers also reported from Alabama, Florida, Idaho, Illinois, Iowa, Kentucky, Montana, New Jersey, New York, Oregon, South Carolina, Tennessee, Texas, Virginia, Washington, and West Virginia.

The Electro Metallurgical Company, a division of Union Carbide Corporation, changed its name in January to Union Carbide Metals Company.

Manganese Alloys.—The 11 producers of ferromanganese made 1 percent less alloy but sold 17 percent more than in 1958. The Vanadium Corporation of America produced ferromanganese commercially for the first time at its Cambridge, Ohio, plant.

Silicon Alloys.—Eleven companies continued to produce ferrosilicon. There was an 18-percent gain in production but only a 6-percent gain in shipments.

---

[1] Commodity specialist.
[2] Statistical assistant.

TABLE 1.—Ferroalloys produced and shipped from furnaces in the United States

	1958				1959			
	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:								
Blast furnace	430,790	77.34	413,272	$98,898	402,698	76.90	454,319	$107,863
Electric furnace	205,946	78.47	194,827	46,749	226,609	78.05	255,677	61,497
Total ferromanganese	636,736	77.70	608,099	145,647	629,307	77.32	709,996	169,360
Silicomanganese	80,977	65.73	82,013	20,638	106,340	65.42	107,396	27,930
Ferrosilicon	286,396	55.78	319,791	54,879	336,702	54.94	338,913	63,298
Silvery iron	228,114	11.47	224,521	18,257	345,132	12.05	363,418	29,880
Ferrochromium	[1] 263,598	66.19	260,469	115,179	[1] 249,054	66.30	246,368	109,843
Other chromium alloys	[2] 40,808	41.86	46,652	14,980	[2] 69,210	42.13	67,331	24,118
Total ferrochromium	304,406	62.94	307,121	130,159	318,264	61.04	313,699	133,961
Ferrotitanium	4,440	26.58	4,612	3,294	4,782	32.02	4,655	3,812
Ferrophosphorus	[3] 84,203	[3] 24.03	[3] 62,013	[3] 2,665	85,198	24.35	64,810	2,675
Ferrocolumbium and ferrotantalum-columbium	430	58.37	467	1,974	607	58.48	564	2,247
Ferronickel	23,793	44.50	24,785	45,943	22,631	44.50	22,979	48,815
Other	[4] 47,673	26.35	48,964		[4] 75,401	27.71	68,708	
Total	[3] 1,697,168	[3] 57.17	[3] 1,682,386	[3] 423,456	1,924,364	53.55	1,995,138	481,978

[1] Includes low- and high-carbon ferrochromium and chromium briquets.
[2] Includes ferrochrome-silicon, exothermic chromium additives, and other chromium alloys.
[3] Revised figure.
[4] Includes alsifer, ferroboron, ferromolybdenum, ferrotungsten, ferrovanadium, simanal, spiegeleisen, zirconium-ferrosilicon, ferrosilicon-zirconium, aluminum silicon alloy, and other miscellaneous ferroalloys.

In April, Ohio Ferro-Alloys Corporation brought three more electric furnaces into operation at its Powhatan Point, Ohio, plant, making a total of five and bringing the plant to full design capacity. The plant produced mostly silicon metal and some silicon alloys. Also, the corporation doubled facilities to produce calcium-silicon and calcium-manganese-silicon at its Philo, Ohio, plant.

Silvery Iron.—Five companies continued to produce silvery iron in three blast-furnace plants and three electric-furnace plants. One producer, Keokuk Electro Metals Company, became a division of the Vanadium Corporation of America by merger in May. These five companies recorded sizable increases in the quantities produced and shipped (51 and 62 percent, respectively) and in total value of shipments (64 percent). The average value per pound of contained silicon was nearly the same as in 1958; the blast-furnace product cost 42 cents and the electric-furnace product, 29 cents per pound.

Chromium Products.—Eleven producers continued to make ferrochromium in 19 plants in 10 States.

Molybdenum Alloys.—Climax Molybdenum Co. (a division of American Metal Climax) and Molybdenum Corp. of America continued to produce ferromolybdenum. Shieldalloy Corp. also became a producer. The molybdenum contained in the products of all three pro-

TABLE 2.—Producers of ferroalloys in the United States in 1959

Producer	Plant	Product [1] and type of furnace [2]
American Agricultural Chemical Co.	Pierce, Fla.	FeP (E).
American Chrome Co.	Nye, Mont.	FeCr (E).
The Anaconda Co.	Anaconda, Mont.	FeMn (E).
Bethlehem Steel Co.	Johnstown, Pa.	FeMn (B).
Chromium Mng. & Smelting Corp., Ltd.	Riverdale, Ill.	FeCr (E).
Climax Molybdenum Co.	Langeloth, Pa.	FeMo (T).
The Hanna Furnace Corp.	Buffalo, N.Y.	Silvery iron (B).
Hanna Nickel Smelting Co.	Riddle, Oreg.	FeSi, FeNi (E).
Hooker Chemical Corp.	Columbia, Tenn.	FeP (E).
Interlake Iron Corp.	Beverly, Ohio	SiMn, FeSi, FeCr (E).
Do	Jackson, Ohio	FeSi (E); silvery iron (B).
Jackson Iron & Steel Co.	do	Silvery iron (B).
Keokuk Electro-Metals Co. Div. of Vanadium Corp. of America.	Keokuk, Iowa	FeSi, FeCr, silvery iron (E).
Do	Wenatchee, Wash.	FeSi (E).
E. J. Lavino & Co.	Sheridan, Pa.; Reusens, Va.	FeMn (B).
Metal & Thermit Corp.	Carteret, N.J.	FeTi, FeB (T).
Molybdenum Corp. of America	Washington, Pa.	FeMo (E) and (T); FeW, FeB, FeCb (E).
Monsanto Chemical Co.	Soda Springs, Idaho; Columbia, Tenn.	FeP (E).
Montana Ferro-Alloys Co., Inc.	Woodstock, Tenn.	FeSi, FeCr (E).
New Jersey Zinc	Palmerton, Pa.	Spln (B).
Ohio Ferro-Alloys Corp.	Brilliant, Ohio	FeSi, FeCr (E).
Do	Philo, Ohio	FeMn, SiMn, FeSi, other [3] (E).
Do	Powhatan Point, Ohio	Si, FeSi, Other (E).
Do	Tacoma, Wash.	FeSi (E).
Pacific Northwest Alloys, Inc.	Mead, Wash.	FeSi, FeCr (E).
Pittsburgh Coke and Chemical Co.	Neville Island, Pa.	FeMn, Spln (B).
Pittsburgh Metallurgical Co.	Niagara Falls, N.Y.	FeMn, SiMn, FeSi, FeCr, silvery iron (E).
Do	Calvert City, Ky.	Do.
Do	Charleston, S.C.	FeMn, FeSi, FeCr (E).
Reading Chemicals	Robesonia, Pa.	FeMo, NiW, FeV, FeCb (T).
Shieldalloy Corp.	Newfield, N.J.	FeMo, FeV, FeCbTa, FeCb (T).
Tennessee Products & Chemical	Chattanooga, Tenn.	FeCr, FeSi (E).
DO	Rockwood, Tenn.	FeMn (B) and (E); SiMn, FeCr, FeSi (E).
Tennessee Valley Authority	Muscle Shoals, Ala.	FeP (E).
Tenn-Tex Alloy Chemical Corp.	Houston, Tex.	FeMn, SiMn, FeSi (E).
Titanium Alloy Mfg. Division, National Lead Company.	Niagara Falls, N.Y.	FeTi, other (E).
Transition Metals & Chemical Co.	Wallkill, N.Y.	FeCb (T).
Union Carbide Metals Co.	Niagara Falls, N.Y.	FeMn, SiMn, FeSi, FeCr, FeTi, FeW, FeB, FeCb, FeCbTa, other (E).
Do	Alloy, W. Va.	FeMn, SiMn, FeSi, FeCr, other (E); FeV (E) and (T).
Do	Marietta, Ohio	FeMn, SiMn, FeSi, FeCr, Spln, other (E).
Do	Ashtabula, Ohio	FeMn, SiMn, FeSi, FeCr (E).
Do	Sheffield, Ala.	FeMn, SiMn, FeSi (E).
Do	Portland, Oreg.	Do.
United States Steel Corporation	Ensley, Ala.; Duquesne, Pa.	FeMn (B).
Vanadium Corp. of America	Niagara Falls, N.Y.	FeMn, SiMn, FeSi, FeCr, FeTi, FeV, FeB, other (E).
Do	Graham, W. Va.	SiMn, FeSi, FeCr, other (E).
Do	Vancoram, Ohio	FeCr (E).
Do	Cambridge, Ohio	FeMn, FeTi, FeV, FeB, FeCb, other (E).
Victor Chemical Works Division of Stauffer Chemical Co.	Mt. Pleasant, Tenn.	FeP (E).
Virginia-Carolina Chemical Corp.	Charleston, S.C.	Do.
Do	Nichols, Fla.	Do.
Westvaco Chem. Div.	Pocatello, Idaho	Do.

---

[1] Abbreviations used: 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; NiW, nickel tungsten; Si, Silicon metal.

[2] E, electric; B, blast; T, aluminothermic.

[3] Includes alsifer, simanal, zirconium alloys, ferrosilicon boron, aluminum silicon alloys, and miscellaneous ferroalloys.

ducers averaged 61.5 percent. Reading Chemicals produced molybdenum-aluminum with 53 percent contained molybdenum.

Titanium Alloys.—Shieldalloy Corp., listed as a new producer in 1958, reported no production in 1959.

Ferrophosphorus.—Producers continued to make ferrophosphorus as a byproduct of the electric-furnace process for smelting phosphate rock to make elemental phosphorus. Nearly 50,000 tons of ferrophosphorus was exported, 15,000 tons was used domestically, and 20,000 tons was added to producers' stocks on hand.

Ferrocolumbium and Ferrotantalum.—Ferrocolumbium was produced in three States by six companies in three electric-furnace plants and three aluminothermic plants. They produced 50 percent more alloy and shipped 39 percent more than in 1958. The average unit value decreased 20 cents to $3.50 per pound of contained columbium.

Two companies continued to produce ferrotantalum-columbium in plants which also made ferrocolumbium. Production rose 9 percent and shipments 24 percent. The value of a pound of the contained duplex alloy averaged $3.57 during the year, an increase of $0.14 over 1958.

Ferronickel.—One company (Hanna Nickel Smelting Co., Riddle, Oreg.) continued as the only ferronickel producer.

Vanadium Alloys.—Three producers made ferrovanadium. Shieldalloy Corp., Newfield, N.J., was a new producer. Reading Chemicals produced aluminum-vanadium commercially in its plant for the first time.

Zirconium Alloys.—Zirconium-ferrosilicon, containing 13 percent zirconium was produced by one company in three plants. Cost per pound of contained zirconium remained the same as in 1958, $0.76. Ferroaluminum-zirconium containing an estimated 44-percent zirconium and aluminum was produced by another company.

Ferroboron.—Ferroboron was produced in four States by four companies in four electric-furnace plants and one aluminothermic plant. A new producer was Union Carbide Metals Co., at its plant in Niagara Falls, N.Y. Production and shipments were double those in 1958. The average boron content was 11.7 percent, and the average value of a pound of contained boron was $7.33.

Tungsten Alloys.—Two companies produced ferrotungsten in electric-furnace plants, and one company produced nickel-tungsten in an aluminothermic plant. The average tungsten content was 80 percent. The average value of contained metal was $2.14 a pound, 16 cents less than in 1958. Production increased 301 percent and shipments 148 percent.

CONSUMPTION AND USES

The steel industry again consumed most of the ferroalloys produced, accounting for about three-fourths of the total. Smaller quantities were used in iron foundries and in the aluminum, copper, nickel, and chemical industries. The alloy-steel ingot production reported to the American Iron and Steel Institute was 8.9 million tons and included: 5.9 million tons of heat-treatable engineering steel ingots; 1 million tons of silicon electric sheets; 777,000 tons of low-alloy, high-strength, and non-heat-treated engineering and constructional steels; 633,000 tons of nominal 18–8 nickel-chromium stainless steels (AISI 300 series); 398,000 tons of essentially nickel-free chromium stainless steels (AISI 400 and 500 series), and 200,000 tons of miscellaneous alloys. Also, ferroalloys were used in 1.4 million tons of cast steel and 13.2 million tons of cast iron in foundries independent of the steel producers. Shipments of alloy-tool and die-steel rods, bars, and other shapes were 83,000 tons.

Tables 4, 5, and 6 were developed from information collected with a new questionnaire. In tables 4 and 5 the consumption of ferroalloying compounds is classified by end uses. Table 4 shows alloying components that were added primarily to aid in the making or subsequent working of the base metal, and table 5 lists alloying components that were added primarily to enhance mechanical properties of the base metal. Table 6 shows the consumption of ferrocolumbium and ferrotantalum-columbium by end uses. Note that the figures in table 4 are in short tons of gross weight, those in table 5 are in short tons of contained weight, and those in table 6 are in pounds of contained weight.

Manganese Alloys.—A total of 918,000 tons of manganese alloys and metal was used, principally by the iron and steel industry. Of this total, 695,000 tons was high-carbon ferromanganese, 61,000 tons medium- and low-carbon ferromanganese, 99,000 tons silicomanganese, 41,000 tons spiegeleisen, 13,000 tons manganese metal, and 9,000 tons briquets. Most of this output was made in domestic smelters and electrolytic plants from 1.5 million tons of manganese ore. Of the 41,000 tons of spiegeleisen, 18,000 tons was used in carbon steels, 11,500 tons in cast iron, and 9,400 tons in alloy steels. Also, 8,374 tons of ferromanganese and silicomanganese briquets was used by the iron foundries out of a total of 8,691 tons.

Silicon Alloys.—Changes have been made in the structure of table 3. The two column headings of previous years, "Steel ingots and castings" and "Steel castings," have been replaced by classifications relating to chemical composition or more specific use.

The apparent distribution in consumption of silicon alloys changed in 1959, largely as a result of the new canvass. The total tonnage of steel products in the first five columns of table 3 was 247,222 in 1959; however, in the less productive year 1958, equivalent columns showed a total of 275,891 tons. On the other hand, the use of silicon alloys in iron castings increased from 245,918 tons in 1958 to 354,786 in 1959. This gain is attributable to a greater effort to canvass all foundries in the United States.

Titanium Alloys.—The steel industry used a greater percentage of ferrotitanium to make stainless steel than to make any other kind of steel; 25 percent of the total consumption of ferrotitanium was used in stainless steel, which accounted for 1.2 percent of the steel output.

Ferrophosphorus.—As heretofore, steelmakers used most of the ferrophosphorus in carbon steels, because phosphorus improves machinability of bar stock and facilitates the separation of thin sheets that have been multiple rolled. Also, a considerable quantity of phosphorus was added to low-alloy steels, apparently to increase their strength and improve resistance to corrosion. Only 18 percent of the ferrophosphorus output was used domestically in 1959; nearly 59 percent was exported; and the remainder was stocked mostly by producers.

Ferroboron.—The ferrous-metals industry consumed ferroboron in alloy steels and iron castings to enhance hardenability or to increase the thermal-neutron absorption cross section.

Chromium Products.—The consumption of ferrochromium, other chromium ferroalloys, and chromium metal increased from 201,490 tons gross weight, containing 117,247 tons of chromium, in 1958 to 285,713 tons, containing 168,964 tons of chromium. Most of this increase resulted from the greater use of stainless steel in which chromium was the principal alloying element.

Molybdenum Alloys.—Iron and steel makers consumed 4,004 tons of contained metal in ferromolybdenum, calcium molybdate, and molybdenum silicide. Although molybdenum is used chiefly as an alloy in engineering steels to improve hardenability, it is also used in stainless steels to increase resistance to corrosion.

Tungsten Alloys.—Makers of high-speed tool and hot-work steels consumed most of the 683 tons of tungsten in tungsten alloys. Steelmakers used 635 tons of the ferrotungsten and other processed forms, compared with 860 tons in 1958. As an alloying element, tungsten contributes wear resistance and hot hardness qualities to steel and some other metals and alloys.

Vanadium Alloys.—The ferrous-metal industry consumed most of the 1,492 tons of vanadium, using more than one-half in engineering alloys. Consumption of ferrovanadium was 18 percent above 1958.

Ferrocolumbium and Ferrotantalum-Columbium.—Consumption of ferrocolumbium and ferrotantalum-columbium increased 24 percent.

TABLE 3.—Consumption by end uses of silicon alloys, and stocks, in the United States in 1959

(Short tons, gross weight)

Alloy	Silicon content, percent	Stainless steels	Other alloy steels	Carbon steels	Tool steels	Steel mill rolls	Gray and malleable castings	Aluminum-base alloys	High-temperature alloys	Other nonferrous alloys[1]	Miscellaneous uses	Total	Stocks, Dec. 31
Silvery pig iron	5-13	------	9,053	618	-----	773	153,409	301	-----	------	-------	164,154	20,263
Do	14-20	7	11,470	15,007	33	189	124,869	------	-----	6,068	[2] 987	158,630	26,752
Ferrosilicon	[3] 21-55	6,967	33,997	84,636	790	705	35,197	48	218	2,643	[4] 19,768	184,969	30,878
Do	56-70	379	9,753	23,963	-----	------	355	------	-----	------	-------	34,450	2,770
Do	71-80	9,237	16,841	5,522	729	37	5,827	------	73	4,035	-------	42,301	5,480
Do	81-89	93	786	1,421	-----	48	2,485	2	1	50	-------	4,886	790
Do	90-95	27	3,087	286	1	19	439	3,416	500	32	57	7,864	806
Silicon metal	96-99	------	122	-------	2	------	7	17,224	128	744	[5] 5,828	24,055	3,331
Ferrosilicon briquets	40-50	2	383	105	-----	12	28,508	------	39	------	-------	29,049	4,957
Miscellaneous silicon alloys[6]	------	742	4,482	4,733	113	52	3,690	380	49	3,784	4	18,029	2,633
Total	------	17,454	89,974	136,291	1,668	1,835	354,786	21,371	1,008	17,356	26,644	668,387	98,660

[1] Includes cutting and wear-resistant materials, welding rods, alloy hard facing rods, permanent-magnet alloys, copper-base alloys, nickel-base alloys, electrical resistance alloys, anodes, and other miscellaneous alloys.

[2] Mainly to beneficiate iron ore.

[3] Mainly from 40 to 55 percent silicon.

[4] Mainly to produce ferronickel.

[5] Mainly for silicones and chemicals.

[6] Includes calcium-silicon, calcium-manganese-silicon, silicon-maganese-zirconium, ferrocarbo, alsifer, and other miscellaneous silicon alloys.

Only one-half as much was used as was shipped. Large quantities were stocked by producers and consumers.

Ferrocolumbium is used increasingly in carbon and low-alloy steels to promote a fine grain structure, which sharply increases both yield and tensile strengths and enhances weldability. Only 0.01 to 0.10 percent columbium is added to steel to make these improvements.

Zirconium-Alloys.—The steelmakers reported to the AISI that they consumed 2,508 tons of ferrozirconium and 57 tons of the minor zirconium alloys, silicon zirconium, aluminum zirconium, and grainal. Consumption of the minor alloys tripled, and 38 percent more ferrozirconium was used.

TABLE 4.—Consumption by end uses of ferroalloys as additives in the United States in 1959[1]

(Short tons, gross weight)

	Stainless steels	Other alloy steels[2]	Carbon steels	Tool steels[3]	Gray and malleable castings	Miscellaneous uses[4]	Total
Ferromanganese[5]	17,608	140,225	607,933	4,567	38,910	10,117	819,360
Silicomanganese	3,222	26,370	63,232	1,585	3,477	753	98,639
Silicon alloys[6]	17,454	91,809	136,291	1,668	354,786	66,379	668,387
Ferrotitanium	997	937	1,658	3	1	314	3,910
Ferrophosphorus	13	2,404	9,382		690	320	12,809
Ferroboron	6	56	1		66	3	132
Total	39,300	261,801	818,497	7,823	397,930	77,886	1,603,237

[1] Except for gray and malleable castings, other items may include steel castings as well as steel ingots.
[2] Includes steel mill rolls.
[3] Includes high-speed, hot-work, and other tool steels.
[4] Includes cutting and wear resistant materials, high-temperature alloys, welding rods, alloy hard facing rods and materials, permanent-magnet alloys, soft-magnetic alloys, nickel-base alloys, titanium-base alloys, wire, rod, and sheet.
[5] Includes spiegeleisen, manganese metal, and briquets.
[6] See table 3 for more detail on silicon alloys.

TABLE 5.—Consumption by end uses of ferroalloys as alloying elements in the United States in 1959

(Short tons of contained alloy)

	Stainless steels	Other alloy steels	Carbon steels	High-speed steels	Other tool steels[1]	Gray and malleable castings	High-temperature alloys	Miscellaneous uses	Total
Ferrochromium[2]	114,389	[3]41,226		838	2,110	3,297	5,055	2,039	168,954
Ferromolybdenum[4]	881	760		444	95	1,389	122	313	4,004
Ferrotungsten		88		385	162		43	5	683
Ferrovanadium	31	771	107	356	154	25		48	1,492
Ferrocolumbium[5]	128	30	5			1	46	15	225
Ferrotantalum-columbium[5]	29	2					23	4	58
Total	115,458	42,877	112	2,023	2,521	4,712	5,289	2,424	175,416

[1] Includes hot-work and die steels.
[2] Includes ferrochromium alloys and chromium metals.
[3] Includes quantities that were believed used in producing high-speed and other tool steels and stainless steels, because some firms failed to specify individual uses.
[4] Includes calcium molybdate and molybdenum silicide.
[5] See table 6 for more detail on end uses.

TABLE 6.—Consumption by end uses of ferrocolumbium and ferrotantalum-Columbium in the United States

(Pounds of contained Cb and Ta)

	1958	1959		1958	1959
Stainless steels	314,169	313,590	High-temperature alloys	93,461	139,131
Other alloy steels	44,643	63,473	Permanent-magnet alloys		3,584
Carbon steels		10,760	Miscellaneous uses	1,352	7,990
Tool steels		118			
Welding rods	2,343	25,382	Total	455,968	565,418
Gray and malleable castings		1,390			

STOCKS

This is the first year that stocks have been given a section in this chapter. During 1959 producers' stocks declined 13 percent. Stocks of manganese ferroalloys decreased 36 percent, whereas stocks of ferrophosphorus continued to increase. Stocks of ferrophosphorus held by the Tennessee Valley Authority totaled 91,000 tons, an increase of 8,600 tons over 1958.

TABLE 7.—Stocks of ferroalloys held by producers and consumers in the United States as of Dec. 31

(Short tons)

	Producers		Consumers	
	1958, gross weight	1959, gross weight	1958, gross weight	1959, gross weight
Manganese ferroalloys [1]	214,741	137,853	156,804	146,003
Silicon alloys [2]	139,296	121,320	101,672	[3] 98,660
Ferrochromium [4]	67,000	72,333	26,000	28,818
Ferrotitanium	1,020	1,111	(5)	969
Ferrophosphorus	[6] 119,236	139,624	(5)	4,535
Ferroboron	62	50	(5)	30
Total	[6] 541,355	472,291		279,015
	1958, contained alloy	1959, contained alloy	1958, contained alloy	1959, contained alloy
Ferromolybdenum [7]	(8)	(8)	561	735
Ferrotungsten	(8)	(8)	143	152
Ferrovanadium	(8)	(8)	203	269
Ferrocolumbium	79	114	(5)	73
Ferrotantalum-columbium	(8)	(8)	(5)	14
Total	738	1,146		1,243

---

[1] Includes manganese metal.
[2] Includes silvery iron, aluminum-silicon alloy, ferrosilicon-boron, ferrosilicon-zirconium, and silicon manganese-aluminum.
[3] For more detail on stocks see table 3.
[4] Includes other chromium ferroalloys and chromium metal.
[5] Not available.
[6] Revised figure.
[7] Includes calcium molybdate and molybdenum silicide.
[8] Figures withheld to avoid disclosing individual company confidential data.

FOREIGN TRADE [3]

The foreign trade in ferroalloys, still small compared with domestic business, increased substantially in 1959. This increase was particularly noticeable in imports of the ferroalloys of chromium, manganese, and silicon. The output of new or expanding ferroalloy plants in India, Union of South Africa, and Japan was evidenced by initial or larger imports from these countries. Some imports may have been the result of barter contracts negotiated by the Commodity Credit Corporation to exchange surplus agricultural products for ferroalloys.

The list of exports, table 10, shows the predominance of ferrophosphorus, which continued to be the principal ferroalloy shipped from the United States.

TABLE 8.—Ferroalloys and ferroalloy metals imported for consumption in the United States by varieties

[Bureau of the Census]

Variety of alloy	1958			1959		
	Gross weight (short tons)	Content (short tons)	Value	Gross weight (short tons)	Content (short tons)	Value
Calcium silicide	65	(1)	$25,111	459	(1)	$138,188
Chromium metal	[2] 2,326	(1)	[2] 4,716,176	2,865	(1)	5,179,482
Ferroboron	2	(1)	3,920	13	(1)	22,553
Ferrocerium and other cerium alloys	6	(1)	46,429	8	(1)	58.808
Ferrochrome and ferrochromium:						
Containing 3 percent or more carbon	12,274	7,068	2,907,111	56,175	38,344	15,760,432
Containing less than 3 percent carbon	12,505	8,897	4,911,090	37,156	25,722	13,989,556
Ferrochromium-tungsten, chromium tungsten, chromium-cobalt-tungsten, tungsten nickel, and other alloys of tungsten, n.s.p.f. (tungsten content)	(1)	(3)	983	(1)	47	104,913
Ferromanganese:						
Containing not over 1 percent carbon	76	64	28,164	805	562	140,105
Containing over 1 and less than 4 percent carbon	8,878	7,180	2,121,722	23,744	19,121	4,634,841
Containing not less than 4 percent carbon	54,978	42,277	8,895,906	65,513	50,549	9,292,233
Ferromolybdenum, molybdenum metal and powder, calcium molybdate, and other compounds and alloys of molybdenum (molybdenum content)	(1)	56	138,347	(1)	1	4,993
Ferrosilicon	11,613	2,398	905,392	[4] 17,486	5,584	1,727,706
Ferrotitanium	101	(1)	72,709	126	(1)	69,870
Ferrotungsten	97	79	153,841	329	267	525,569
Ferrovanadium	----	----	----	16	(1)	38,598
Manganese metal (manganese content)	----	----	----	(1)	32	14,416
Manganese silicon (manganese content)	(1)	8,908	1,656,054	(1)	12,495	2,296,397
Silicon-aluminum and aluminum-silicon	27	(1)	13,757	----	----	----
Silicon metal (silicon content)	7	6	2,948	3,142	3,095	804,745
Tungsten in combinations, in lump, grains, or powder (tungsten content)	(1)	51	230,323	(1)	98	425,494
Tungstic acid and other alloys of tungsten, n.s.p.f. (tungsten content)	(1)	(5)	1,299	----	----	----
Zirconium silicon	----	----	----	1	(1)	262

[1] Not recorded.
[2] Revised figure.
[3] 83 pounds.
[4] Adjusted by Bureau of Mines.
[5] 220 pounds.

---

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 9.—Ferromanganese and ferrosilicon imported for consumption in the United States, by countries

[Bureau of the Census]

Country	Ferromanganese (manganese content) (excluding silicomanganese)				Ferrosilicon (silicon content)			
	1958		1959		1958		1959	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
North America:								
Canada	153	$46,281	101	$40,821	2,291	$840,484	3,192	$1,033,064
Mexico	624	147,688	-------	-------	-------	-------	-------	-------
Total	777	193,969	101	40,821	2,291	840,484	3,192	1,033,064
South America: Chile	1,513	276,500	1,233	244,297	-------	-------	-------	-------
Europe:								
Belgium-Luxembourg	3,182	519,715	5,297	787,733	-------	-------	-------	-------
France	12,394	3,135,993	17,198	3,245,611	3	1,567	169	30,000
Germany, West	-------	-------	3,594	618,892	43	46,050	270	272,419
Italy	-------	-------	2,285	412,532	54	15,555	-------	-------
Norway	43	9,850	12,780	2,626,543	-------	-------	1,721	333,362
Sweden	-------	-------	1,005	175,911	-------	-------	-------	-------
Yugoslavia	3,525	738,044	4,726	877,201	-------	-------	-------	-------
Total	19,144	4,403,602	46,885	8,744,423	100	63,172	2,160	635,781
Asia:								
India	483	114,796	4,143	721,075	-------	-------	-------	-------
Japan	27,604	6,056,925	17,870	4,316,563	-------	-------	213	54,758
Total	28,087	6,171,721	22,013	5,037,638	-------	-------	213	54,758
Africa: Union of South Africa	-------	-------	-------	-------	7	1,736	19	4,103
Grand total	49,521	11,045,792	70,232	14,067,179	2,398	905,392	5,584	1,727,706

TABLE 10.—Ferroalloys and ferroalloy metals exported from the United States, by varieties

[Bureau of the Census]

Variety of alloy	1956		1957		1958		1959	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Ferrochrome	5,538	$2,891.379	4,535	$2,419,102	1,920	$1,012,260	6,127	$2,095,978
Ferromanganese	2,248	682,257	7,395	1,866,456	1,406	463,896	947	388,134
Ferromolybdenum	472	1,052,281	192	447,098	113	244,755	124	280,495
Ferrophosphorus	75,411	2,339,328	50,318	1,901,036	44,503	1,468,445	49,903	1,798,592
Ferrosilicon	2,115	483,021	2,649	502,401	2,177	391,621	10,558	980,658
Ferrotitanium and ferro-carbon-titanium	364	148,459	367	130,046	323	138,431	321	145,621
Ferrotungsten	1	4,203	2	10,092	1	3,508	38	57,147
Ferrovanadium	139	650,955	134	519,955	76	294,933	152	529,697
Other ferroalloys	316	158,805	262	129,468	[1] 189	[1] 109,146	[1] 323	[1] 194,187
Spiegeleisen	-------	-------	29	2,735	834	79,243	380	37,862
Total	86,604	8,410,688	65,883	7,928,389	[1] 51,542	[1] 4,206,238	[1] 68,873	[1] 6,508,371

---

[1] Owing to changes in classifications by Bureau of the Census, data not strictly comparable with other years.

Fluorspar and Cryolite

By Robert B. McDougal [1] and James M. Foley [2]

⁂

FLUORSPAR

OUTPUT of fluorspar from domestic mines was the smallest in 21 years, but imports increased significantly. Consumption of fluorspar increased appreciably over 1958 despite lower demand from the steel industry, idled by a strike in the second half of 1959. Government purchases were no longer a factor in maintaining domestic production of acid and metallurgical fluorspar, as Federal buying terminated in 1958. In an effort to meet competition from imports, domestic producers reduced prices on acid fluorspar. Pursuant to a Senate Finance Committee resolution, the Tariff Commission initiated a study of the effects of fluorspar imports on the domestic industry. Legislation designed to control domestic output and imports was proposed but not enacted by Congress.

TABLE 1.—Salient statistics of crude and finished fluorspar, in short tons

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Production:						
Crude fluorspar:						
Mine production	748,000	656,500	922,100	861,500	818,100	405,700
Crude material milled or washed	682,393	667,500	775,700	790,600	814,800	442,000
Cleaned or concentrated fluorspar recovered	308,120	268,400	306,500	322,600	310,600	195,100
Finished fluorspar production (shipment from mines and mills)	308,694	279,540	329,719	328,872	319,513	185,091
Value, thousands	$13,683	$12,590	$14,257	$15,777	$15,071	$8,680
Imports for consumption	270,260	363,420	485,552	631,367	392,164	555,750
Value, thousands	$7,521	$8,540	$11,225	$16,031	$9,777	$13,368
Exports	773	874	197	754	3,374	1,144
Value, thousands	$50	$65	$31	$81	$191	$69
Consumption	502,100	570,261	621,354	644,688	494,227	589,979
Stocks on hand at end of year:						
Domestic mines:						
Crude [1]	120,084	139,077	189,021	214,934	207,210	156,268
Finished	23,610	23,439	19,161	17,317	18,677	21,417
Consumers' plants	191,466	140,577	189,679	227,990	185,291	179,771
Importers	16,667	54,021	53,900	[2] 51,410	[2] 39,035	46,422
World: Production [2]	1,220,000	1,550,000	1,900,000	1,925,000	1,830,000	1,855,000

[1] This crude (run-of-mine) fluorspar usually is subjected to some type of processing before it can be marketed.

[2] Revised figures.

---

[1] Commodity specialist.

[2] Supervisory statistical assistant.

LEGISLATION AND GOVERNMENT PROGRAMS

Legislation introduced in Congress early in the year was designed to divide the commercial market between domestic and foreign producers. After considerable discussion the Senate bill was referred to the Senate Finance Committee, and the companion House bills were sent to the House Ways and Means Committee.

Office of Minerals Exploration.—Exploration programs were encouraged by financial assistance from the Office of Minerals Exploration (OME). No exploration contracts were in force December 31, 1959. Under the Defense Minerals Exploration Administration program begun in 1951, 20 contracts for fluorspar had been executed by December 31, 1959. Of these, 1 was canceled and 11 were terminated. Certificates of discovery had been issued on the other eight with approved costs of $315,316, the Government's share was $162,659.

Commodity Credit Corporation.—Fluorspar was acquired by the Federal Government through barter for surplus agricultural products authorized under the Agricultural Trade Development Act of 1954.

On September 25, the Director of OCDM reported that fluorspar imports were not threatening to impair national security. The report was in response to a petition filed October 29, 1958, by the American Fluorspar Producers Association, with OCDM, under Section Eight of the Trade Agreements Extension Act of 1958.

Pursuant to a Senate Finance Committee resolution, the U.S. Tariff Commission initiated a general investigation of the fluorspar industry under authority of Section 332 of the Tariff Act of 1930. Public hearings were held December 15–17 at which representatives of producers, importers, and consumers appeared. In its report to the Senate Finance Committee February 29, 1960, the Tariff Commission made no proposals for changes in the present tariff or for import quotas on fluorspar from Mexico and Western Europe.[3]

DOMESTIC PRODUCTION

Fluorspar was produced in Colorado, Illinois, Kentucky, Montana, Nevada, New Mexico, and Utah. Finished fluorspar shipped from mines totaled 185,091 short tons and comprised, by grade, 116,700 tons acid at $6,311,400, 25,600 tons ceramic at $1,108,400, and 42,800 tons metallurgical at $1,260,300. Illinois produced about 61 percent of the domestic output.

Domestic mines produced 405,700 tons of crude ore, a decrease of 50 percent from 1958. Mines that produced over 20,000 tons accounted for 84 percent of the mine-run ore. Thirteen independent and consumer-operated mills processed 442,000 tons of crude ore from which was recovered 195,100 tons of finished fluorspar, including 145,800 tons of flotation concentrate. The remainder consisted of gravel and lump-sized fluorspar and material reclaimed from several

---

[3] United States Tariff Commission, Fluorspar: Report to the Congress on Investigation No. 332–29 (Supp.) Made Pursuant to Senate Resolution 163, Adopted Aug. 21, 1959, February 1960, 115 pp.

mine dumps. In 1958, 17 mills operated by independent firms and consumers processed 814,800 tons of crude ore and recovered 310,600 tons of finished fluorspar, of which 210,900 tons was flotation concentrate. Gravel and lump-sized fluorspar, a small quantity of hand-sorted acid fluorspar, and material from reworked dumps comprised the balance. During 1959, 16,900 tons of crude fluorspar was marketed as mined, compared with 12,100 tons (including dump and tailing material and some hand-sorted acid fluorspar) the previous year.

Captive mines produced 157,800 tons of ore, and their mills recovered 75,800 tons of concentrate from 180,900 tons of ore.

Output of fluorspar in Illinois dropped 26 percent. Production decreased in all States but Nevada, where it increased 36 percent. Although two Government purchase programs were terminated in 1958, shipments of metallurgical fluorspar to GSA continued under previously negotiated contracts. Ozark-Mahoning Mining Co. closed its two operations at Jamestown and Northgate, Colo., and the Southern Illinois Mining Co. closed its mill at Rosiclare, Ill., and sold most of the equipment early in 1959.

A fire destroyed the crushing and screening section of the Ozark-Mahoning Mining Co. mill at Rosiclare, Ill., causing the company to close the facility for about 1 month to replace damaged equipment. The company closed its mines and mill from August 28 to September

TABLE 2.—Domestic mine production of crude fluorspar according to size of operation

Production	1958		1959	
	Short tons	Percent	Short tons	Percent
Under 1,000 [1]	6,800	0.8	2,800	0.7
1,000–10,000	55,300	6.8	40,200	9.9
10,000–20,000	43,600	5.3	20,400	5.0
Over 20,000	712,400	87.1	342,300	84.4
Total	818,100	100.0	405,700	100.0

[1] Includes prospects and reworked dumps and tailings of previous mining and milling operations.

TABLE 3.—Shipments of finished fluorspar

State	1958			1959		
	Short tons	Value		Short tons	Value	
		Total	Average per ton		Total	Average per ton
Illinois	152,087	$7,930,613	$52.15	112,469	$5,908,307	$52.53
Kentucky	25,861	1,201,408	46.46	18,579	886,572	47.72
Montana	53,654	(1)	(1)	18,542	(1)	(1)
Nevada	12,338	339,987	27.56	16,743	407,300	24.33
New Mexico				200	6,900	34.50
Utah	16,109	563,726	34.99	(1)	(1)	(1)
Other [2]	59,464	5,035,655	44.52	18,558	1,471,072	39.65
Total	319,513	15,071,389	47.17	185,091	8,680,151	46.90

[1] Figure withheld to avoid disclosing individual company confidential data; included with "Other".
[2] Includes Arizona and California for 1958 only and Colorado.

7 because of low demand. The Minerva Oil Co. operated its mills at Cave-in-Rock and Elizabethtown, Ill., alternately, late in the year. Minerva Oil Co. opened a new mine near Rosiclare to tap a deep fluorspar vein discovered in 1955 by geochemical prospecting methods.

The Atwood Mining Co. began operations in Livingston County, Ky., early in the year. A washing plant was installed, and plans called for installation of jigs later.

TABLE 4.—Fluorspar shipped from mines in the United States, by grades and industries

Grade and industry	1958				1959			
	Quantity		Value		Quantity		Value	
	Short tons	Percent of total	Total	Average	Short tons	Percent of total	Total	Average
Ground and flotation concentrates:								
Hydrofluoric acid	[1] 189, 816	88. 4	[1] $10, 333, 620	$54. 44	113, 982	80. 0	$6, 183, 980	$54. 25
Glass	14, 818	7. 0	642, 107	43. 33	16, 877	11. 9	721, 211	42. 73
Ceramic and enamel	3, 724	1. 7	174, 982	46. 99	3, 957	2. 8	180, 339	45. 57
Nonferrous	2, 240	1. 0	106, 999	47. 77	2, 863	2. 0	124, 816	43. 60
Ferrous	2, 363	1. 1	103, 025	43. 60	2, 672	1. 9	115, 286	43. 15
Miscellaneous [2]	1, 676	. 8	74, 814	44. 64	1, 983	1. 4	94, 233	47. 52
Total	214, 637	100. 0	11, 435, 547	53. 28	142, 334	100. 0	7, 419, 865	52. 13
Fluxing gravel and foundry lump:								
Ceramic and enamel	(3)	(3)	(3)	(3)	--------	--------	--------	--------
Nonferrous	74	. 1	3, 177	42. 93	96	. 2	3, 975	41. 41
Ferrous [1]	101, 240	96. 5	3, 545, 649	35. 02	35, 967	84. 1	1, 099, 847	30. 58
Miscellaneous	3, 562	3. 4	87, 016	24. 43	6, 694	15. 7	156, 464	23. 37
Total	104, 876	100. 0	3, 635, 842	34. 67	42, 757	100. 0	1, 260, 286	29. 48
All grades:								
Hydrofluoric acid	[1] 189, 816	59. 4	[1] 10, 333, 620	54. 44	113, 982	61. 6	6, 183, 980	54. 25
Glass	14, 818	4. 6	642, 107	43. 33	16, 877	9. 1	721, 211	42. 73
Ceramic and enamel	3, 724	1. 2	174, 982	46. 99	3, 957	2. 1	180, 339	45. 57
Nonferrous	2, 314	. 7	110. 176	47. 61	2, 959	1. 6	128, 791	43. 53
Ferrous [1]	103, 603	32. 4	3. 648, 674	35. 22	38, 639	20. 9	1, 215, 133	31. 45
Miscellaneous [2]	5, 238	1. 7	161, 830	30. 89	8, 677	4. 7	250, 697	28. 89
Total	319, 513	100. 0	15, 071, 389	47. 17	185, 091	100. 0	8, 680, 151	46. 90

[1] Includes shipments to GSA.

[2] Includes exports.

[3] Included with ceramic and enamel under ground and flotation concentrates to avoid disclosing individual company confidential data.

CONSUMPTION AND USES

Industrial plants consumed 19 percent more fluorspar despite a long strike from July into November at many steel plants and iron foundries. Fluorspar was reported consumed in 37 States. However, reports from producers, brokers, dealers, and importers indicated shipments were made to consumers in several additional States. Illinois, Ohio, and Pennsylvania accounted for 40 percent of the quantity used.

Acid fluorspar consumed by hydrofluoric acid plants increased 25 percent above 1958, in part due to increased output by aluminum plants and increased demand for chemicals derived from hydrogen fluoride.

An expanding market for fluorinated hydrocarbons as aerosol propellants in food containers was predicted.[4] Research was progressing to market food propellants that can be liquefied under pressure at normal temperatures.

The National Aeronautics and Space Administration (NASA) awarded to Bell Aircraft Corp., in April, the Government's second major contract for fluorine rocket-engine studies.[5] The contract was to determine the feasibility of a high-energy fluorine-liquid hydrogen rocket engine. NASA chemists believed it would be several years before serious consideration would be given to fluorine by engine designers. Considerable research centered on finding nonmetallic materials compatible with liquid fluorine for gaskets, seals, and lines. Under laboratory conditions fluorocarbon gaskets were satisfactory with liquid fluorine; however, under operational pressure and friction, the gaskets deteriorated.

Controlled fluoridation was reported to be an inexpensive and safe method to prevent dental decay. However, Secretary Flemming of the Department of Health, Education, and Welfare (HEW) stated that a "militant minority" had slowed the progress of fluoridating city water supplies in 1957 and 1958.[6] The number of new communities that adopted the program each year dropped from a peak of 378 in 1953 to 110 in 1957 and 131 in 1958. The number of communities that discontinued the programs steadily increased from 1954 through 1958.

STOCKS

Producers reported that fluorspar in stock at mines, mills, and shipping points at the end of 1959 totaled 177,700 short tons, of which 156,300 tons was crude (mine-run) fluorspar and 21,400 tons finished fluorspar.

Consumers reported that fluorspar stocks of December 31, 1959, totaled 179,800 tons, 3 percent lower than at the end of 1958. Fluorspar held in stock at steel plants increased 5 percent and comprised nearly a 5-month supply based on the December rate of consumption.

---

[4] **Chemical and Engineering News, More Aerosol Propellants: Vol. 37, No. 43, Oct. 26, 1959, p. 26.**

[5] **Chemical and Engineering News, Bell Aircraft Gets F_2 Contract: Vol. 37, No. 17, Apr. 27, 1959, p. 25.**

[6] **Oil, Paint and Drug Reporter, Fluoridation of Water Supplies Losing Out and HEW Is Worried; "Militant Minority" Gets Blame: Vol. 175, No. 7, Feb. 16, 1959, pp. 7, 67.**

TABLE 5.—Fluorspar (domestic and foreign) consumed and in stock in the United States, by grades and industries, in short tons

Grade and industry	1958[1]		1959	
	Consumption	Stocks at consumers' plants on Dec. 31	Consumption	Stocks at consumers' plants on Dec. 31
Acid grade:				
Hydrofluoric acid	258,935	47,163	324,519	40,814
Glass	3,916	481	3,864	591
Enamel	125	40	185	31
Welding rod coatings	810	61	818	44
Nonferrous	25	40	17	5
Special flux	2,137	1,224	2,532	983
Ferroalloys				
Primary aluminum				
Total	265,948	49,009	331,935	42,468
Ceramic grade:				
Glass	25,123	3,653	25,560	3,306
Enamel	4,776	944	5,561	692
Welding rod coatings	200	34	1,188	120
Nonferrous	5,339	911	37	17
Special flux	1,134	193	6,989	1,595
Ferroalloys				
Total	36,572	5,735	39,335	5,730
Metallurgical grade:				
Glass	824	171	751	162
Enamel	88	----------	5	3
Welding rod coatings	164	164	349	81
Nonferrous	1,773	1,778	7,692	1,228
Special flux	1,467	971	2,153	1,004
Ferroalloys				
Primary magnesium				
Iron foundry	12,883	8,826	13,529	5,025
Basic open-hearth steel	150,328	118,637	157,660	124,070
Electric-furnace steel	24,033		36,377	
Bessemer steel	147		193	
Total	191,707	130,547	218,709	131,573
All grades:				
Hydrofluoric acid	258,935	47,163	324,519	40,814
Glass	29,863	4,305	30,175	4,059
Enamel	4,989	984	5,751	726
Welding rod coatings	1,174	259	2,355	245
Nonferrous	7,137	2,729	7,746	1,250
Special flux	257	157	5,293	1,047
Ferroalloys	1,691	869	3,381	1,443
Primary aluminum	2,790	1,362	3,000	1,092
Primary magnesium				
Iron foundry	12,883	8,826	13,529	5,025
Basic open-hearth steel	150,328	118,637	157,660	124,070
Electric-furnace steel	24,033		36,377	
Bessemer steel	147		193	
Total	494,227	185,291	589,979	179,771

[1] Glass, enamel, and other (including welding rod coatings, nonferrous, special flux, and ferroalloys), partly estimated from sample canvass of consumers who accounted for more than 95 percent of total usage in 1957.

TABLE 6.—Production of steel and consumption and stocks of fluorspar (domestic and foreign) at basic open-hearth and electric-furnace steel plants

	1950-54 (average)	1955	1956	1957	1958	1959
Production of basic open-hearth steel ingots and castings at plants consuming fluorspar.......thousand short tons..	87, 418	99, 927	95, 175	100, 297	75, 215	76, 500
Consumption of fluorspar in basic open-hearth steel production thousand short tons..	224	217	228	212	150	158
Consumption of fluorspar per short ton of basic open-hearth steel made...pounds..	5. 1	4. 3	4. 8	4. 2	4. 0	4. 1
Stocks of fluorspar at basic open-hearth steel plants at end of year thousand short tons..	143	102	143	158	111	108
Production of electric-furnace steel ingots and castings at plants consuming fluorspar........thousand short tons..	6, 524	7, 511	8, 814	9, 551	6, 462	7, 953
Consumption of fluorspar in electric-furnace steel production thousand short tons..	31	33	36	30	24	36
Consumption of fluorspar per short ton of electric-furnace steel made.....pounds..	9. 3	8. 9	8. 2	6. 4	7. 4	9. 2
Stocks of fluorspar at electric-furnace steel plants at end of year thousand short tons..	6	5	12	6	8	16

TABLE 7.—Fluorspar (domestic and foreign) consumed in the United States, by States, in short tons

State	1958 [1]	1959
Alabama, Georgia, North Carolina, and South Carolina................	[2] 10, 155	10, 107
Arkansas, Kansas, Louisiana, and Oklahoma...	29, 096	76, 448
California................	12, 621	13, 774
Colorado and Utah........	17, 607	16, 387
Connecticut..............	747	1, 254
Delaware and New Jersey....................	120, 944	84, 240
Florida, Rhode Island, and Virginia...........	698	980
Illinois....................	62, 974	97, 871
Indiana....................	25, 307	22, 685
Iowa, Minnesota, Nebraska, South Dakota, and Wisconsin..........	[3] 3, 828	3, 880
Kentucky................	29, 197	35, 187
Maryland................	5, 330	6, 367
Massachusetts...........	324	130
Michigan................	14, 594	19, 867
Missouri................	3, 738	2, 779
New York................	13, 832	15, 819
Ohio....................	58, 360	69, 644
Oregon and Washington..	670	826
Pennsylvania............	55, 164	66, 157
Tennessee...............	499	1, 043
Texas...................	15, 848	23, 329
West Virginia...........	5, 924	21, 205
Undistributed...........	6, 770	....
Total...............	494, 227	589, 979

[1] Consumption partly estimated from sample canvass of consumers who accounted for more than 95 percent of total usage in 1957.
[2] Alabama, Georgia, and South Carolina.
[3] Iowa, Minnesota, and Wisconsin.

TABLE 8.—Stocks of fluorspar at mines or shipping points in the United States by States, at end of year, in short tons

State	1957		1958		1959	
	Crude [1]	Finished	Crude [1]	Finished	Crude [1]	Finished
Arizona [2]	73,121	1,089	26,384	410	40,083	7,259
California						
Colorado						
Nevada [3]						
Montana	2,813	2,964	21,830	6,765		
Utah	5	------------	5	------------	(4)	------------
Illinois	133,081	7,359	147,657	7,377	108,892	10,311
Kentucky	5,914	5,905	11,334	4,125	7,293	3,847
Total	214,934	17,317	207,210	18,677	156,268	21,417

[1] This crude (run-of-mine) fluorspar usually is subjected to some type of processing before it can be marketed.

[2] 1957–58 only.

[3] Crude only.

[4] Stocks abandoned.

PRICES

Fluorspar prices during 1959 according to E&MJ Metal and Mineral Markets were as follows: Domestic acid concentrates, dry basis, per short ton, bulk, carlots, f.o.b. Illinois-Kentucky and Colorado, $50 from January to August 6, when the price was reduced to $49 spotlots and $45 contract. In bags the price was $4 to $5 extra and was similarly reduced to $3 on August 6. European acid fluorspar, c.i.f. U.S. ports, duty paid, was quoted at $50 to $52, and spotlots $1 more until January 15 when only the $50 price on contracts and spotlots of $1 more went into effect for the remainder of the year.

Ceramic fluorspar containing 95 percent CaF_2 was quoted at $45 to $48 per short ton, bulk, f.o.b. Illinois-Kentucky during the year. On August 6, the price in 100-pound bags decreased from $4 to $5 extra to $3 extra. The price of this grade containing 93 to 94 percent CaF_2, variable amounts of silica and calcite, and 0.14 percent Fe_2O_3 at the first of the year was $43 to $46 per short ton, bulk, f.o.b. Illinois-Kentucky, plus $4 to $5 extra in 100-pound bags. On August 6 the price changed to $43 to $45 per ton and $3 extra in 100-pound bags.

Metallurgical fluorspar with effective CaF_2 contents of 72½ and 70 percent, per short ton, f.o.b. shipping point, Illinois-Kentucky, was quoted at $37 to $41 and $36 to $40, respectively, throughout 1959. Metallurgical fluorspar containing 60 percent CaF_2 was quoted at $33 to $36.50 to January 15, when it changed to $33 to $36.

European metallurgical fluorspar containing 72½ percent effective CaF_2, c.i.f. U.S. ports, duty paid, was quoted at $34 to $35 for spotlots and $30 to $33 for contract to January 15, when a change to $34 for spotlots occurred. On August 6 the price for spotlots became $33 to $34 and that for contract increased to $32 to $34. Mexican fluorspar containing 72½ percent effective CaF_2, all rail, duty paid, f.o.b. border, was quoted at $25 per short ton until August 6, when the price increased to $26.50 to $27.50. This grade, f.o.b. border, barge, Brownsville, Tex., was $27 per short ton until August 6, when the price increased to $28.50 to $29.50 per ton.

FOREIGN TRADE[7]

Imports.—Fluorspar imported for consumption totaled 555,800 short tons valued at $13.4 million. This represented an increase of 42 percent over that imported in 1958. The principal source again was Mexico, which supplied 59 percent of the total imports. Italy supplied 24 and Spain 13 percent. Canada reported only 3,774 tons exported to the United States. The difference between this figure and the 11,440 tons in table 9 may represent transshipments. The U.S. Government imported 79,300 tons from Italy and Mexico, compared with 80,700 tons in 1958.

Fluorspar containing more than 97 percent CaF_2 was subject to a duty of $1.875 per short ton ($2.10 per long ton), and that containing not more than 97 percent CaF_2 was dutiable at $7.50 per short ton ($8.40 per long ton).

Exports.—Fluorspar exports totaled 1,144 short tons valued at $69,204, compared with 3,374 tons valued at $191,386 in 1958. Canada received 1,058 tons; the remainder was shipped to Chile, Mexico, the Netherlands, Peru, and Venezuela.

---

[7] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 9.—Fluorspar imported for consumption in the United States, by countries and customs district

[Bureau of the Census]

	1958						1959					
	Containing more than 97 percent calcium fluoride		Containing not more than 97 percent calcium fluoride		Total		Containing more than 97 percent calcium fluoride		Containing not more than 97 percent calcium fluoride		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
North America:												
Canada:												
Buffalo									420	$13,905	420	$13,905
El Paso	37	$919			37	$919						
Laredo							63	$1,882			63	1,882
Michigan									3,931	64,926	3,931	64,926
Ohio	5,627	126,235			5,627	126,235	1,077	24,287	2,554	55,451	3,631	79,738
Philadelphia	2,471	94,743			2,471	94,743	444	14,825	2,951	73,780	3,395	88,605
Washington	22	645			22	645						
Total	8,157	222,542			8,157	222,542	1,584	40,994	9,856	208,062	11,440	249,056
Mexico:												
Buffalo									8,263	138,398	8,263	138,398
Dakota	59	610			59	610						
El Paso	17,205	443,564	13,951	$290,508	31,156	734,072	4,867	124,133	27,555	534,285	32,422	658,418
Galveston							629	19,741	53	1,147	682	20,888
Laredo	109,945	3,699,374	85,252	1,142,296	195,197	4,841,670	105,262	3,293,460	128,843	1,941,729	234,105	5,235,189
Maryland							290	8,966	3,493	52,256	3,783	61,222
Massachusetts			8	153	8	153						
Michigan			2,110	34,457	2,110	34,457	1,109	49,341	7,495	91,577	8,604	140,918
Minnesota									8	159	8	159
Mobile			4,879	69,564	4,879	69,564						
New Orleans							7,562	213,000			7,562	213,000
Ohio			2,644	39,648	2,644	39,648			2,168	34,846	2,168	34,846
Philadelphia	1,545	56,953	7,385	208,347	8,930	265,300	7,876	249,491	21,522	348,234	29,398	597,725
San Diego							50	1,425			50	1,425
Total	128,754	4,200,501	116,229	1,784,973	244,983	5,985,474	127,645	3,959,557	199,400	3,142,631	327,045	7,102,188
Total North America	136,911	4,423,043	116,229	1,784,973	253,140	6,208,016	129,229	4,000,551	209,256	3,350,693	338,485	7,351,244

Europe:												
France: Philadelphia							2,645	70,800			2,645	70,800
Germany, West:												
New Orleans	10,146	310,959			10,146	310,959						
Philadelphia	9,192	368,468			9,192	368,468						
Total	19,338	679,427			19,338	679,427						
Italy:												
Michigan	3,854	131,748			3,854	131,748	2,742	88,461			2,742	88,461
New Orleans							15,625	441,270			15,625	441,270
Ohio	6,129	156,681			6,129	156,681	5,097	133,342			5,097	133,342
Philadelphia	44,030	1,058,310			44,030	1,058,310	111,767	3,356,165			111,767	3,356,165
San Francisco	5,118	132,600			5,118	132,600						
Total	59,131	1,479,339			59,131	1,479,339	135,231	4,019,238			135,231	4,019,238
Spain:												
Maryland			3,042	40,368	3,042	40,368						
New Orleans	5,159	121,650			5,159	121,650	5,824	123,600			5,824	123,600
Ohio	10,246	260,208			10,246	260,208	10,091	256,350			10,091	256,350
Philadelphia	32,965	801,061	5,102	68,325	38,067	869,386	49,642	1,226,939			49,642	1,226,939
San Francisco							6,059	147,500			6,059	147,500
Total	48,370	1,182,919	8,144	108,693	56,514	1,291,612	71,616	1,754,389			71,616	1,754,389
Switzerland: Philadelphia	3,959	116,357			3,959	116,357						
United Kingdom: Puerto Rico							299	15,303			299	15,303
Total Europe	130,798	3,458,042	8,144	108,693	138,942	3,566,735	209,791	5,859,730			209,791	5,859,730
Africa:												
Mozambique: Buffalo									4,212	73,882	4,212	73,882
Union of South Africa:												
Buffalo									105	4,667	105	4,667
Michigan	82	2,206			82	2,206						
Ohio									2,701	67,902	2,701	67,902
Philadelphia							456	10,847			456	10,847
Total	82	2,206			82	2,206	456	10,847	2,806	72,569	3,262	83,416
Total Africa	82	2,206			82	2,206	456	10,847	7,018	146,451	7,474	157,298
Grand total	267,791	7,883,291	124,373	1,893,666	392,164	9,776,957	339,476	9,871,128	216,274	3,497,144	555,750	13,368,272

TABLE 10.—Imported fluorspar delivered to consumers in the United States, by uses [1]

Use	1958			1959		
	Short tons	Selling prices at tidewater, border, or f.o.b. mill in the United States including duty		Short tons	Selling prices at tidewater, border, or f.o.b. mill in the United States including duty	
		Total	Average		Total	Average
Hydrofluoric acid [2]	205,593	$8,774,021	$42.68	190,104	$8,014,620	$42.16
Glass, ceramic, and enamel	23,439	1,155,676	49.31	24,376	1,183,862	48.57
Ferrous [2]	115,961	3,274,766	28.24	157,190	4,480,453	28.50
Nonferrous	3,008	108,402	36.04	683	30,950	45.31
Other	3,679	137,872	37.48	6,171	242,106	39.23
Total	351,680	13,450,737	38.25	378,524	13,951,991	36.86

[1] Estimated in part.
[2] Includes shipments to GSA.

TABLE 11.—Fluorspar exported from the United States

[Bureau of the Census]

Year	Short tons	Value		Year	Short tons	Value	
		Total	Average			Total	Average
1950-54 (average)	773	$49,693	$64.29	1957	754	$80,703	$107.00
1955	874	64,981	74.35	1958	3,374	191,386	56.72
1956	197	31,275	158.76	1959	1,144	69,204	60.49

WORLD REVIEW

NORTH AMERICA

Canada.—The value of fluorspar produced in Canada in 1958 declined to $1,598,823 from $1,809,546 in 1957.[8] A decrease in industrial activity, particularly in the aluminum industry, and increased competition from foreign sources resulted in a decreased demand for Canadian fluorspar. Two fluorspar companies operated in 1958—the Newfoundland Fluorspar, Ltd., a subsidiary of the Aluminum Co. of Canada, at St. Lawrence, Newfoundland, and the Huntingdon Fluorspar Mines, Ltd., at Madoc, Ontario. A third company, the Pacific Silica, Ltd., operated a quarry near Oliver, British Columbia, and recovered a small quantity of fluorspar as a byproduct of its silica operations.

Only 7 short tons valued at $1,009 was exported in 1958; in 1957, 23,630 tons valued at $608,472 was shipped—all to the United States.

---

[8] Canada Department of Mines and Technical Surveys, Fluorspar in Canada, 1958 (preliminary): Ottawa, 8 pp.

Imports in 1958 were 30,408 tons compared with 14,547 tons in 1957. Most was shipped from Mexico (21,250 tons), United States (6,019 tons), and Spain (2,750 tons). Fluorspar consumed in 1957 totaled 70,761 tons and comprised 53,198 tons for the manufacture of heavy chemicals (76,452 tons in 1956), 16,935 tons at steel plants (18,979 tons in 1956), and 628 tons at glass plants (669 tons in 1956).

TABLE 12.—World production of fluorspar, by countries,[1] in short tons[2]

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country[1]	1950-54 (average)	1955	1956	1957	1958	1959
North America:						
Canada	85, 630	128, 114	140, 071	66, 245	[3] 62, 000	[3] 83, 000
Mexico (exports)	132, 803	200, 220	360, 117	389, 807	310, 465	341, 186
United States (shipments)	308, 694	279, 540	329, 719	328, 872	319, 513	185, 091
Total	527, 127	607, 874	829, 907	784, 924	[3] 691, 978	[3] 609, 277
South America:						
Argentina	8, 057	16, 031	12, 983	8, 544	13, 266	[3] 13, 200
Bolivia (exports)	86	569	300	-----	-----	-----
Brazil	331	-----	-----	-----	-----	-----
Total	8, 474	16, 600	13, 283	8, 544	13, 266	[3] 13, 200
Europe:						
France	67, 241	94, 863	93, 412	103, 066	92, 594	97, 003
Germany:						
East[3]	82, 000	90, 000	90, 000	68, 000	72, 000	72, 000
West	156, 772	170, 816	161, 332	149, 289	137, 048	133, 715
Italy	61, 904	112, 195	137, 675	159, 405	162, 916	170, 978
Norway	787	317	198	331	-----	-----
Spain	61, 078	73, 653	81, 281	97, 439	99, 743	97, 384
Sweden (sales)	4, 834	1, 459	976	2, 966	3, 188	3, 197
United Kingdom	84, 090	96, 235	102, 536	104, 467	86, 694	93, 078
Total[1 3]	530, 000	650, 000	680, 000	695, 000	665, 000	680, 000
Asia:						
China[3]	(4)	100, 000	145, 000	165, 000	165, 000	220, 000
Japan	5, 083	5, 738	8, 911	8, 542	6, 069	5, 869
Korea, Republic of	7, 664	11, 105	3, 431	5, 644	1, 786	6, 748
Turkey	77	23	-----	-----	88	74
U.S.S.R.[3 5]	93, 000	110, 000	165, 000	165, 000	180, 000	190, 000
Total[1 3]	130, 000	240, 000	335, 000	400, 000	410, 000	480, 000
Africa:						
Morocco: Southern zone	2, 046	44	137	-----	-----	-----
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	222	480	942	97	6	10
South-West Africa	2, 902	675	-----	24	4	141
Tunisia	994	-----	-----	-----	-----	-----
Union of South Africa	14, 113	32, 839	35, 065	35, 106	48, 251	70, 317
Total	20, 277	34, 038	36, 144	35, 227	48, 261	70, 468
Oceania: Australia	336	316	834	784	1, 059	[3] 1, 100
World total (estimate)[1 2]	1, 220, 000	1, 550, 000	1, 900, 000	1, 925, 000	1, 830, 000	1, 855, 000

[1] Fluorspar is produced in Belgium, Bulgaria, and North Korea; estimates are included in the total.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Estimate.

[4] Data not available; estimate included in total.

[5] U.S.S.R. in Europe included with U.S.S.R. in Asia, as the deposits are predominantly in Asiatic U.S.S.R.

SOUTH AMERICA

Brazil.—Brazilian trade with the Soviet Bloc in the first half of 1959 included imports of 7 short tons of hydrofluoric acid valued at $3,120, 10 tons of fluorides valued at $2,217 from Czechoslovakia, and 22 tons of fluorides valued at $2,263 from Poland.[9]

EUROPE

France.—Ste. Comi-fluor was formed jointly by Denain-Anzin, S.A., the Pechiney Chemical and Electrometallurgical Products Company, and the Company of Electro-Chemistry, Electro-Metallurgy, and Electric Steel of Ugine to exploit large deposits of high-grade fluorspar in the Eastern Pyrenees.[10] The deposits were believed to be the largest in France and among the largest in the world. The company was to build a flotation plant at Olette about 6 miles from the deposits.

United Kingdom.—Fluorspar produced in 1959, reported by the Board of Trade, was as follows: Acid, 28,987 short tons; metallurgical 58,397 tons; and ungraded or crude, 5,694 tons; the total was 93,078 tons.[11]

ASIA

India.—Extensive fluorite deposits containing an estimated 1.5 million tons of 22 percent CaF_2 were located in the Durgapur district of the State of Rajasthan. Prospecting continued.

Japan.—Fluorspar output in Japan decreased in 1957 and 1958, but imports in the first half of 1959 (41,200 tons) were greater than for all of 1958 (40,500 tons), due to the rapidly rising aluminum and iron and steel output.[12] After trade with China was disrupted in 1958, other countries, notably the Union of South Africa, increased their exports to Japan. Korea was the other important supplier.

---

[9] U.S. Embassy, Rio de Janerio, Brazil, State Department Dispatch 507; Nov. 16, 1959, encl. 1, pp. 1, 10.

[10] Chemical Trade Journal and Chemical Engineer (London), vol. 144, No. 3755, May 22, 1959, p. 1174.

[11] U.S. Embassy, London, England, State Department Dispatch 3497: June 3, 1960, 1 p.

[12] U.S. Embassy, Tokyo, Japan, State Department Dispatch 596: Nov. 18, 1959, p. 9.

TABLE 13.—Production and trade of fluorspar in 1958, by major countries, in short tons

[Compiled by Corra A. Barry and Berenice B. Mitchell]

Exports, by countries of origin	Production	Exports	Exports, by countries of destination									
			North America		South America	Europe		Asia		Africa		Other countrie
			Canada	United States		East	West	Japan	Other	Kenya	Other	
North America:												
Canada	[1] 62,000	8		8								
Mexico	[2] 310,465	310,465	14,126	290,471	137			4,091	1,640			
United States	319,513	3,373	3,289		78		6					
South America: Argentina	13,266	875			875							
Europe:												
France	92,594	5,377					5,245					132
Germany:												
East	[1] 72,000	(3)										
West	137,048	[4] 33,668		[5] 19,338			14,330					
Italy	162,916	91,304		77,001	8	27	13,480		788			
Spain	99,743	71,759	2,756	65,435			3,568					
Sweden	3,188	270					270					
United Kingdom	86,694											
Asia:												
China	[1] 165,000	[1] 121,254				[5] 101,964		[5] 11,486				7,804
Japan	6,069	31							31			
Korea, Republic of	1,786	12,999						12,899				100
U.S.S.R.[6]	[1] 180,000											
Africa:												
South-West Africa	4	39						39				
Union of South Africa	48,251	36,075	261				12,337	17,770	37	3,946	1,603	121
Oceania: Australia	1,059											
Other countries	68,404	[4] 40,896				[4] 40,896						
Total	1,830,000	728,393	20,432	452,253	1,098	142,887	49,236	46,285	2,496	3,946	1,603	8,157

[1] Estimate.
[2] Exports.
[3] Data not available.
[4] Incomplete data.
[5] Imports.
[6] U.S.S.R. in Europe included with U.S.S.R. in Asia, as the deposits are predominantly in Asiatic U.S.S.R.

TECHNOLOGY

Interest in industrial uses of fluorine remained high throughout the year.

Numerous patents relating to fluorspar and fluorine compounds, their manufacture, recovery, and removal were issued during the year. One patent, pertaining to preparing magnesium fluoride,[13] described a process of intermixing finely ground fluorspar with an aqueous magnesium chloride solution, heating the mixture to 150° to 190° C. under sufficient pressure to maintain the mixture in liquid phase to react the calcium fluoride with the magnesium chloride, and separating the magnesium fluoride thus formed. Another patent related to a method for making a high-quality synthetic gypsum cement from the calcium sulfate byproduct obtained during production of hydrofluoric acid from fluorspar.[14]

A process for removing fluorides from industrial waste waters was patented.[15]

Farmers and citrus growers claimed that their cattle and citrus groves were poisoned by fluorine compounds in the air near Florida's phosphate chemical plants. After a one-half-million-dollar suit was filed against them, seven of the phosphate-chemical producers initiated a joint research program to determine the cause and extent of damage to cattle and citrus from fumes of their superphosphate plants.[16]

The Washington State College at Pullman, Wash., studied fluorides in conjunction with its development of the Mini-Adak automatic detector.[17] This study had two objectives: First, to determine the reaction of the analyzer to the fluorides, and, second, to recommend the best method for separating fluoride pollutants from the air. The Stanford Research Institute developed a new fluoride recorder, which can measure concentrations as low as 1 or 2 parts per 10 billion within minutes.[18]

Chemically treated cloth dust collectors proved useful in reducing air pollution by gaseous fluorides in stack discharges.[19] The efficiency and low cost of the adsorption process permitted its use for reducing concentrations of fluorides previously considered too low for economic treatment. Use of these dust collectors made it possible to remove up to 99 percent of gaseous fluorides contained in industrial effluents.

The use of Freon gas in the graphitizing furnace to produce graphite of extremely high-purity for nuclear reactors was described.[20] Forced through the furnace beds, the Freon decomposes at the high graphitizing temperatures to form free fluorine and chlorine, which attack and convert the boron and vanadium impurities into volatile

---

[13] Anderson, Raymond J. (assigned to Dow Chemical Co.), Preparation of Magnesium Fluoride: U.S. Patent 2,877,095, Mar. 10, 1959.

[14] Kaufmann, H. G., Cement and Process For Making Same: U.S. Patent 2,890,129, June 9, 1959.

[15] Hillyer, John C., and Wilson, Joseph F. (assigned to Phillips Petroleum Co.), Removal of Fluorides From Industrial Waste Waters: U.S. Patent 2,914,474, Nov. 24, 1959.

[16] Rock Products, vol. 62, No. 8, August 1959, p. 14.

[17] Chemical Week, vol. 84, No. 25, June 20, 1959, pp. 48, 50.

[18] Chemical Engineering, vol. 66, No. 13, June 29, 1959, p. 76.

[19] Engineering and Mining Journal, vol. 160, No. 5, May 1959, p. 112.

[20] Chemical Engineering, Purifying Route to Nuclear-Grade Graphite: Vol. 66, No. 4, Feb. 23, 1959. pp. 114–117.

boron trifluoride and vanadium-chlorides that are then discharged from the furnace.

Union Carbide Corp. reported a new continuous process to produce uranium hexafluoride at the gaseous diffusion plant at Paducah, Ky., which it operated for AEC.[21] A mixture of gas-solid phase reactions comprised the process of H_2 reducing the UO_3 to UO_2, hydrofluorinating the UO_2 to UF_4, and fluorinating the UF_4 to UF_6.

Results of a study on the phase equilibrium of the system NaF-LiF-UF_4 at the Oak Ridge National Laboratory were published.[22]

In France, the manufacturer of glass and chemical products of Saint-Gobain, Chauny & Cirey, was reported to have produced hydrofluoric acid from low-grade fluorspar on a pilot-plant scale.[23] Fluorite was converted to a molten slag by adding alumina and then subjecting the melt to the action of water vapor in an electric furnace. Recovery of 80 percent of the fluorine content of the feed was possible after condensation of a 25–30-percent hydrofluoric acid. The HF was completely free from fluosilicic acid. Furnace-design problems were reduced by using zirconia refractories.

Sodium fluoride was used on a trial basis in fluoridating milk in Winterthur, Switzerland, to reduce dental cavities. Small quantities (2.2 mg./l.) of the sodium fluoride added to the milk did not alter its taste. Results to date were favorable.

CRYOLITE

The world's only known cryolite deposit of commercial importance was operated at Ivigtut, Greenland, by a Danish concern under a concession from the Danish Government. Part of the mine output was exported to the United States, where the ore was milled at Natrona, Pa., by the Pennsalt Chemicals Corp. Synthetic cryolite was produced in the United States by Reynolds Metals Co., at Bauxite, Ark.; the Aluminum Company of America, at East St. Louis, Ill.; Kaiser Aluminum and Chemical Corp., at Chalmette, La.; and United Heckathorn Co., at Garfield, Utah. Cryolite was reclaimed from the scrapped pot linings of aluminum reduction cells by the first three companies.

Prices as quoted in the Oil, Paint and Drug Reporter in 1959 remained unchanged from those that appeared in the Fluorspar and Cryolite chapter of Minerals Yearbook 1958.

General Services Administration announced April 3, 1959, that its stockpile of 22,423 short tons of synthetic cryolite would be offered for public sale. The supply was declared surplus to Government requirements and was eligible for disposal as a nonstrategic item.

Cryolite imports for 1950–59, shown in table 14, do not distinguish between natural and synthetic, although most of the imports from countries other than Denmark and Greenland are believed to have been synthetic cryolite.

---

[21] Chemical Engineering, Conversion of Uranium Trioxide to Uranium Hexafluoride in Three-Step Process: Vol. 66, No. 6, Mar. 23, 1959, pp. 140–143.

[22] Thoma, R. E., Insley, Herbert, Landau, B. S., Friedman, H. A., and Grimes, W. R., Phase Equilibria in the Alkali Fluoride-Uranium Tetrafluoride Fused Salt Systems: III, The System NaF-LiF-UF_4: Jour. Am. Ceram Soc., vol. 42, No. 1, January 1959, pp. 21–26.

[23] Chemical Trade Journal and Chemical Engineer (London), vol. 145, No. 3786, Dec. 25, 1959, p. 1252.

Natural and synthetic cryolite exports in 1959 totaled 176 short tons valued at $52,566, of which 121 tons at $30,652 went to Canada. Argentina, Mexico, Portugal, and the Union of South Africa received the remainder.

TABLE 14.—Cryolite imported for consumption in the United States, in short tons

[Bureau of the Census]

	Short tons	Value
1950-54 (average)	28, 991	$2, 407, 427
1955	21, 980	3, 189, 761
1956	23, 122	2, 901, 355
1957	32, 712	4, 001, 481
1958		
North America: Greenland [1]	14, 754	611, 550
Europe:		
Denmark	329	19, 721
France	662	135, 600
Germany, West	4, 240	826, 257
Italy	3, 711	647, 899
Netherlands	489	91, 172
U.S.S.R	1	260
Total	9, 432	1, 720, 909
Grand total	24, 186	2, 332, 459
1959		
North America: Greenland [1]	14, 308	739, 614
Europe:		
Belgium-Luxembourg	551	114, 750
Denmark	571	48, 418
France	150	23, 490
Germany, West	560	106, 443
Italy	5, 945	959, 039
Netherlands	17	2, 719
Total	7, 794	1, 254, 859
Grand Total	22, 102	1, 994, 473

[1] Crude natural cryolite.

Gem Stones

By John W. Hartwell[1] and Betty Ann Brett[2]

❖

GEM stones and mineral specimens produced in the United States during 1959 had an estimated value of $1,185,000, nearly 18 percent more than in 1958. This increase was primarily due to a 235-percent gain from Utah and increases from 28 other States.

New gem stone deposits continue to be found in all sections of the United States. A few old deposits, thought depleted, were reestablished as producing localities with the introduction of new mining methods.

DOMESTIC PRODUCTION

Because of the many scattered, part-time, and amateur producers of gem stones it was not possible for the Bureau to canvass all operations. Therefore, the information is based on a partial survey, and the domestic production figures given in this chapter are estimates based on available data.

Production was reported for the first time from the 50th State, Hawaii. Oregon was the leading producing State, with an estimated $200,000, the same as in 1958. Eleven States—Oregon, California, Utah, Nevada, Texas, Arizona, Wyoming, Washington, Colorado, New Mexico, and Montana—produced 88 percent of the total value.

During the year petrified wood, turquoise, jade, agate, quartz crystal, and mineral specimens, in that order, comprised about 27 percent of the value of all gem materials and mineral specimens collected. Principal varieties produced, in decreasing order by weight, were petrified wood, agate, rose quartz, unclassified mineral specimens, quartz crystals, and jasper. These materials comprised about 10 percent of the total weight collected.

Agate.—Producers in 27 States reported recovering 35 tons of agate valued at $30,000, a 10-percent decrease in weight, and a 40-percent decrease in value from 1958. Principal producing States, in decreasing order of production, were Oregon, Utah, Wyoming, California, and Texas. Gem-stone industry representatives estimated that agate production from Oregon, Washington, Idaho, and Montana ranged from 50 to 200 tons.

Jade.—Over 11,000 pounds of jade valued at $35,000 was produced during 1959. Wyoming was the leading State in value ($17,000); Alaska led in quantity (5,625 pounds). Some processed jade, mined at Dahl Creek near Kobuk, Alaska, was sold at auction at the Anchorage Fur Rendezvous, Anchorage, at prices ranging from $3 to $22

---

[1] Commodity specialist.
[2] Statistical clerk.

per pound. The average price paid for Alaskan jade, rough and uncut, was more than $2 per pound. Quantities of jade continued to be sent to West Germany for cutting and polishing.

Petrified Wood.—An estimated 350 tons of petrified wood valued at more than $100,000 was produced by 16 States during 1959—greater than three times the estimated 110 tons reported in 1958. Utah was the leading State, with nearly 200 tons valued at $60,000, followed by Arizona, Oregon, and Wyoming.

Quartz Crystal.—About 16 tons of quartz crystal valued at $10,000 was produced in 12 States. Arkansas led with over 13 tons valued at $5,000. About 11,000 carats of smoky quartz crystal valued at $1,000 was reported recovered in New Hampshire.

Turquoise.—Total U.S. production was estimated at 16,000 pounds with a value of $63,000. Arizona remained the leading producing State with 9,000 pounds valued at $18,200. The area around Globe and Miami yielded about 6,000 pounds valued at nearly $12,000. An additional 1,000 pounds valued at $2,000 was reported produced in the Cerbat Mountains in Mohave County.

In Nevada Lone Mountain Turquoise Mine, Esmeralda County, reported production of 550 pounds valued at $11,000. Total State production was nearly 1,500 pounds valued at $22,600.

The Villa Grove Lode Mine, Saguache County, Colo., reported production of 340 pounds valued at $16,000.

Miscellaneous Gem Material.—The quantity of mineral specimens produced in the United States was estimated at over 125,000 pounds valued at nearly $90,000. The principal producing States were Arizona and Colorado.

Tourmaline production at a Mesa Grande location in San Diego County, Calif., was 80 pounds valued at $7,200.

Production of 1.25 pounds of fire opal valued at $1,500 was reported from the Rainbow Ridge and Bonanza mines in Humboldt County, Nev. A new opal discovery near Yerington, Nev., was reported. One opal recovered in this deposit weighed 55 pounds.

Diamond production in Arkansas was reported at 110 carats valued at $825. During the year a 6.42 carat stone reportedly was found.

Sapphire production in North Carolina was estimated at $2,500. Montana production was reported by a mine owner to average about $6,000 per day; annual production was not given.

Rose quartz production at the Scott Mine, S. Dak., was 134,000 pounds valued at $5,000. Total U.S. production was estimated at 140,000 pounds with a value of $6,000.

The quantity and value of some other gem stones produced were: Amazonite, 2,000 pounds, $2,000; beryl specimens, 750 pounds, $1,300; fluorite, 7,000 pounds, $2,500; garnet, 500 pounds, $2,100; jasper, 23,000 pounds, $7,000; obsidian, 10,000 pounds, $6,500; peridot, 680 pounds, $1,600; and rhodonite, 9,000 pounds, $2,200.

CONSUMPTION

Consumption of diamond ($180 million) was about 28 percent higher; sales of cultured pearl ($13 million) were 25 percent higher; and sales of synthetic and imitation stones ($10 million) about 10 percent higher than 1958.

TABLE 1.—Estimated production of gem stones in the United States
(In thousand dollars)

	1958	1959		1958	1959
Alaska	(1)	$18	New Mexico	$28	$39
Arizona	$86	88	New York	8	8
Arkansas	23	18	North Carolina	1	9
California	150	150	North Dakota	1	1
Colorado	38	43	Ohio	(1)	2
Connecticut	3	5	Oklahoma	------	(1)
Florida	------	3	Oregon	200	200
Hawaii	------	(1)	Pennsylvania	2	3
Idaho	5	5	South Dakota	16	20
Illinois	1	1	Tennessee	1	------
Kansas	------	1	Texas	100	100
Maine	5	10	Utah	40	134
Maryland	2	2	Vermont	1	1
Massachusetts	------	(1)	Virginia	3	4
Michigan	------	1	Washington	75	75
Minnesota	1	------	West Virginia	1	1
Missouri	------	3	Wyoming	52	76
Montana	35	35	Other States	17	9
Nebraska	2	3			
Nevada	100	100	Total	1,006	1,184
New Hampshire	5	10			
New Jersey	4	6			

[1] Included with "Other States."

Apparent consumption (domestic production plus imports minus exports) of gem stones in the United States in 1959 was about $189 million.

PRICES

A booklet published early in 1960 listed retail replacement prices (for insurance purposes) for excellent and good quality, 1- to 40-carat, cut and polished gem stones.[3] The gem stones included agate, aquamarine, alexandrite, amazonite, amethyst, bloodstone, chrysoprase, cairngorm, citrine, diamond, emerald, garnet, hematite, jade, kunzite, labradorite, lapis lazuli, moonstone, morganite, onyx, opal, pearl, peridot, ruby, sardonyx, sapphire, synthetic gems, topaz, tourmaline, turquoise, and zircon. Prices ranged from $1 for a good quality 1-carat agate gem to $16,000 for an excellent quality 8-carat Siberian emerald, or ruby. Diamond prices were quoted for stones up to and including 3 carats.

FOREIGN TRADE[4]

Value of gem-stone imports into the United States in 1959 increased 28 percent over that of 1958. Gem diamond accounted for 85 percent of the total imports, about the same as had been reported since 1954.

Import value of natural pearls remained the same as in 1958, but cultivated pearls showed a 26-percent increase, primarily due to an increase of imports from Japan.

Emerald imports, cut but not set, showed an increase of $1.4 million, primarily because of imports from Switzerland of $1.1 million, compared with $170,300 in 1958. The average value per carat of emeralds imported from Switzerland in 1959 was $725.

---

[3] Guffey, Neal, Gem Appraisers' Guide: Lapidary Jewelers, Inc. (Georgetown), Washington, D.C., 1960, 56 pp.

[4] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

Exports of gem stones, precious and semiprecious, from the United States was \$5.6 million in 1959, compared with \$3.6 million in 1958; and reexports were \$19.6 million, compared with \$11.5 million in 1958.

TABLE 2.—Precious and semiprecious stones (exclusive of industrial diamonds) imported for consumption in the United States

[Bureau of the Census]

Item	1958		1959	
	Carats	Value (thousands)	Carats	Value (thousands)
Diamonds:				
Rough or uncut (suitable for cutting into gem stones), duty free	[1] 1,129,808	[1] \$72,563	1,599,720	\$94,299
Cut, but unset, suitable for jewelry, dutiable	718,422	[1] 68,068	928,699	86,366
Emeralds: Cut but not set, dutiable	38,848	1,100	88,875	2,450
Pearls and parts, not strung or set, dutiable:				
Natural	----------	597	----------	595
Cultured or cultivated	----------	10,347	----------	13,083
Other precious and semiprecious stones:				
Rough or uncut, duty free	----------	717	----------	678
Cut but not set, dutiable	----------	2,904	----------	3,990
Imitation, except opaque, dutiable:				
Not cut or faceted	----------	65	----------	64
Cut or faceted:				
Synthetic	----------	228	----------	243
Other	----------	9,311	----------	10,746
Imitation, opaque, including imitation pearls, dutiable	----------	17	----------	14
Marcasites: Real and imitation, dutiable	----------	26	----------	8
Total	----------	[1] 165,943	----------	212,536

[1] Revised figure.

WORLD REVIEW

World diamond production decreased 1.2 million carats below that of 1958—the first annual decrease in 13 years. Decreases from Sierra Leone (200,000 carats) and the Belgian Congo (1.8 million carats) were the principal causes of lower production. Increases in other countries reduced the difference, bringing total production to 26.8 million carats.

Sales of gem diamonds (reported by the Central Selling Organization, London, which sold about 90 percent of the world total) were \$177 million, compared with sales of \$138 million in 1958.

NORTH AMERICA

Dominican Republic.—Production and sales of amber in 1959 were about 161 pounds valued at \$520.[5]

SOUTH AMERICA

Brazil.—Possibilities of exploiting the Brazilian diamond deposits by large companies were discussed. Brazil produced only 3 percent of the world's diamonds, but deposits were known in 12 States. These deposits were worked by large numbers of individuals who used

---

[5] U.S. Embassy, Ciudad Trujillo, Dominican Republic, State Department Dispatch 354: Apr. 22, 1960, p. 1.

TABLE 3.—Diamonds (exclusive of industrial diamonds) imported for consumption in the United States, by countries

[Bureau of the Census]

Country	1958				1959			
	Rough or uncut		Cut but unset		Rough or uncut		Cut but unset	
	Carats	Value (thousands)	Carats	Value (thousands)	Carats	Value (thousands)	Carats	Value (thousands)
North America:								
Canada	8,085	$885	1,318	$103	13,322	$1,259	817	$61
Mexico	--------	--------	--------	--------	--------	--------	15	1
Total	8,085	885	1,318	103	13,322	1,259	832	62
South America:								
Argentina	290	7	10	12	508	11	--------	--------
Brazil	5,631	295	287	17	22,032	725	213	18
British Guiana	6,739	210	40	6	7,461	241	67	8
Colombia	--------	--------	--------	--------	216	5	--------	--------
Surinam	27	1	--------	--------	--------	--------	25	3
Venezuela	39,405	1,114	40	4	47,518	1,411	19	2
Total	52,092	1,627	377	39	77,735	2,393	324	31
Europe:								
Austria	--------	--------	62	9	--------	--------	220	28
Belgium-Luxembourg	192,980	12,831	455,267	40,740	398,790	20,003	538,811	50,786
France	[1] 11,581	[1] 463	7,386	898	24,373	1,257	13,981	1,461
Germany, West	784	19	35,323	2,442	2,418	57	49,400	3,438
Italy	--------	--------	119	60	1,152	28	58	14
Netherlands	8,252	983	24,046	2,927	6,900	546	35,782	3,987
Switzerland	--------	--------	279	100	3,134	91	918	433
United Kingdom	[1] 646,274	[1] 50,542	6,543	1,447	877,236	63,669	7,398	1,016
Total	[1] 859,871	[1] 64,838	529,025	48,623	1,314,003	85,651	646,568	61,163
Asia:								
Ceylon	--------	--------	142	21	--------	--------	--------	--------
Hong Kong	--------	--------	207	15	--------	--------	--------	--------
India	--------	--------	57	4	--------	--------	1,970	331
Israel	7,088	146	150,438	12,769	6,625	158	240,552	17,497
Japan	--------	--------	308	22	--------	--------	1,828	159
Lebanon	1,250	60	--------	--------	--------	--------	3	1
Singapore, Colony of	290	42	--------	--------	--------	--------	32	13
Total	8,628	248	151,152	12,831	6,625	158	244,385	18,001
Africa:								
Belgian Congo	5,025	30	--------	--------	--------	--------	--------	--------
British East Africa	479	15	--------	--------	--------	--------	--------	--------
French Equatorial Africa	6,521	224	--------	--------	1,796	85	--------	--------
French West Africa and Togo, Republic of	3,686	92	--------	--------	5,546	224	--------	--------
Ghana	72,951	553	--------	--------	43,508	404	--------	--------
Liberia	22,989	805	4	(2)	30,384	905	--------	--------
Union of South Africa	88,815	3,191	36,546	[1] 6,472	106,801	3,220	36,590	7,109
Western Portuguese Africa	666	55	--------	--------	--------	--------	--------	--------
Total	201,132	4,965	36,550	[1] 6,472	188,035	4,838	36,590	7,109
Grand total	[1] 1,129,808	[1] 72,563	718,422	[1] 68,068	1,599,720	94,299	928,699	86,366

[1] Revised figure.
[2] Less than $1,000.

TABLE 4.—World production of diamond, by countries

[In thousand carats]

Country	1958		1959	
	Gem	Industrial	Gem	Industrial
Africa:				
Angola	601	400	516	500
Belgian Congo:				
Bakwanga	304	15,700	396	13,800
Kasai	469	200	259	400
French Equitorial Africa [1]	45	60	40	60
French West Africa [1]	195	260	200	400
Ghana	1,232	2,200	876	2,200
Liberia [2]	323	500	470	500
Sierra Leone	590	900	644	650
South-West Africa	844	60	841	90
Tanganyika	231	290	274	350
Union of South Africa:				
Premier	316	960	323	950
De Beers Group	488	480	562	500
Other "pipe" mines [1]	40	70	30	70
Alluvial [1] [3]	100	100	250	150
Other regions:				
Brazil [1]	150	150	180	170
British Guiana	13	20	22	40
Venezuela	15	75	15	80
India, Borneo, Australia, U.S.S.R., and Others [1]	5	5	5	10
World total	5,961	22,430	5,903	20,920

[1] Estimate.
[2] Exports only.
[3] Including State-owned mines.

primitive recovery methods. Over 90 percent of the diamond recovered was gem stone, because little effort was made to save the small and industrial stones. Recovery of diamond by large companies may be difficult because of the low ratio of payable diamond material to worthless rock.[6]

The variety and approximate quantity of uncut gem stones exported from Brazil in 1959 are given in table 5.[7]

British Guiana.—Production of diamond in 1959 was more than 430,000 stones weighing about 62,330 carats, compared with more than 280,000 stones weighing about 33,000 carats in 1958.[8]

Colombia.—During 1958 the Banco de la Republica decided to reorganize the Muzo and Cosquez emerald mines. In mid-1959 a proposal was made by the Minister of Mines to establish the emerald mining industry as a "public utility," with exploitation rights

TABLE 5.—Gem stone exports from Brazil, uncut, 1959

Variety	Quantity (pounds)	Variety	Quantity (pounds)
Agate	357,300	Topaz	400
Amethyst	33,100	Tourmaline	600
Aquamarine	1,000	Other, n.e.s	352,800
Cat's eye	10	Diamond (carats)	25,000
Citrine	1,800		

---

[6] Mieritz, R. E., Brazil, An Untapped Diamond Source: Min. World, vol. 21, No. 1, January 1959, pp. 41–43.
[7] U.S. Embassy, Rio de Janeiro, Brazil, State Department Dispatch 1044: Apr. 28, 1960, pp. 2–3.
[8] Industrial Diamond Review (London), News in Brief: Vol. 20, No. 231, February 1960, p. 38.

reserved for the Government. Renewable 5-year contracts could be granted to private companies under government supervision.[9]

Early in 1960 it was announced that these emerald mines would be worked by a new company, The Colombia Emerald Co. This company was organized with government and private capital. (Private capital came from foreign and domestic sources.)[10]

Production of emeralds in 1958 was over 93,000 carats of third-, fourth-, fifth-, and sixth-class material; 68,000 carats was classed as Morrallas (semicrystallized product having the appearance of turquoise matrix, but green in color). Emerald production in 1957 was estimated at 12,500 carats.[11]

Venezuela.—Production of gem diamond in 1959 was 15,103 carats.[12]

EUROPE

Belgium.—A decline in recent years in the number of apprentices for some parts of the Belgium diamond industry was due to lower wages, increased production demand, and inadequate training facilities. The industry, in recognition of the importance for a number of skilled workers, was considering establishing technical schools.[13]

Imports of cuttable gem diamonds in 1959 were about 4.4 million carats valued at $102 million, compared with 4.4 million carats worth more than $90 million in 1958. Exports of cuttable and polished diamond in 1959 were about 1.1 million carats valued at $115 million. Nearly 50 percent of the polished diamond, valued at $50 million, was exported to the United States.[14]

Finland.—Gem materials found in Finland include chrome diopside, which usually occurs as nontransparent material suitable for cabochons. (Transparent crystals of this diopside are rare.) Other gem materials reportedly found were almandine, blue cordierite, staurolite, quartz crystals, and garnet.[15]

Germany, East.—Russian authorities reported opening an amber mine at Palmniken, East Germany. Production was reported at 25 to 30 tons annually.[16]

Netherlands.—The Netherland Institute of Scientific Research of Precious Stones and Pearls installed X-ray equipment to distinguish natural and cultivated pearls. Examinations were available to private individuals for a fee.[17]

U.S.S.R.—A new diamond discovery in the northern Ural Mountains was reported. These diamonds were of gem quality.[18]

The quality of diamond produced from the Yakutian area was unknown, but 80 percent of the stones were small, ranging from 0.5 to 32.5 carats. The largest found was a 54.14-carat stone. Stones

---

[9] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 1, January 1960, p. 18.
[10] Mining World, vol. 22, No. 3, March 1960, pp. 81–82.
[11] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 2, August 1959, p. 45.
[12] U.S. Embassy, Caracas, Venezuela, State Department Dispatch 942: Apr. 26, 1960, p. 1.
[13] U.S. Consulate, Antwerp, Belgium, State Department Dispatch 125: Dec. 23, 1959, 4 pp.
[14] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 6, June 1960, pp. 8–9.
[15] Laitakari, Aarne, Some Unusual Stones in Finland: Rocks and Minerals, vol. 34, No. 7–8, July-August 1959, p. 297.
[16] Mining Journal (London), vol. 253, No. 6477, Oct. 9, 1959, p. 340.
[17] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 4, October 1959, p. 40.
[18] Mining Journal (London), Russian Diamonds: Vol. 254, No. 6490, Jan. 8, 1960, p. 46.

of gem quality were rare, although enough were found to start a small-scale jewelry-making industry.[19]

United Kingdom.—The Central Selling Organization in London reported that sales of gem diamond in 1959 rose to $176,492,923 from $138,377,948 in 1958. Sales of diamond in the United States (about three-fourths of world sales) benefited from increased business activity and restocking of inventories depleted during 1958.[20]

Cairngorms, amethysts, topaz, royal blue beryl, sapphires, garnets, sard, and agates from Scotland were described.[21]

ASIA

Afghanistan.—Lapis lazuli production in 1959 was about 2 tons, compared with 1.5 tons in 1958. Unit value of cut and uncut material ranged from $41 to $136, the same as in 1958.[22]

Bahrein, State of.—Reports indicated that the value of pearl production would reach $210,000 in 1959. The pearling industry had been declining for several years owing to consumer preference for Japanese cultured pearls.[23]

Burma.—The quantity and value of gem stones produced in 1959 were: Jadeite, 47,700 pounds valued at $72,800; ruby, 15,200 carats valued at $415,800; sapphire, 438,500 carats valued at $214,600; and spinel, 73,900 carats valued at $119,100.[24]

China.—Geologists reportedly discovered a diamond deposit in the Yuan River, Province of Hunan.[25]

India.—Production of emeralds totaled 249,000 carats, compared with 80,000 in 1958, and 338,000 in 1957. Diamond production was 682 carats in 1959, 1,535 in 1958, and 790 in 1957. Other precious and semiprecious stones also were produced during these years.[26]

A directory of mines, firms, and mineral commodities of India, giving the name and address of each company owning or operating mines, was published.[27]

Israel.—Israel was able to compete in world gem-diamond trade because of a low-wage level, high rate of raw material usage, and technical improvements in its production processes. Therefore, during 1959, new workers were trained, and additional diamond-cutting and -polishing enterprises were established. The raw materials and financial assistance were supplied by the Government.[28]

Exports of polished diamond were about 470,000 carats. This was a 37-percent increase over the 1958 production of 341,000 carats.[29]

---

[19] Katkoff, V. Russia's Diamond Strike, How Potent?: Jewelers' Circ.-Keystone, vol. 129, No. 7, April 1959, pp. 85–91.

[20] Wall Street Journal, vol. 155, No. 5, Jan. 8, 1960, p. 15.

[21] Rhodesian Mining Journal, Gem Stones of Scotland: Vol. 30, No. 378, November 1958, p. 312.

[22] U.S. Embassy, Kabul, Afghanistan, State Department Dispatch 199: Apr. 9, 1960, p. 1.

[23] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 1, January 1960, p. 18.

[24] U.S. Embassy, Rangoon, Burma, State Department Dispatch 520: Apr. 27, 1960, Encl. 1, p. 1.

[25] Jewelers' Circular-Keystone, Briefly: Vol. 129, No. 12, September 1959, p. 144.

[26] U.S. Embassy, New Delhi, India, State Department Dispatch 1431; June 4, 1959, p. 35; Dispatch 1006: Apr. 25, 1960, Encl. 1, p. 1.

[27] Mine and Quarry Engineering (London), List of Indian Mines: Vol. 25, No. 6, June 1959, p. 281.

[28] Gemmologist, Report From Israel; Vol. 28, No. 338, September 1959, pp. 177–178.

[29] South African Mining and Engineering Journal (Johannesburg), Israeli Diamond Exports: Vol. 71, No. 3500, Mar. 4, 1960, p. 551.

Japan.—Pearl exports in 1959 were valued at nearly $29 million, an increase of $6 million over 1958.[30] Higher prices were expected because a typhoon in September 1959 caused about $15 million damage to the pearl industry. A shortage of quality cultured pearls might result for 2 to 5 years.[31]

A short history of the cultured-pearl industry of Japan, and recent techniques introduced by the industry, was reported.[32]

Thailand.—About 1 million carats of gem stones was imported in 1959, compared with 6.9 million in 1958. Of the 1959 imports, 99 percent were "precious and semiprecious stones, including synthetics, cut but not set, n.e.c." Exports, 1.1 million carats in 1958, rose to 3.4 million carats in 1959. Exports in 1959 included uncut sapphires (163,000 carats), cut sapphires (314,000 carats), and cut zircons (217,000 carats).[33]

AFRICA

French West Africa.—Upper Guinea has many alluvial diamond deposits, about which production data are not available. However, two mining companies, Soginex, a De Beers subsidiary, and Compagnie Miniere de Beyla, a French company, exported about 52,000 carats of gem diamond in 1959.[34]

Rhodesia and Nyasaland, Federation of.—Vulcan Minerals (Pvt.), Ltd., sold its emerald deposit in the Belingwe district of Southern Rhodesia to Rio Tinto Ltd. The new owner planned to make a geological and mining survey of the area.[35]

Amethyst production in 1958 was about 3,800 pounds valued at $462, reported by the Northern Rodesian Department of Mines.[36]

South-West Africa.—Gem-diamond exports in 1959 were 819,351 carats valued at $42,530,000. Other gem materials produced were rose quartz (4.25 tons), tourmaline (41.3 pounds), chalcedony (670 pounds), topaz (20,300 pounds), and amethyst. Almost 3 tons of amethyst valued at $1,176 was exported.[37]

Tanganyika.—The Tanganyika Corundum Corp. produced a few small specimens from its ruby-corundum claim acquired in 1958.[38]

A three-part historical and operational account of the Williamson Diamond mine was given. Part one described the property and the services rendered to the community. Part two discussed geology and mining operations. Part three gave information on the process of concentrating diamond.[39]

---

[30] Foreign Commerce Weekly, Japanese Pearl Exports Set Record in 1959: Vol. 63, No. 5, Feb. 1, 1960, p. 29.

[31] Wall Street Journal, Cultured Pearl Sales Expected to Rise in '60 Despite Higher Prices: Vol. 155, No. 9, Jan. 14, 1960, p. 19.
Jewelers' Circular Keystone, Japan Typhoon Will Cause Pearl Shortage: Vol. 130, No. 4, January 1960, p. 116.

[32] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 1, January 1960, pp. 18–24.

[33] U.S. Embassy, Bangkok, Thailand, State Department Dispatch 552: Mar. 30, 1960, Encl. 10, p. 1; Dispatch 673: May 27, 1959, Encl. 10, p. 1.

[34] U.S. Embassy, Canakry, Republic of Guinea, State Department Dispatch 242: Mar. 30, 1960, p. 10.

[35] South African Mining and Engineering Journal (Johannesburg), Rio Tinto and Emeralds: Vol. 70, No. 3482, Nov. 6, 1959, p. 1153.

[36] U.S. Consulate, Johannesburg, Union of South Africa, State Department Dispatch 78: Sept. 29, 1959, Encl. 1, p. 1.

[37] U.S. Consulate, Johannesburg, Union of South Africa, State Department Dispatch 252: Mar. 31, 1960, p. 1.

[38] Mining Magazine (London), Tanganyika Mining Industry, 1959: Vol. 102, No. 3, March 1960, p. 161.

[39] Du Toit, G. J., The Williamson Diamond Mine: Mine and Quarry Eng. (London), vol. 25, No. 3, March 1959, pp. 98–103; No. 4, April 1959, pp. 146–153; No. 5, May 1959, pp. 194–200.

Union of South Africa.—Production of emerald crystals totaled 145 pounds in 1958, compared with 13 pounds in 1957. The leading producer in 1958 was the African Emerald Mining Co. (Pty.), Ltd., Pretoria. Tigers-eye production in 1958 and 1957 was 20 and 40 short tons, respectively.[40]

OCEANIA

Australia.—All important gem stones except ruby and jade have been found in Australia. However, only opal and to a lesser extent sapphire, diamond, and emerald have been recovered commercially.

The principal opal- producing areas were Coober Pedy and Andamooka in South Australia, Lightning Ridge and White Cliffs in New South Wales, and the Hayrick mine near Quilpie, Queensland.

TABLE 6.—Exports of opal from Australia[1] by destination

Country	1954	1955	1956	1957	1958
Ceylon	$20,906	$48,010	$22,340	$19,889	$17,703
Germany, West	55,662	64,180	76,715	143,777	156,507
Hong Kong	511	17,284	24,201	23,598	6,982
Japan	645	12,947	115,752	244,966	369,531
New Zealand	1,485	4,382	710	3,689	2,437
United Kingdom	5,103	7,397	2,860	27,554	12,611
Other British countries	3,519	7,775	981	18,543	5,519
United States	114,406	109,912	127,725	130,442	166,640
Other	1,861	3,559	18,106	34,769	49,076
Total	204,098	275,446	389,390	647,227	787,006

[1] Converted from Australian Mineral Industry, Quarterly Review: Vol. 12, No. 2, pt. 1, November 1959, p. 24.

Sapphire has been produced from the Anakie field, Queensland, and the Inverell district of northeastern New South Wales. In 1920 gems valued at $125,000 were produced in the Anakie field; however, by 1958 the annual production value had fallen to about $1,800. The sapphire was found in the form of water-worn fragments, presumably liberated from basalt deposits. Other gem stones found in these alluvial deposits were green, yellow, and orange-yellow transparent to translucent corundum.

In 1959 Tungsten Consolidated Ltd., bought 40 percent interest in an Inverell sapphire deposit. While developing the property, more than 100 ounces of gem-quality corundum was produced per week; about 30 ounces was cuttable.

Diamond was small, off color, and not of gem quality. The principal producing areas were Copeton, Bingara, and Cudgegong fields of New South Wales.

Emerald production also was small. The principal producing area was near Poona, Western Australia.

Complete statistical information on Australian and Japanese pearl-fishing operations in areas off the Australian coast were compiled by the Australian Fisheries Division, Department of Primary Industry. These statistics, published in two volumes, covered the

---

[40] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 6, December 1959, pp. 41–42.

industry from mid-19th century through 1957. Annual supplements were planned for succeeding years.[41]

Pearl production values from 1954 to 1957 were $8,192, $7,493, $16,173, and $28,067, respectively. Ornamental shell (mother-of-pearl, trochus, and green snail) production for fiscal year 1957–58 was 2,809 short tons, about $2.9 million in value.[42]

French Oceania.—Mother-of-pearl shell exports totaled 535 short tons at $795,000 in 1957, and 693 tons at $1,132,000 in 1956. About 85 percent of the exports were to France and West Germany.[43]

TECHNOLOGY

A guide to the minerals and rocks of Minnesota was published.[44]

The quartz family minerals, including the phanero and cryptocrystalline varieties found in California, were described. General references also were included.[45]

The geographical, geological, morphological, and economic conditions of the important mineral deposits of the Burmese Union were discussed. These minerals included precious gem stones and jade.[46]

An occurrence of jadeite in Kotaki, Niigata Prefecture, Japan, and its association with albite and a calciferous rock was studied. It was stated that albite placed under high pressure was transformed into jadeite with liberation of SiO_2.[47]

Studies were made on rocks from the west slope of the Urals containing genetic accessory minerals which accompany diamond in Ordovician gravels.[48]

A pale green, fine-grained, ornamental rock from the Transvaal, Union of South Africa, known as South African jade, and another type of garnet, uvarovite, were described.[49]

The Jewelers' Circular-Keystone magazine, beginning with the January 1959 issue, gave facts and legends about birthstones for each month of the year. These gem stones in chronological order were garnet, amethyst, aquamarine, diamond, emerald, pearl, ruby, sardonyx, sapphire, opal, topaz, and turquoise.

Each monthly issue of the Mine and Quarry Engineering (London) journal beginning with October 1953 described a mineral, giving the synonyms, nomenclature, varieties, composition, crystallography, physical and optical properties, tests, diagnoses, occurrences, and uses. Each mineral was illustrated in color. In the 1959 issues the minerals in chronological order were: Ilmenite, aragonite, tourmaline, adamite,

---

[41] U.S. Embassy, Canberra, Australia, State Department Dispatch 509: June 22, 1959, 2 pp.

[42] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 1, January 1960, pp. 16–17.

[43] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 4, October 1959, p. 40.

[44] Schwartz, G. M., and Thiel, G. A., Guide to the Minerals and Rocks of Minnesota: Univ. of Minnesota, 1958, pp. 1–26.

[45] California Division of Mines, Quartz Family Minerals: Min. Inf. Service, vol. 12, No. 4, April 1959, pp. 1–5.

[46] Jungwirth, Josef, Mining in Burmese Union—Present Status and Development Possibilities: Berg-u hüttenmänn. Monatsh. montan. Hochschule Leoben, vol. 104, 1959, pp. 143–151; Chem. Abs., vol. 53, No. 21, Nov. 10, 1959, col. 19721b.

[47] Shido, Fumiko, Calciferous Amphibole Rich in Sodium From Jadeite Bearing Albite of Kotaki, Niigata Prefecture: Chishitsugaku Zasshi (Tokyo), No. 64, 1958, pp. 595–600; Chem. Abs., vol. 53, No. 11, June 10, 1959, col. 9914c.

[48] Verbitskaya, N. P., and Gapeeva, G. M., Possible Sources of Diamonds in Alluvial Deposits of the West Slope of the Urals: Razvedka i Okhrana Nebr., vol. 25, No. 3, 1959, pp. 8–12; Chem. Abs., vol. 53, No. 18, Sept. 25, 1959, col. 16840e.

[49] Frankel, J. J., Uvarovite Garnet and South African Jade (Hydrogrossular) From the Bushveld Complex, Transvaal: Am. Mineral., vol. 44, No. 5–6, May–June 1959, pp. 565–591.

campylite, asbestos, autunite, analcime, epidote, anglesite, prehnite, and niccolite.

An inexpensive cardboard-mounted dichroscope was offered for sale in the latter part of 1959. This simple instrument helps in identifying colored stones and in distinguishing many synthetic from natural gems.[50]

An article on the atomic structure of diamond crystal presented new knowledge and led to a better understanding of the properties of diamonds. Also, current theories concerning the hardness of diamond were given.[51]

Sizable diamonds have been sold that were coated in such a way that some of the objectionable color was absorbed or neutralized. The coating made the stones appear whiter and therefore more valuable. Methods of restoring the original color and the efforts of the Jewelers Vigilance Committee to discover some simple optical test to detect the coatings was reported.[52]

Four types of facets may be made when recutting diamonds with old-fashioned designs. This recutting is said to give better refraction but causes a weight loss of 10 to 50 percent.[53]

The refractive indices, absorption coefficients, and biabsorption were determined for two synthetic ruby samples, one colored pink by 0.11 percent Cr_20_3 (chromic oxide) and the other colored deep red by 1.40 percent Cr_20_3.[54]

A method for making rubies, similar to the hydrothermal growth technique used to make emeralds, was announced. About 2 years was required to produce these rubies, and they were made in batches of 3,000 to 4,000 carats. Emeralds could be manufactured in about a year.[55]

White sapphires reported to be more perfect than natural stones were produced by the Bell Telephone Laboratories.[56]

Studies were made on unusual star-beryl, which contained a multitude of crystal inclusions.[57]

A study was made of the directional variation of grinding hardness in strontium titanate.[58]

Chrysoberyl and its special optical properties were described.[59]

Care and restoration of pearl luster were explained. Scratch hardness of pearls, tested with a sceleroscope, is 58 to 64 compared with 178 for quartz, 304 for spinel, and 667 for ruby.[60]

---

[50] Pough, F. H., New Low-Cost Dichroscope on Market—Or You Can Make Your Own: Jewelers' Circ.-Keystone, vol. 129, No. 11, August 1959, pp. 172, 174.

[51] Wedepohl, P. T., Why Diamonds Are So Hard: Jewelers' Circ.-Keystone, vol. 129, No. 11, August 1959, pp. 132–133, 188, 190, 192, 195.

[52] Jewelers' Circular-Keystone, More Gyps Now "Coat" Diamonds, JVC Warns: Vol. 129, No. 12, September 1959, p. 159.

[53] Deutcher Goldschmiede Zeitung (Stuttgart), [Re-cutting Diamonds]: Vol. 57, No. 9, September 1959, p. 499; Ind. Diamond Abs., vol. 16, November 1959, p. A212.

[54] Mandarino, J. A., Refraction, Absorption, and Biabsorption in Synthetic Ruby: Am. Mineral., vol. 44, No. 9–10, September–October 1959, pp. 961–973.

[55] Jewelers' Circular-Keystone, "Cultured" Rubies Shown to Jewelers by Chatham: Vol. 129, No. 12, September 1959, p. 158.

[56] Science Newsletter, Sapphires Brewed in "Pressure Cooker": Vol. 76, No. 10, Sept. 5, 1959, p. 152.

[57] Eppler, W. F., An Unusual Star-Beryl: Jour. Gemmology (London), vol. 7, No. 5, January 1960, pp. 183–191; Ind. Diamond Abs., vol. 17, March 1960, p. A61.

[58] Giardini, A. A., and Conrad, M. A., Directional Hardness of Strontium Titanate by Peripheral Grinding: Ceram. Abs., vol. 42, No. 4, April 1959, pp. 165–168.

[59] Webster, R., The Prized Chrysoberyl: Gemmologist (London), vol. 28, No. 339, October 1958, pp. 190–194.

[60] Jewelers' Circular-Keystone, Why Pearls Deserve Loving Care: Vol. 129, No. 9, June 1959, p. 68.

A conference on crystal growth was held at the Institute of Crystallography, Academy of Sciences, U.S.S.R., during 1959. Talks were given on hydrothermal synthesis of quartz and methods for crystallization at ultrahigh pressures.[61]

An apparatus for extracting diamond from concentrates was patented in the U.S.S.R.[62]

A method was patented for examining and classifying gem diamond, which also produced a record by means of which the diamond could be positively identified.[63]

A patent was issued on a process for manufacturing synthetic gems.[64]

Artificial gem stones were made by pulverizing colored ceramics, porcelain, and glass, pressing the powder into briquets with or without binders, and firing the briquets at 950° to 1,300° C. The fired material was then worked into finished gem stones by cutting, grinding, engraving, polishing, and boring.[65]

---

[61] Central Intelligence Agency, A. U.S.S.R. Conference on the Growth of Crystals: Sci. Inf. Rept. PB131891 T–30, Sept. 18, 1959, pp. 37–39.

[62] Dubinskii, S. A., Shvetsov, G. F., and Khaidarov, A. A., Apparatus for Extraction of Diamonds from Concentrates: U.S.S.R. Patent 113,055, Aug. 15, 1958; Chem. Abs., vol. 53, No. 3, Feb. 10, 1959, col. 2511d.

[63] Samuels, A. S., Sr., Method of Examining and Classifying Diamonds: U.S. Patent 2,909,961, Oct. 27, 1959.

[64] Kato, Ichiro, Ultrahigh-Pressure Furnace for Manufacture of Synthetic Gems: Japanese Patent 9960, Nov. 19, 1958; Chem. Abs., vol. 53, No. 5, Mar. 10, 1959, col. 4619b.

[65] Weichel, Fritz, and Maurer, Karl, Gem Stones From Ceramics, Porcelain, and (or) Glass: German Patent 936,739, Dec. 22, 1955; Chem. Abs., vol. 53, No. 3, Feb. 10, 1959, col. 2511e.

Gold

By J. P. Ryan [1] and Kathleen M. McBreen [2]

⁂

DOMESTIC mine production of gold in 1959 was 1.6 million ounces valued at $56.1 million, a decrease of 8 percent and the lowest since 1892, except for the war years 1943–46. World gold production gained 5 percent over 1958 and rose for the sixth successive year reaching a record 42.8 million ounces valued at $1,498 million.

The drop in domestic output resulted principally from strikes at major copper mines that recover gold as a byproduct but lower production was also recorded from gold mines.

The increase in world production was attributed again almost entirely to greater output from South African gold mines. This more than offset lower production in the United States and Canada.

Consumption of gold in the arts and industries of the United States increased 38 percent to 2.5 million ounces valued at $88 million, about 57 percent more than domestic mine production.

Outflow of gold from U.S. reserve continued at a high rate for the second successive year because of a balance-of-payments deficit that increased about $0.7 billion in 1959 to $3.7 billion. About $1 billion of the 1959 deficit was met by delivery of gold, and U.S. gold reserve dropped to $19.5 billion. Estimated free-world gold reserve gained $0.8 billion and reached $40.7 billion at the yearend.

Nearly all restrictions on gold trading in the London gold market were dropped, and turnover increased substantially over 1958. The U.S.S.R. sold on the London market in 1959 over 7 million ounces of gold valued at $245 million.

LEGISLATION AND GOVERNMENT PROGRAMS

Several bills were again introduced in the 86th Congress, 1st Session, to (1) permit free marketing of gold and to increase the price paid to domestic producers to $70 an ounce, (2) authorize unrestricted private transactions in gold and limit its use by the Treasury or Federal Reserve banks to monetary purposes exclusively, and (3) provide for a return to the gold standard with free coinage of gold and redemption of currency. These bills were referred to the respective Committees on Banking and Currency of the House of Representatives and the Senate. As in 1958, joint resolutions were introduced to establish a

---

[1] Commodity specialist.

[2] Statistical assistant.

commission to study the domestic gold-mining industry and to recommend legislation. The resolutions were referred to the respective House and Senate Committees on Interior and Insular Affairs. A bill (S. 2285) introduced in the Senate, referring to the U.S. Court of Claims matters relative to compensation for losses incurred as a result of restrictions imposed by War Production Board Limitation Order L-208, was referred to the Committee on the Judiciary. No further action was taken on any of the proposed legislation.

TABLE 1.—Salient gold statistics

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Mine production___thousand ounces__	2,013	1,880	1,827	1,794	1,739	1,604
Value_________________thousands__	$70,445	$65,805	$63,951	$62,776	$60,874	$56,133
Ore (dry and siliceous) produced:						
Gold ore____thousand short tons__	2,595	2,234	2,255	2,359	2,411	2,289
Gold-silver ore______________do____	233	120	245	116	107	137
Silver ore__________________do____	571	570	687	712	639	597
Percentage derived from—						
Dry and siliceous ores_____________	41	41	42	43	47	50
Base-metal ores___________________	36	37	39	38	32	28
Placers___________________________	23	22	19	19	21	22
Imports___________thousand ounces [1]__	6,108	2,930	3,730	7,701	8,120	8,485
Exports_______________________do____	6,863	162	734	4,806	886	50
Monetary stocks (end of year) millions [2]__	----------	$21,690	$21,949	$22,857	$20,582	$19,507
Net consumption in industry and the arts______________thousand ounces__	2,189	1,300	1,400	1,450	1,833	2,522
Price, average, per troy ounce [3]________	$35.00	$35.00	$35.00	$35.00	$35.00	$35.00
World: Production thousand ounces (estimated)__	33,800	36,300	38,400	39,600	[4] 40,600	42,800

[1] Excludes coinage.
[2] Owned by Treasury Department; privately held coinage not included.
[3] Price under authority of Gold Reserve Act of Jan. 31, 1934.
[4] Revised figure.

DOMESTIC PRODUCTION

Continuing the postwar trend, output of recoverable gold of the U.S. mines dropped 8 percent to 1.6 million ounces valued at $56.1 million. The drop was the fourth successive annual decline in production, and output was at the lowest level in peacetime since 1892. Most of the decrease was attributed to strikes at copper mines recovering gold as a byproduct, particularly in Arizona and Utah, but part of the decrease reflected lower output by gold mines, especially by placer mines in Alaska and California. Of the total production, 50 percent was recovered from precious metal ores, 22 percent from placers, and 28 percent as a byproduct of base-metal ores.

South Dakota continued to lead in gold production by a wide margin, followed by Utah, Alaska, and California, the same as in 1958. These four States produced 71 percent of the total. As in preceding years, nearly all the gold from South Dakota came from gold ore at the Homestake mine; gold production in Utah was almost entirely a byproduct of base-metal ores, chiefly copper ore at the Utah Copper mine; Alaska gold was recovered from placers, chiefly by bucketline dredging; and California production came almost exclusively from both placer and lode gold mines.

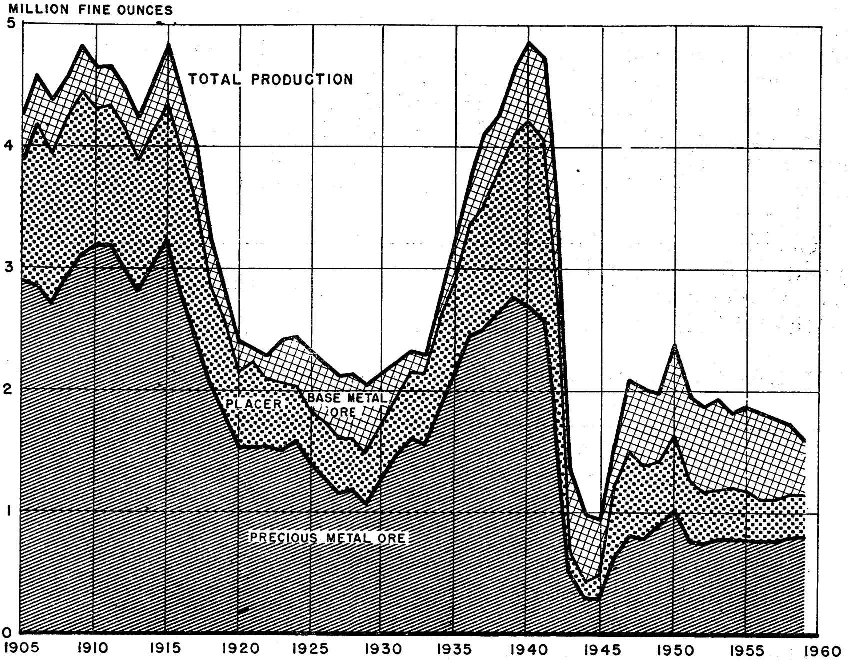

FIGURE 1.—Gold production in the United States, 1905–59.

TABLE 2.—Gold produced in the United States according to mine and mint returns, in troy ounces of recoverable metal

	1950–54 (average)	1955	1956	1957	1958	1959
Mine	2,012,721	1,880,142	1,827,159	1,793,597	1,739,249	1,603,802
Mint	1,987,887	1,876,830	1,865,200	1,800,000	1,759,000	1,635,000

TABLE 3.—Mine production of gold in the United States in 1959, by months

Month	Troy ounces	Month	Troy ounces
January	143,950	August	145,236
February	129,176	September	114,991
March	136,183	October	104,822
April	142,043	November	102,800
May	157,574	December	94,409
June	163,781		
July	168,837	Total	1,603,802

Of the 25 leading gold producers in the United States, 9 were lode gold mines, 7 placer gold mines, 6 copper mines, 2 lead-zinc mines, and a copper-lead-zinc mine. The 25 leading mines supplied about 90 percent of domestic output.

The Homestake mine, the largest domestic gold producer, reported the highest annual production in its 82 years of operation. Output of 573,384 ounces, valued at $20 million, brought the total output of the mine to 24.4 million ounces valued at $855.7 million. The company reported an estimated ore reserve at yearend of 13.8 million tons with an average grade of $12.40 a ton, compared with 13.2 million tons with a grade of $12.30 a ton, at the end of 1958.

According to preliminary data compiled by the Bureau of Mines, approximately 5,200 persons were employed in the gold, and gold-silver mining industry in 1959 at 800 lode and placer mines and mining operations.

Classification methods of recovery, and metal yields of all gold-yielding ores in the United States in 1959 are given in tables 6 to 9. Terminology used in classifying ores is described in the Gold chapter of the 1954 Minerals Yearbook.

TABLE 4.—Twenty-five leading gold-producing mines in the United States in 1959, in order of output

Rank	Mine	District or region	State	Operator	Source of gold
1	Homestake	Whitewood (Lead).	South Dakota	Homestake Mining Co.	Gold ore.
2	Utah Copper	West Mountain (Bingham).	Utah	Kennecott Copper Corp.	Copper ore.
3	Knob Hill & Gold Dollar.	Republic	Washington	Knob Hill Mines, Inc.	Gold ore.
4	Fairbanks Unit	Fairbanks	Alaska	U.S. Smelting, Refining & Mining Co.	Dredge.
5	Yuba Unit	Yuba River	California	Yuba Consolidated Industries, Inc.	Do.
6	Round Mountain	Round Mountain	Nevada	Round Mountain Gold Dredging Corp.	Do.
7	New Cornelia	Ajo	Arizona	Phelps Dodge Corp.	Copper, gold-silver ores.
8	Copper Queen-Lavender Pit.	Warren	do	do	Copper ore.
9	Gold King	Wenatchee River	Washington	Lovitt Mining Co., Inc.	Gold ore.
10	Iron King	Big Bug	Arizona	Shattuck Denn Mining Co.	Lead-zinc ore.
11	Nome Unit	Nome	Alaska	U.S. Smelting, Refining & Mining Co.	Dredge.
12	Natomas	American River (Folsom).	California	The Natomas Co.	Do.
13	Ajax	Cripple Creek	Colorado	Golden Cycle Corp.	Gold ore.
14	Treasury Tunnel-Black Bear-Smuggler Union.	Upper San Miguel	do	Idarado Mining Co.	Copper-lead-zinc ore.
15	Liberty Pit	Robinson	Nevada	Kennecott Copper Corp.	Copper ore.
16	Hogatza River	Hughes	Alaska	U.S. Smelting, Refining & Mining Co.	Dredge.
17	Brush Creek	Sierra County	California	Best Mines Co., Inc.	Gold ore.
18	Nyac	Aniak	Alaska	New York-Alaska Gold Dredging Co.	Dredge.
19	San Manuel	Old Hat	Arizona	San Manuel Copper Corp.	Copper ore.
20	Goldacres	Bullion	Nevada	The London Extension Mining Co.	Gold ore.
21	Magma	Pioneer	Arizona	Magma Copper Co.	Copper ore.
22	United States and Lark.	West Mountain (Bingham).	Utah	U.S. Smelting, Refining & Mining Co.	Gold-silver, lead, lead-zinc ores.
23	Siskon	Klamath River	California	Siskon Corp.	Gold ore.
24	Sixteen to One	Sierra County	do	Original Sixteen to One Mine, Inc.	Do.
25	West Mayflower	Cedar Hollow	Montana	Estate of Peter Antonioli.	Do.

TABLE 5.—Mine production of recoverable gold in the United States, by States, in troy ounces

State	1950-54 (average)	1955	1956	1957	1958	1959
Alaska	254,322	249,294	209,296	215,467	186,435	178,918
Arizona	114,879	127,616	146,110	152,449	142,979	124,627
California	296,501	251,737	193,816	170,885	185,385	146,141
Colorado	117,370	88,577	97,668	87,928	79,539	61,097
Idaho	37,718	10,572	9,210	12,301	15,896	10,479
Montana	30,971	28,123	38,121	32,766	26,003	28,551
Nevada	119,510	72,913	68,040	76,752	105,087	113,443
New Mexico	3,295	1,917	3,275	3,212	3,378	3,155
North Carolina	43	190	882	1,373	876	965
Oregon	7,900	1,708	2,738	3,381	1,423	686
Pennsylvania	1,579	1,610	(1)	(2)	(2)	(2)
South Dakota	517,013	529,865	568,523	568,130	570,830	577,730
Tennessee	204	221	189	172	124	99
Texas	24	----------	----------	----------	----------	----------
Utah	442,421	441,206	416,031	378,438	307,824	239,517
Vermont	164	181	[1] 1,829	62	----------	----------
Washington	68,720	74,360	70,669	[2] 89,708	[2] 113,353	[2] 118,394
Wyoming	83	52	762	573	117	----------
Total	[3] 2,012,721	1,880,142	1,827,159	1,793,597	1,739,249	1,603,802

[1] Production in Pennsylvania and Vermont combined.

[2] Production in Pennsylvania and Washington combined.

[3] Includes 4 oz. from Maryland.

TABLE 6.—Ore, old tailings, etc., yielding gold, produced in the United States, and average recoverable content in troy ounces of gold per ton in 1959

State	Gold ore		Gold-silver ore		Silver ore		Copper ore	
	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton
Alaska	564	1.096					53	
Arizona	11,758	.029	68,959	0.014	66,247		53,155,199	0.018
California	138,599	.275			137	0.153	860	[2].238
Colorado	71,443	.457	606	.061	5,762	.004	17,378	.136
Idaho	1,133	.372	33	.303	435,760	.002	379,563	.015
Montana	12,328	.673	2,830	.142	27,141	.032	8,069,191	.002
Nevada	174,770	.097	47	.255	57,792	.064	8,547,263	.003
New Mexico	52	.038	25,543	.056	529	.008	4,593,458	
Oregon	356	.663						
South Dakota	1,778,316	.325						
Utah			38,877	.010	3,117	.011	19,678,903	.011
Undistributed [3]	99,387	1.180	115	.009	23	.043	235,196	.004
Total	2,288,706	.346	137,010	.024	596,508	.009	94,677,064	.004

State	Lead ore		Zinc ore		Zinc-lead, zinc-copper, and zinc-lead-copper ores		Total ore	
	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton
Alaska							617	1.002
Arizona	4,087	0.017	16,139	0.002	442,446	[1] 0.061	53,764,835	.002
California	485	.019			1,555	.021	141,636	.271
Colorado	13,204	.142	67		660,863	.033	769,323	.077
Idaho	84,927	.007	98,937		833,352	.001	1,833,705	.005
Montana	17,560	.008	648,214	.008	1,438	.044	8,778,702	.003
Nevada	6,713	.289			1,034	.009	8,787,619	.005
New Mexico	7,723	.003	60,594		9,735	.001	4,697,634	.001
Oregon							356	.663
South Dakota							1,778,316	.325
Utah	2,042	.090	33,675		469,459	[1].032	20,226,073	.012
Undistributed [3]	114		400		2,338,881		[4] 2,674,116	[4].044
Total	136,855	.035	858,026	.006	4,758,763	.014	103,452,932	.012

[1] Includes gold recovered from uranium ore.

[2] Includes gold recovered from tungsten ore.

[3] Includes North Carolina, Tennessee and Washington.

[4] Excludes magnetite-pyrite-chalcopyrite ore and gold therefrom in Pennsylvania.

TABLE 7.—Mine and refinery production of gold in the United States in 1959, by States and sources, in troy ounces of recoverable metals

State	Mine production							Refinery production[1]
	Placers	Dry ore	Copper ore	Lead ore	Zinc ore	Zinc-lead, zinc-copper, lead-copper, and zinc-lead-copper ores	Total	
Alaska	178,300	618	----------	--------	--------	------------	178,918	177,400
Arizona	77	1,325	96,189	68	27	[2] 26,941	124,627	114,100
California	107,773	38,121	[3] 205	9	--------	33	146,141	147,800
Colorado	2,006	32,737	2,357	1,870	--------	22,127	61,097	58,350
Idaho	1,967	1,295	5,626	597	10	984	10,479	9,000
Montana	1,002	9,565	12,917	140	4,864	63	28,551	30,600
Nevada	66,999	20,638	23,858	1,939	--------	9	113,443	123,600
New Mexico	1	1,424	1,688	25	4	13	3,155	2,990
North Carolina	----------	----------	965	--------	--------	------------	965	1,150
Oregon	450	236	----------	--------	--------	------------	686	800
Pennsylvania[4]	----------	----------	----------	--------	--------	------------	------------	850
South Dakota	----------	577,730	----------	--------	--------	------------	577,730	588,000
Tennessee	----------	----------	----------	--------	--------	99	99	270
Utah	----------	406	223,708	183	5	[2] 15,215	239,517	267,900
Vermont	----------	----------	----------	--------	--------	------------	------------	10
Washington[5]	1	117,283	1,110	--------	--------	------------	118,394	112,180
Total	358,576	801,378	368,623	4,831	4,910	65,484	1,603,802	1,635,000
Percent	22.3	50.0	23.0	.3	.3	4.1	100	------------

[1] U.S. Bureau of the Mint.

[2] Includes gold recovered from uranium ore.

[3] Includes gold recovered from tungsten ore.

[4] Included with Washington.

[5] Includes gold recovered from magnetite-pyrite-chalcopyrite ores in Pennsylvania.

TABLE 8.—Gold produced in the United States from ore and old tailings, in 1959, by States and methods of recovery, in terms of recoverable metal

State	Total ore, old tailings, etc. treated (short tons)	Ore and old tailings to mills					Crude ore to smelters	
		Short tons	Recoverable in bullion		Concentrates smelted and recoverable metal			
			Amalgamation (troy ounces)	Cyanidation (troy ounces)	Concentrates (short tons)	Troy ounces	Short tons	Troy ounces
Alaska	617	564	618	----------	----------	----------	53	--------
Arizona	53,764,835	53,200,557	7	4,253	1,668,945	96,243	564,278	24,047
California	141,636	138,433	25,760	8,156	1,933	3,656	3,203	796
Colorado	769,323	745,023	6,686	31,423	103,447	18,321	24,300	2,661
Idaho	1,833,705	1,746,726	106	----------	209,571	8,093	86,979	313
Montana	8,778,702	8,685,007	29	----------	338,590	18,401	93,695	9,119
Nevada	8,787,619	8,748,089	703	19,084	168,732	23,394	39,530	3,263
New Mexico	4,697,634	4,620,918	----------	----------	160,119	1,701	76,716	1,453
Oregon	356	351	123	----------	10	83	5	30
South Dakota	1,778,316	1,778,316	425,788	151,942	----------	----------	----------	--------
Utah	20,226,073	20,142,679	----------	----------	592,321	238,846	83,394	671
Undistributed[1]	[2] 2,674,116	[2] 2,642,145	37	21,188	[2] 130,662	69,064	31,971	29,168
Total	103,452,932	102,448,808	459,857	236,046	3,374,330	477,802	1,004,124	71,521

[1] Includes North Carolina, Pennsylvania, Tennessee, and Washington.

[2] Excludes magnetite-pyrite-chalcopyrite ore and concentrates therefrom in Pennsylvania.

TABLE 9.—Gold produced at amalgamation and cyanidation mills in the United States and percentage of gold recoverable from all sources

	Bullion and precipitates recoverable (troy ounces)		Gold from all sources (percent)			
	Amalgamation	Cyanidation	Amalgamation	Cyanidation	Smelting [1]	Placers
1950–54 (average)	462, 358	267, 016	23. 0	13. 3	40. 3	23. 4
1955	445, 135	268, 600	23. 7	14. 3	40. 2	21. 8
1956	439, 180	270, 785	24. 0	14. 8	42. 2	19. 0
1957	435, 387	257, 008	24. 3	14. 3	42. 3	19. 1
1958	446, 886	245, 397	25. 7	14. 1	38. 9	21. 3
1959	459, 857	236, 046	28. 7	14. 7	34. 3	22. 3

[1] Both crude ores and concentrates.

TABLE 10.—Gold production at placer mines in the United States, by method of recovery

Method	Mines producing	Washing plants (dredges)	Material treated (thousand cubic yards)	Gold recoverable		
				Thousand troy ounces	Value (thousands)	Average value per cubic yard
Bucketline dredging:						
1950–54 (average)	32	52	79, 760	391	$13, 684	$0. 172
1955	25	20	53, 352	348	12, 185	. 228
1956	19	32	48, 955	295	10, 310	. 210
1957	18	33	45, 489	297	10, 402	. 229
1958	17	31	43, 693	287	10, 038	. 230
1959	16	30	36, 998	251	8, 767	. 237
Dragline dredging:						
1950–54 (average)	19	18	2, 024	9	315	. 156
1955	19	7	480	3	103	. 214
1956	16	7	774	3	88	. 113
1957	13	14	[1] 378	2	55	. 145
1958	11	11	[1] 132	1	40	. 301
1959	12	12	[1] 157	2	73	. 464
Suction dredging and Hydraulicking:						
1950–54 (average)	63	9	467	3	112	. 239
1955	49	5	202	2	55	. 272
1956	38	2	74	1	51	. 697
1957	30	----------	100	2	75	. 752
1958	52	3	351	3	116	. 331
1959	39	39	108	3	89	. 825
Nonfloating washing plants:						
1950–54 (average)	132	131	5, 469	64	2, 248	. 411
1955	118	109	2, 259	53	1, 867	. 826
1956	110	99	1, 355	48	1, 673	1. 235
1957	94	111	[1] 2, 188	40	1, 381	. 631
1958	107	118	[1] 2, 601	77	2, 698	1. 037
1959	89	97	[1] 2, 569	100	3, 511	1. 367
Underground placer and small-scale hand methods:						
1950–54 (average)	178	----------	167	[2] 4	[2] 140	. 841
1955	98	----------	242	4	135	. 560
1956	83	----------	103	2	83	. 798
1957	73	----------	64	2	81	1. 270
1958	102	----------	80	3	92	1. 162
1959	75	----------	41	[3] 3	[3] 110	2. 708
Grand total, placers:						
1950–54 (average)	424	----------	87, 887	[2] 471	[2] 16, 499	. 188
1955	309	----------	56, 535	410	14, 345	. 254
1956	266	----------	51, 261	349	12, 205	. 238
1957	228	----------	[1] 48, 219	343	11, 994	. 249
1958	289	----------	[1] 46, 857	371	12, 984	. 277
1959	231	----------	[1] 39, 873	[3] 359	[3] 12, 550	. 315

[1] Does not include commercial sand and gravel operations recovering byproduct gold.
[2] Includes 1,476 ounces of gold valued at $51,660 recovered from unclassified placers.
[3] Includes 974 ounces of gold valued at $34,090 recovered from electrostatic separation.

CONSUMPTION AND USES

Industry and the Arts.—Domestic consumption of gold in industry and the arts rose 38 percent to 2.5 million ounces, according to data compiled by the Bureau of the Mint. This was about 57 percent more than the output of domestic mines.

According to reports of producers, about 1,800 ounces of natural gold was sold on the open market. In addition to its traditional uses in manufacturing jewelry, watches, decorative articles, dental supplies, scientific, chemical and other equipment, industrial uses of gold continued to expand, especially as protective and decorative coatings on ceramic materials and metals.

Gold coatings on missile and aircraft sections proved unequaled for reflecting infrared radiation. A gold solution sprayed on vulnerable surfaces and baked to form a thin metallic film reduced the rate of heat transfer on engine shrouds, drag-chute containers, tailcone assemblies and blast shields. The gold solution was applied to porcelain-enamel, stainless steel, fiber-glass laminates, and other heat-resistant materials.

A transparent conductive film of gold deposited electrically on safety glass was developed to overcome the hazards of obstructed vision caused by fog and frost on windows in transport vehicles. Increased quantities of high-purity gold were employed in fabricating silicon transistors and diodes for use in computers, aircraft, missiles, and satellites. For silicon devices, gold was alloyed with silica, antimony, germanium, and other elements. Gold plating applied to microwave vacuum tubes improved the operation of communications equipment.

Monetary.—The chief use of gold continued to be in the monetary systems of the world.

Sales of gold by the Bank of England, the largest seller, were much higher than in 1958. Most of the gold sold on the London market went to central banks in Europe and elsewhere. Demand for gold by Far Eastern countries increased, but demand by Middle Eastern countries declined. Hoarding demand for gold in Europe dropped as economic conditions improved, but demand by South American countries was sustained.[3]

TABLE 11.—Net industrial[1] consumption of gold in the United States, in troy ounces

[U.S. Bureau of the Mint]

Year	Issued for industrial use	Returned from industrial use	Net industrial consumption
1950–54 (average)	3, 185, 341	996, 105	2, 189, 236
1955	1, 964, 500	664, 500	1, 300, 000
1956	2, 186, 450	786, 450	1, 400, 000
1957	2, 241, 892	791, 892	1, 450, 000
1958	2, 602, 512	769, 261	1, 833, 251
1959	3, 175, 386	653, 586	2, 521, 800

[1] Including the arts.

---

[3] Samuel Montagu & Co., Ltd., Annual Bullion Review, 1959, pp. 6–8.

MONETARY STOCKS

U.S. gold stocks dropped $1,075 million to $19,507 million, the second successive annual gold loss resulting from a deficit in balance-of-payments transactions with foreign countries.[4] The ratio of gold reserve to Federal Reserve note and deposit liabilities declined 2 percent to 40 percent at the end of 1959 as against 25 percent required for legal cover.

Balance-of-payments deficit in foreign-exchange transactions totaled $3.7 billion, comprising deficits of $0.9 billion on account of goods and services and $2.8 million in net outflow of capital and Government grants. Part of the total deficit was met by delivery of gold. Net short-term banking liabilities to foreign sources payable in dollars, which constitute a potential claim on U.S. gold reserves, increased $3,100 million to $16,860 million. The U.S. balance-of-payments problem and ways and means of reducing the deficit incurred during 1958–59 were discussed.[5]

The estimated world gold reserve, excluding the Soviet bloc, at yearend was $40,670 million, according to the Federal Reserve Bulletin, a gain of $810 million for the year. The U.S. gold reserve thus was about 48 percent of the total free-world reserve, compared with about 50 percent at the end of 1958. Gold reserves of the principal free-world central banks and governments outside the United States in million dollars were: United Kingdom, 2,685; West Germany, 2,638; Switzerland, 1,826; Netherlands, 1,132; Belgium, 1,143; Canada, 952; France, 875; and International Monetary Fund, 2,416.

The international financial position of the United States resulting from adverse balance-of-payments in every year since 1949, except 1957, was attributed principally to foreign aid grants and loans, military expenditures and private investments; corrective measures needed to redress the adverse balance that affects our gold reserves were discussed by an economist.[6]

PRICES

The substantial drop in U.S. gold reserves and the gain in short-term dollar liabilities to foreign sources stimulated renewed speculation on revaluation of gold. However, U.S. Treasury officials again denied that any change in the official price of $35 an ounce was contemplated.

At the 14th Annual Meeting of the International Monetary Fund in Washington, D.C., September 28–October 2, Secretary of the Treasury, Robert B. Anderson, again stated the U.S. Government position regarding revaluation of gold:

> * * * The credit and monetary policies of the United States, including our firm policy of maintaining unchanged the present official price of gold, have also been directed toward promoting financial stability in the interest of sustainable economic growth . . .

---

[4] Federal Reserve Bulletin, vol. 46, No. 3, March 1960, pp. 257–258.

[5] Von Klemperer, A. H., The United States Balance of Payments in a Changing World Economy: Address, meeting of Am. Management Assoc., New York City, N.Y., Feb. 22, 1960.

[6] Smith, Frank, Why We Are Losing Gold: Am. Metal Market reprint (vol. 66, No. 231), Dec. 1, 1959, 8 pp.

Virtually all domestic gold production continued to be sold to mints of the U.S. Treasury or to licensed private refiners and dealers at the official price, established under authority of the Gold Reserve Act of 1934 of $35 a fine troy ounce, less handling and refining charges. Government and private sales of gold for industrial and artistic use also were based on the official price.

In the London gold market, external convertibility of sterling was restored, and nearly all restrictive controls were dropped. The removal of convertibility restrictions strengthened the position of London as the center of international gold trading, and turnover of gold increased substantially over 1958. The price of gold in London, in terms of U.S. dollars, continued to fluctuate in a narrow range of about 10 cents an ounce between $35.04 and $35.14, chiefly reflecting changes in the sterling-dollar exchange rate. During most of the year, however, the London price exceeded the effective U.S. selling price of $35.08¾.

Sales of gold bars to private investors increased and "gold certificates", which enable the holders to secure options on delivery of gold, were issued by several international banking groups. The demand for these certificates and the continuing hoarding demand for gold bullion also reflected speculation that the price of gold eventually will be increased.

In most foreign markets other than London, the price at which gold was traded remained close to the London price, except in a few markets where trading was in local inconvertible currencies that reflected local political conditions and monetary habits.

The average price[1] of "free" gold bars (12.5 kg.) per fine troy ounce in the principal trading centers outside of London in 1959 was:[2]

Market:	*Price*	Market:	*Price*
Manila	$36.04	Beirut	$34.35
Hong Kong	38.60	Paris	35.56
Bombay	58.58	Buenos Aires	35.95
Tangier	35.23		

[1] Prices quoted at "free" or black-market value of U.S. dollar in local markets.
[2] Engineering and Mining Journal, vol. 160, Nos. 2–12 February–December 1959; vol. 161, No. 1, January 1960; Markets section of each issue.

The price of gold in relation to the cost of production, present and future supplies of gold, and the advantages and disadvantages of revaluation were investigated by a research group.[7]

FOREIGN TRADE [8]

Net imports of gold rose to $302.4 million from $258.8 million in 1958 as imports continued to exceed exports by a wide margin. Canada supplied 93 percent of the total imports; the Philippines supplied most of the remainder. About 50 percent of the gold exported by the United States went to Portugal, and 11 percent went to the Philippines.

---

[7] Williamson, D. R., and Burgin, Lorraine, The Price For Gold. Colo. School of Mines, Min. Ind. Bull., vol. 2, No. 6, November 1959, 16 pp.

[8] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 12.—Gold imported into the United States in 1959, by countries of origin

[Bureau of the Census]

Country of origin	Ore and base bullion		Refined bullion	
	Troy ounces	Value	Troy ounces	Value
North America:				
Canada	100,866	$3,529,403	7,765,790	$271,802,883
Cuba	615	21,540		
El Salvador	2,343	82,215		
Honduras	2,798	98,211		
Mexico	32,312	1,125,447		
Netherlands Antilles			32	1,125
Nicaragua	140,575	4,910,038		
Panama	472	16,507	4,601	161,984
Total	279,981	9,783,361	7,770,423	271,965,992
South America:				
Argentina	1,782	62,195		
Bolivia	55	1,858		
Chile	25,790	906,177		
Colombia	12,953	453,336	44,721	1,558,976
Ecuador	18,643	648,583		
Peru	25,301	882,183		
Tota	84,524	2,954,332	44,721	1,558,976
Europe:				
Austria			18	664
Germany, West			143	5,015
Ireland			9	315
Malta, Gozo, and Cyprus	1,494	52,226		
Portugal	19,300	675,582		
Sweden	112	3,920		
United Kingdom	10,216	357,180	22	767
Total	31,122	1,088,908	192	6,761
Asia:				
Japan			1,330	46,572
Korea, Republic of	1	29		
Philippines	33,793	1,170,455	223,762	15,273,545
Turkey	522	18,270		
Total	34,316	1,188,754	225,092	15,320,117
Africa:				
Rhodesia and Nyasaland, Federation of	4,314	151,139		
Union of South Africa	848	29,680		
Total	5,162	180,819		
Oceania: Australia	9,311	325,935	100	3,546
Grand total	444,416	15,522,109	8,040,528	288,855,392

TABLE 13.—Gold exported from the United States in 1959, by countries of destination

[Bureau of the Census]

Country of destination	Ore and base bullion		Refined bullion	
	Troy ounces	Value	Troy ounces	Value
North America:				
Canada	10,708	$374,739	192	$6,758
Cuba			305	11,100
El Salvador			3,546	129,000
Mexico	29	1,015		
Panama			64	2,258
Total	10,737	375,754	4,107	149,116
South America: Chile			29	1,016
Europe:				
Iceland			204	7,279
Portugal			19,542	685,075
United Kingdom	9,761	339,680		
Total	9,761	339,680	19,746	692,354
Asia: Philippines			5,222	375,221
Grand total	20,498	715,434	29,104	1,217,707

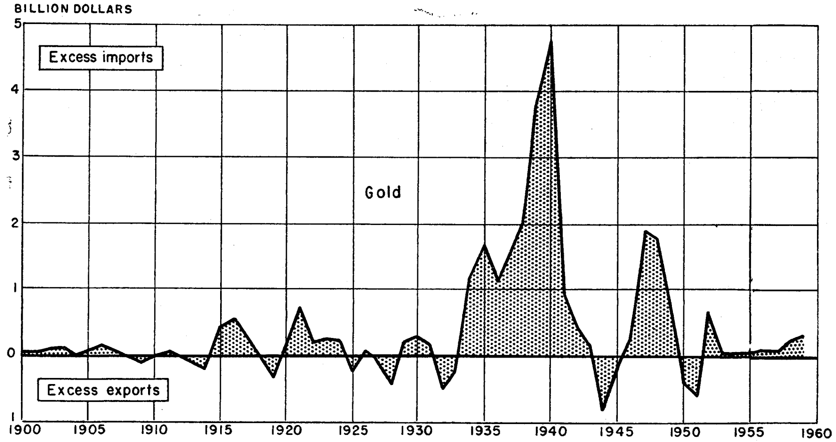

FIGURE 2.—Net imports or exports of gold, 1900–59.

WORLD REVIEW

World production of gold rose to 42.8 million ounces valued at $1,498 million—a new record. The gain was again attributed almost entirely to a sharp rise in output from the Union of South Africa, which more than offset lower production in the United States and Canada. Several of the major gold-producing countries, except the United States, continued to extend financial aid to marginal mines by granting subsidies or tax concessions to offset rising costs and declining minable reserves.

Demand for gold for investment purposes increased, and some countries provided facilities for buying gold directly or for purchasing gold certificates for future delivery. Over 7 million ounces of gold from the U.S.S.R. were sold on the London market.

TABLE 14.—World production of gold, by countries,[1] in fine ounces [2]

[Compiled by Augusta W. Jann and Berenice B. Mitchell]

Country [1]	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada	4,345,573	4,541,962	4,383,863	4,433,894	4,571,347	4,483,688
Central America and West Indies:						
Costa Rica [3]	23	---	535	705	310	---
Cuba [3]	2,098	2,024	1,008	915	804	615
Dominican Republic	244	---	290	286	780	[4] 700
Guatemala [4]	202	300	360	360	370	---
Honduras	33,536	817	1,611	2,025	1,714	[3] 2,798
Nicaragua	245,830	237,376	217,140	203,636	214,882	217,849
Panama	803	---	---	---	---	---
Salvador	21,818	3,818	2,983	2,508	2,372	2,474
Mexico	426,370	382,883	350,218	357,369	332,246	313,662
United States (incl. Alaska)[5]	1,987,887	1,876,830	1,865,200	1,800,000	1,759,000	1,635,000
Total	7,064,000	7,046,000	6,823,000	6,802,000	6,884,000	6,657,000
South America:						
Argentina	6,160	7,330	11,381	7,732	3,054	[3] 1,782
Bolivia	14,645	31,508	35,549	27,685	[6] 19,115	[6] 35,237
Brazil [4]	171,100	145,000	162,000	150,000	186,000	180,000
British Guiana	19,198	23,766	15,815	16,490	17,500	3,448
Chile	158,183	136,062	94,459	103,590	110,952	[4] 110,000
Colombia	409,426	380,824	438,349	325,114	371,715	397,929
Ecuador	36,296	15,289	15,076	16,247	19,685	18,450
French Guiana	7,327	8,713	5,832	8,954	20,000	16,100
Peru	138,357	170,747	159,074	161,831	159,127	139,820
Surinam	6,085	7,204	6,736	6,516	4,258	5,826
Venezuela	25,100	61,140	69,826	89,654	76,009	53,766
Total [4]	992,000	988,000	1,014,000	914,000	987,000	962,000
Europe:						
Finland	16,493	18,840	18,229	22,377	28,499	[4] 35,000
France	56,250	30,286	30,608	35,173	33,598	35,366
Germany, West	3,203	3,839	4,369	3,681	[4] 4,000	[4] 4,000
Greece	[7] 4,834	6,655	3,504	7,877	5,787	4,340
Italy	[5] 10,996	5,902	5,726	6,334	4,802	[4] 4,000
Portugal	17,040	28,807	22,120	23,777	17,747	20,765
Spain	10,576	10,449	11,510	11,901	14,211	6,269
Sweden	82,750	98,767	95,745	97,063	100,953	[4] 88,000
U.S.S.R. [4] [8]	9,000,000	9,000,000	10,000,000	10,000,000	10,000,000	10,000,000
Yugoslavia	36,362	41,635	47,808	51,988	55,364	59,640
Total [1] [4]	9,400,000	9,400,000	10,400,000	10,400,000	10,400,000	10,400,000
Asia:						
Burma	237	124	179	104	190	212
Cambodia	---	---	482	1,608	322	4,823
India	227,819	210,880	209,251	179,182	170,090	165,383
Japan	197,008	240,732	241,422	252,563	260,630	258,010
Korea:						
North [4]	127,000	130,000	130,000	130,000	130,000	130,000
Republic of	21,868	47,676	49,903	66,578	72,071	65,690
Malaya	18,900	22,838	20,253	11,157	22,484	26,739
Philippines	418,736	419,112	406,163	379,982	422,833	402,615
Sarawak	837	463	599	883	864	2,450
Saudi Arabia	64,913	---	---	---	---	---
Taiwan	29,263	28,100	33,131	20,548	21,345	13,497
Total [4] [8]	1,280,000	1,310,000	1,350,000	1,300,000	1,460,000	1,430,000

See footnotes at end of table.

TABLE 14.—World production of gold, by countries,[1] in fine ounces [2]—Continued

Country [1]	1950–54 (average)	1955	1956	1957	1958	1959
Africa:						
Angola	72	57	34	-----	26	42
Bechuanaland	865	560	590	190	215	198
Belgian Congo (incl. Ruanda-Urundi)	359, 394	369, 926	373, 849	374, 235	356, 134	351, 086
Central Africa, Republic of	[7] 695	502	338	614	932	495
Congo, Republic of the	[7] 12, 340	9, 214	7, 289	7, 404	6, 048	3, 665
Eritrea	1, 053	161	3, 215	4, 501	6, 430	[4] 6, 000
Ethiopa	32, 868	22, 058	25, 700	[4] 25, 000	36, 369	41, 439
French Cameroon	3, 381	556	463	10, 899	2, 009	971
French West Africa	21, 097	579	431	331	3, 200	[4] 3, 000
Gabon, Republic of	[7] 36, 708	36, 832	33, 086	22, 727	15, 921	16, 171
Ghana	719, 523	687, 151	637, 755	790, 381	852, 834	913, 200
Kenya	13, 826	9, 528	13, 843	7, 388	7, 753	9, 145
Liberia	4, 756	[6] 672	[9] 500	[9] 381	[4] 400	1, 401
Madagascar	1, 735	1, 074	903	862	797	434
Morocco: Southern zone	2, 468	4, 270	265	-----	-----	-----
Mozambique	1, 150	1, 248	1, 247	1, 080	695	[4] 700
Nigeria	1, 314	681	439	389	646	950
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	2, 113	2, 234	3, 367	3, 270	3, 673	4, 735
Southern Rhodesia	506, 342	524, 701	536, 392	536, 849	554, 838	566, 883
Sierra Leone	2, 618	474	[6] 452	-----	-----	-----
Sudan	2, 054	1, 526	3, 100	1, 158	1, 571	2, 300
Swaziland	423	-----	252	7	-----	-----
Tanganyika [10]	69, 456	75, 135	69, 699	63, 485	68, 250	96, 011
Uganda (exports)	402	450	297	212	329	334
Union of South Africa	12, 035, 316	14, 602, 267	15, 896, 693	17, 031, 690	17, 665, 739	20, 064, 105
United Arab Republic (Egypt Region)	15, 175	6, 524	7, 697	3, 026	1, 812	2, 500
Total	13, 850, 000	16, 360, 000	17, 620, 000	18, 890, 000	19, 590, 000	22, 090, 000
Oceania:						
Australia	987, 349	1, 049, 039	1, 029, 821	1, 083, 941	1, 100, 404	1, 089, 574
Fiji	84, 902	70, 100	67, 475	75, 150	86, 794	72, 565
New Guinea	100, 676	73, 980	79, 085	68, 564	43, 254	46, 663
New Zealand	58, 232	26, 443	26, 063	30, 195	24, 981	37, 662
Papua	329	873	391	466	558	156
Total	1, 231, 488	1, 220, 435	1, 202, 835	1, 258, 316	1, 255, 991	1, 246, 620
World total (estimate)	33, 800, 000	36, 300, 000	38, 400, 000	39, 600, 000	40, 600, 000	42, 800 000

---

[1] In addition to countries listed, gold also produced in Austria, Bulgaria, China, Czechoslovakia, East Germany, Hungary, Indonesia, Rumania, and Thailand, but production data not available; estimates for these countries included in total. For some countries accurate figures impossible to obtain owing to clandestine trade in gold (as for example, French West Africa).

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in detail.

[3] Imports into United States.

[4] Estimate.

[5] Refinery production.

[6] Exports.

[7] Average for 1953–54.

[8] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.

[9] Purchases. Production may be much greater.

[10] Including gold in lead concentrates exported amounting to: 2,109 oz. in 1950–54 (average); 6,141 oz. in 1955; 11,871 oz. in 1956; 9,192 oz. in 1957; 11,951 oz. in 1958; and 10,608 oz. in 1959.

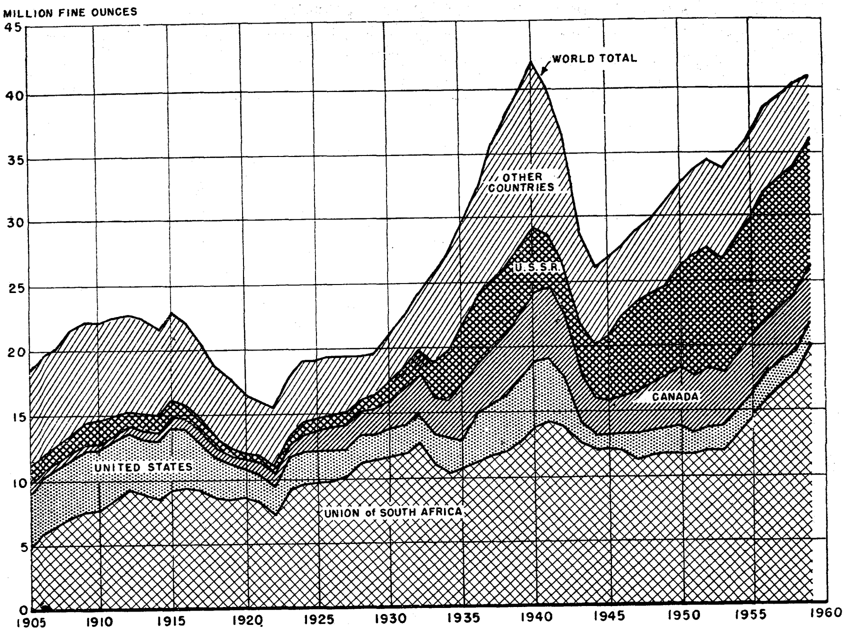

FIGURE 3.—World production of gold, 1905–59.

Australia.—Gold output in Australia dropped 2 percent to 1.07 million ounces—about 4 percent below the postwar peak of 1.12 million ounces in 1954. Western Australia, supplied nearly 80 percent, 861,000 ounces, of the Commonwealth gold, Queensland supplied 8 percent, and Northern Territory supplied 6 percent. Kalgoorlie mines maintained their outputs and reserves. Lake View and Star reported an ore reserve of 3.5 million tons averaging 0.24 ounces a ton; Great Boulder Mines, Ltd., reported a reserve of 2 million tons averaging 0.28 ounces; and other Kalgoorlie mines reported a total reserve of 3.6 million tons averaging about 0.28 ounces a ton. Central Norseman Gold Corp. reported an estimated reserve of 592,000 tons averaging 0.46 ounces a ton. The Tennant Creek mine, which treats 35,000 tons a year, in the Northern Territory reported reserves totaling 158,000 tons with a grade of 1.34 ounces a ton.

The Commonwealth Government extended the Gold Mining Assistance Act for another 3 years and raised the maximum subsidy from 55 shillings ($7.70) to 65 shillings ($9.10) an ounce.

Canada.—Production of gold was 4.48 million ounces valued at $150 million, 2 percent less than the 1958 output. The decline was attributed principally to less favorable economic conditions resulting from a lower mint price for gold and increased mine labor costs, which acted as a deterrent to increased gold production. The average mint price per ounce in Canadian dollars dropped from $33.98 to $33.57 in 1959, reflecting an increase in the premium on the Canadian dollar in relation to the U.S. dollar.

Under the Emergency Gold Mining Assistance Act to marginal mines, 43 lode gold mines received subsidy payments; 11 mines with low operating costs were not eligible for aid.

Gold production increased only in the Northwest Territories. Ontario was again the leading gold-producing province supplying nearly 60 percent of the total; Quebec continued in second place with 22 percent. Lode and placer gold mines again supplied 87 percent of the total output; base-metal operations recovering gold as a byproduct supplied the remainder. The gold mines continued to employ about 16,600 persons. Two lode gold mines closed during the year, and one new mine began production. Several new placer operations were reported in the Yukon Territory.

The geographical distribution of Canada's gold production was as follows:

	Troy ounces	
Province or Territory:	*1958*	*1959*
British Columbia	210, 612	191, 386
Northwest Territories	343, 838	404, 824
Ontario	2, 716, 514	2, 678, 488
Prairie Provinces[1]	174, 228	131, 277
Quebec	1, 044, 846	997, 467
Yukon	67, 745	66, 958
Newfoundland and Nova Scotia	13, 564	13, 288
Total	4, 571, 347	4, 483, 688

[1] Alberta, Saskatchewan, and Manitoba.

Kerr-Addison, the leading gold mine, reported record production in 1959. Output totaled 567,305 ounces, compared with 542,270 ounces in 1958. Average recovery value was $11.50 a ton in 1959, compared with $11.08 in 1958. The proved ore reserve above the 3,950-foot horizon totaled 9.6 million tons with an average gold content of 0.39 ounces a ton.

An international gold market was established in Toronto, and the Toronto Stock Exchange began to give daily price quotations on 1-kilogram gold bars. Gold certificates issued by the Bank of Nova Scotia became exchangeable with other international banks. Merchandising of gold, using a system of certified warehouse receipts, was also begun by a Toronto firm during the year.

Colombia.—Gold production, 397,900 ounces, in Colombia increased 7 percent. South American Gold & Platinum Co., the largest producer, reported a gold output from wholly-owned subsidiaries of 144,800 ounces compared with 158,700 ounces in 1958. Output from placer operations of South American Gold & Platinum Co. in Choco and Narino departments increased, but did not offset the drop in production at the company's underground mines in Antioquia which were adversely affected by a labor strike. The company reported dredging reserves at yearend to be 55.8 million cubic yards with an estimated recoverable content of 2.16 grains of crude gold and 0.62 grains of crude platinum per cubic yard, a total equivalent value of 21.9 cents a cubic yard.[9] Six bucketline dredges were operated during the year. Underground reserves totaled 398,800 ounces with an average grade

---

[9] South America Gold & Platinum Co., 43d Annual Report, 1959, pp. 4–7.

of 0.78 ounces of gold per ton, compared with 442,300 tons with the same average grade at the end of 1958.

Most of the gold produced by the company was sold through the Colombian Mining Association for an equivalent in pesos of $32.35 an ounce, compared with the average equivalent price of $30.66 an ounce obtainable from the Banco de la Republica. The higher price realized resulted from an effective tax of 7.6 percent, compared with the 15-percent export tax.

Ghana.—Output of gold, the principal mineral in Ghana, rose for the third successive year and reached a record of 913,200 ounces. The gain of 7 percent in 1959 was attributed principally to increased production by Ashanti Goldfields Corp., which reached a record level of 332,400 ounces—more than one-third the country's total. Significant increases in production were also noted at the Ariston and Bremang mines.

Ashanti Goldfields Corp. reported, as of Septmeber 30, 1959, a reserve of nearly 2 million tons of ore with an average grade of 0.86 ounces a ton, compared with 1.6 million tons averaging 0.95 ounces a ton in 1958. The company announced plans to increase milling from 406,000 to 425,000 tons in 1960 giving a corresponding increase in gold output to at least 346,000 ounces.

The Chamber of Mines established a 3-year Mines Training Course supported by the Government to educate Africans in mine operation. The Government also commenced a program of financial assistance to mining companies for developing new properties and expanding operations. Substantial development loans were made to Amalgamated Blanket Areas, Ltd., the second largest gold producer, and to Bremang Gold Dredging Co., Ltd.

India.—Gold production in India declined for the fifth successive year, dropping 3 percent to 165,400 ounces, the lowest output since 1946. The downward trend in production chiefly reflects the decline in quantity and grade of ore in reserves at the mines of the Kolar Gold Fields, which supply the bulk of India's gold. Extensive research on pressure-control problems to improve working conditions and increase mining efficiency were continued, especially at the Champion Reef mine, 10,233 feet deep.

Philippines.—Gold output in the Philippines dropped 5 percent to 402,600 ounces, and ore reserves continued to decline, but the value of production increased because of purchases by holders of "blocked" pesos, which supported the price at 150 pesos an ounce, equivalent to $75. Ten mines reported gold production during the year. Benguet Consolidated, Inc., the largest producer, recovered 234,400 ounces of gold from 1.2 million tons of ore; Itogon-Suyoc Mines, Inc. produced 33,000 ounces from 250,000 tons; Baguio Gold Mining Co. recovered 27,100 ounces from 142,300 tons of ore; and Surigao Consolidated Mining Co. reported 13,500 ounces of gold from 74,400 tons of ore. Three copper mines recovering byproduct gold contributed to the 1959 output. Lepanto Consolidated Mining Co. recovered 46,000 ounces; Atlas Consolidated, 9,800 ounces; and Philex Mining Corp. recovered 11,800 ounces of gold.

Rhodesia and Nyasaland, Federation of.—Gold output in Southern Rhodesia totaled 566,900 ounces, 2 percent more than in 1958 and the fourth successive annual increase. Control of the Cam and Motor mine, the leading producer and one of the oldest mines in Southern Rhodesia, was acquired by Rio Tinto (S. R.) Ltd.; output during the year from the mine was nearly 90,000 ounces. The Barberton group of mines was acquired by Dawn Gold Mining Co., Ltd., a subsidiary of New Consolidated Gold Fields. The Federation exported 557,400 ounces of gold bullion, and 159,500 pounds of gold-bearing concentrate.[10]

Union of South Africa.—Gold production continued to rise in South Africa, reaching a new record of 20.1 million ounces valued at $702 million, nearly 14 percent above that of 1958 and the eighth successive annual increase. The sharp increase in 1959 was attributed principally to increased milling rates and higher grade ore at the younger mines of the Transvaal and Orange Free State and partly to a larger supply of skilled labor. The older mines of the Central Rand also increased production and reduced unit costs as a result of improved labor conditions. Reflecting the gains in ore milling and average grade, and the reduction in unit costs, estimated working profit from gold increased from $171.8 million to $241 million.

On the Far East Rand, continued expansion of operations and increases in grade and quantity of reserves at the Winkelhaak mine were noteworthy. Two potentially large new mines adjoining Winkelhaak, which began underground development, were expected to reach production in 1963.

Significant progress and spectacular results were achieved at mines on the Far West Rand. The West Driefontein mine established a record working profit of more than $2.8 million in 1 month from milling 118,000 tons of ore with a grade of 0.92 ounces per ton at a working cost of $9.66 a ton or $10.50 an ounce. Underground development was begun at Western Areas, where a 200,000-ton-a-month reduction plant was planned. Ore from the initial stages of operation was to be treated at the plant of Randfontein Estates.

Progress in sinking the twin-shaft systems at Western Deep Levels was accelerated, and the mine was expected to begin production much sooner than originally planned. The No. 3 shaft was completed to the 6,300-foot level, and further sinking was to continue to the Carbon Leader horizon at 9,000 feet.

In the Orange Free State, two world records for sinking shafts were established at the President Steyn gold mine. At the Lorraine gold mine the opening of the Elsburg reefs as an economic deposit was an important development. Free State Geduld continued to develop high-grade ore, and St. Helena opened an extensive highly mineralized zone, which was expected to contribute substantially to the ultimate reserves and to increased average grade.

Tax concessions to ultradeep gold mining, as additional amortization allowance, were extended to all mines over 7,500 feet deep.

---

[10] Mineral Trade Notes, vol. 51, No. 2, August 1960, p. 29.

TABLE 15.—Salient statistics of the gold mining industry in the Union of South Africa

[Transvaal Chamber of Mines]

	1950–54 (average)	1955	1956	1957	1958	1959
Ore milled____tons__	59, 993, 500	65, 950, 700	67, 524, 700	66, 114, 000	65, 542, 350	70, 478, 800
Gold recovered__troy ounces__	11, 824, 400	[1] 14, 093, 668	[1] 15, 373, 680	16, 540, 817	17, 665, 739	20, 066, 753
Gold recovered_ ounces per ton__	0. 192	0. 214	0. 228	0. 250	0. 261	0. 278
Working revenue (gold)______	$402, 688, 238	$496, 759, 463	$555, 798, 578	$595, 271, 015	$613, 649, 940	$700, 426, 000
Working revenue per ton milled______	6. 72	7. 54	8. 02	8. 80	9. 21	9. 79
Working cost______	286, 562, 340	372, 851, 091	405, 338, 704	419, 641, 522	430, 714, 819	448, 130, 152
Working cost per ton______	4. 77	5. 66	6. 01	6. 35	6. 57	6. 35
Working cost per ounce of gold_	24. 80	26. 47	26. 37	25. 38	25. 03	22. 74
Estimated working profit from gold______	116, 213, 852	123, 908, 372	135, 661, 140	161, 934, 060	171, 797, 394	241, 019, 080
Estimated working profit per ton from gold______	1. 94	1. 88	2. 01	2. 45	2. 64	3. 44
Premium gold sales______	----------	655, 038	2, 470, 630	2, 596, 894	2, 454, 794	----------
Uranium and thorium exports_	----------	83, 886, 849	107, 999, 346	139, 606, 589	148, 980, 336	145, 982, 466
Estimated uranium profits____	----------	49, 162, 982	69, 053, 751	93, 262, 946	105, 677, 765	76, 268, 469
Dividends______	59, 031, 700	62, 613, 284	78, 896, 560	102, 758, 244	119, 198, 775	127, 039, 822

[1] Excludes gold produced by nonmembers of Chamber of Mines.

TECHNOLOGY

High-purity gold (99.999+ percent) was produced by American Smelting & Refining Co. for fabricating silicon transistors and diodes for use in computers, aircraft, missiles and satellites. The superpure product, which sold for $65 a troy ounce, contained only 10 p.p.m. or less of impurities, compared with 200 p.p.m. impurities in commercial gold.

New flocculents developed by American Cyanamid Co. greatly improved the speed and efficiency of sand-slime separation from cyanide solutions. At two African plants, the cost of extracting gold was reduced significantly through improved clarification, precipitation, and filtration from the use of the new flocculents.

A low-cost method of recovering gold and other metals from sea water reportedly was developed in the Union of South Africa; selected soaps are used to form bubbles, which lift the desired minerals to the surface for collection.[11] A possible yield of 240 ounces of gold a day was estimated. World patents on the process were held by an American chemical firm.

Radioactive gold was used as a source of heat in a thermionic converter to produce an electric current for use in space vehicles.[12]

Increased efficiency in extractive metallurgy of gold may be expected to result from certain techniques and equipment developed for uranium extraction.[13] Areas of possible improvement included greater use of hydrocyclones in classification and thickening, high-intensity mechanical air agitators, flocculents in thickening and filtration, and, especially, modern instrumentation in process control.

---

[11] Chemical Engineering & Mining Review (Melbourne, Australia), Collecting Metals in Solution: Vol. 52, No. 1, Oct. 15, 1959, p. 73.

[12] Chemical and Engineering News, Gold Gets Role in Outer Space: Vol. 37, No. 6, Feb. 9, 1959, p. 52.

[13] Raring, R. H., and Murray, G. Y., Gold Plants of the Future—Lessons From Uranium: Mines Mag., vol. 49, No. 3, March 1959, pp. 51–56.

A hydrometallurgical process that recovers more than 90 percent of the gold and silver contained in anode slime from electrolytic refining of copper was patented in Japan.[14] The process involves pressure leaching with sulfuric acid, treatment of the residue with ammonia, and further treatment of the residual solution with cyanide and lime.

The use of liquid cyanide in a 32-percent solution, instead of the solid type, gave equally good extraction with better control and a large saving in inventory at the Chibougamau operation of Anacon Lead Mines in Canada.[15]

A patent was issued for a device to recover a gold concentrate from placer gravels in the bed of a flowing river.[16] The device must be cleaned periodically to remove waste and permit continued effective operation.

Several other significant articles pertaining to the technology of gold were published in 1959.[17]

---

[14] Tamura, T., and Kozaburo, K. (assigned to Furukawa Electric Co., Ltd.), Recovery of Gold and Silver From the Anode Slime From Electrolytic Refining of Copper: Japan Patent 1,254, March 11, 1959.

[15] Pickett, D. E., and Djingheuzian, L. E., Technical Advances in Milling and Process Metallurgy in Canada During 1959: Can. Min. Jour., vol. 81, No. 2, February 1960, p. 192.

[16] McQueen, G. A., Ore Separator: Canadian Patent 592,711, Feb. 16, 1960.

[17] Woodcock, J. T., Wattle Gully's New Flowsheet and Mill: Chem. Eng. & Min. Review (Melbourne, Australia), vol. 52, No. 4, January 1960, pp. 38–45.

Jackson, O. A. E., Pebble Milling Practice at the South African Gold Mines of Union Corp., Ltd.: Min. Eng., vol. 11, No. 11, November 1959, pp. 1133–1144.

Benitez, Fernando, Floating Chile's Oxidized Gold Ores: Eng. Min. Jour., vol. 160, No. 6, June 1959, pp. 116–122.

Brown, C. E., Dadson, A. S., and Wrigglesworth, L. A., On the Ore-Bearing Structures of the Giant Yellowknife Gold Mine: Canada Inst. Min. and Met. Bull., vol. 52, No. 564, April 1959, pp. 235–244.

Graphite

By Donald R. Irving[1] and Betty Ann Brett[2]

DOMESTIC GRAPHITE consumption rebounded in 1959 to the 1957 level despite reduced sales to the steel industry as a result of a year-end strike. World production equaled the high set in 1957, mainly because of greatly expanded output in Austria.

In December, the General Services Administration offered for sale 533 short tons of Government-owned graphite produced under an incentive program authorized by the Defense Production Act.

TABLE 1.—Salient graphite statistics

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Natural graphite consumed:						
Short tons	30,800	45,200	40,400	41,000	28,800	40,200
Value	$4,261,800	$6,289,400	$5,920,300	$5,568,000	$3,971,800	$5,394,800
Imports:						
Short tons	46,600	48,800	47,900	41,500	27,100	37,000
Value	$2,608,300	$2,386,600	$2,593,700	$2,106,800	$1,203,100	$1,526,900
Exports:						
Short tons	1,400	1,400	1,100	1,300	1,200	1,400
Value	$177,300	$199,400	$159,800	$225,500	$192,800	$222,100
World: Production (estimated):						
Short tons	200,000	290,000	285,000	410,000	350,000	410,000

DOMESTIC PRODUCTION

The only domestic producer of amorphous graphite, Graphite Mines, Inc., Cranston, R.I., ceased operating early in 1959. This company had mined amorphous graphite since 1917. Southwestern Graphite Co. continued to produce crystalline flake graphite at Burnet, Tex., and a new crystalline flake producer, Graphite Corporation of America, began operating at Chester Springs, Pa.

Manufactured (artificial) graphite powder and products were produced by National Carbon Co., Division of Union Carbide Corp., at Niagara Falls, N.Y., Clarksburg, W. Va., and Columbia, Tenn.; by Great Lakes Carbon Corp., at Niagara Falls, N.Y., Morganton, N.C., and Antelope Valley, Calif. (formerly owned by Crescent Carbon Corp.); International Graphite & Electrode Division, Speer Carbon Co., St. Marys, Pa., and Niagara Falls, N.Y.; and Stackpole Carbon Co., St. Marys, Pa. The Dow Chemical Co. produced graphite electrodes for its own use at Midland, Mich.

---

[1] Assistant to the chief, Division of Minerals.
[2] Statistical clerk.

CONSUMPTION AND USES

Graphite consumption rebounded from the low reported in 1958. It approached the 1957 total despite the drop in sales to the steel industry. Four uses—foundry facings, steel making, lubricants, and crucibles—accounted for 76 percent of consumption.

TABLE 2.—Consumption of natural graphite in the United States

Year	Short tons	Value	Year	Short tons	Value
1950–54 (average)	30,806	$4,261,800	1957	41,029	$5,568,000
1955	45,245	6,289,400	1958	28,823	3,971,800
1956	40,401	5,920,300	1959	40,239	5,394,800

TABLE 3.—Consumption of natural graphite in the United States in 1959, by uses

Use	Crystalline flake		Ceylon amorphous		Other amorphous [1]		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Batteries	26	$22,238	-----	-----	1,085	$92,952	1,111	$115,190
Bearings	6	2,795	67	$34,357	74	24,207	147	61,359
Brake linings	442	127,832	292	79,225	211	65,512	945	272,569
Carbon brushes	155	60,663	280	156,754	421	53,425	856	270,842
Crucibles, retorts, stoppers, sleeves, and nozzles	3,483	632,428	32	7,305	-----	-----	3,515	639,733
Foundry facings	410	50,784	499	110,002	12,788	898,844	13,697	1,059,630
Lubricants	2,083	458,523	1,894	347,337	2,612	304,761	6,589	1,110,621
Packings	234	119,391	12	13,455	152	29,232	398	162,078
Paints and polishes	-----	-----	92	13,976	224	28,682	316	42,658
Pencils	323	90,939	589	204,944	796	116,642	1,708	412,525
Refractories	-----	-----	-----	-----	3,769	435,670	3,769	435,670
Rubber	63	26,236	-----	-----	108	20,596	171	46,832
Steelmaking	149	23,325	-----	-----	6,653	683,206	6,802	706,531
Other [2]	65	22,968	17	11,450	133	24,159	215	58,577
Total	7,439	1,638,122	3,774	978,805	29,026	2,777,888	40,239	5,394,815

[1] Includes small quantities of crystalline flake and Ceylon amorphous, and mixtures of natural and manufactured graphite.

[2] Includes adhesives, carbon resistors, catalyst manufacture, chemical equipment and processes, electrodes, electronic products, insulation, plastics, powdered-metal parts, roofing granules, specialties, and other uses not specified.

PRICES

Quoted prices for graphite merely indicate the range of prices; actual prices are negotiated between buyer and seller on the basis of a wide range of specifications.

Yearend quotations for natural graphite were reported in E&MJ Metal and Mineral Markets. Prices for crystalline flake were as follows per pound, carlots, c.i.f. U.S. ports: 86 to 88 percent carbon, crucible grade, 7½ to 14 cents; 94 percent carbon, normal and wire drawing, 20 to 27 cents; 96 percent carbon, special and dry usage, 22 to 27 cents; 98 percent carbon, special for such articles as brushes, 25 to 30 cents; Madagascar, special grades, 85 to 87 percent carbon, 10 cents; special mesh, 13 cents; special grade, 99 percent carbon, 40 cents. These prices included costs from point of origin and importers' handling costs and commissions.

Prices for amorphous, crude, bulk carlots, per short tons, f.o.b point of origin, were listed as follows: Mexican, 80 to 85 percent carbon, $15 to $19; Hong Kong, 78 to 85 percent carbon, $15 to $19; Korean, $18.

FOREIGN TRADE[3]

Graphite imports from all major countries of origin except Hong Kong increased over 1958 but failed to reach the 1957 level. Exports also increased. Total exports of natural graphite, 1955–57, were: 1955, 1,394 tons, $199,383; 1956, 1,062 tons, $159,792; 1957, 1,349 tons, $225,536.

WORLD REVIEW

A 200-percent increase in the output of graphite in Austria was mainly responsible for bringing 1959 world graphite production to the alltime high of 1957.

Austria.—An open-pit crystalline flake graphite mine at Zettlitz, in Lower Austria, began operating during the year. The ore was said to average 50 percent carbon.[4]

Canada.—Joseph Dixon Crucible Co., Jersey City, N.J., took an option on a graphite deposit in Leeds County, southeastern Ontario. The deposit, about 2,000 feet long and 200 feet wide, was reported to be amenable to open-pit mining and, on the basis of preliminary sampling, was said to contain about 25 percent graphite.

Ceylon.—The number of producing graphite mines dropped from 44 in 1955 to 20 in 1957, and several additional small mines were reported closed in 1958 because of decreasing world demand for Ceylon graphite. Throughout 1959, the Ceylon Chamber of Commerce appealed to the Ceylon Government to suspend the export duty on graphite. The Chamber stated that increasing competition from other sources and rising production and shipping costs in Ceylon, coupled with the export duty of 50 rupees (US$10.50) per long ton of graphite, were threatening to destroy the Ceylon graphite industry. Late in the year the Government reduced the duty to 20 rupees (US$4.20) per long ton.

Guinea.—Reconnaissance drilling near the village of Lola disclosed a crystalline flake graphite deposit about 2½ miles long averaging 165 feet wide. The ore occurs in weathered mica schist.[5]

India.—Exploration of graphitic schist in the Baramulla district, Kashmir, by the Geological Survey of India disclosed an estimated 36 million tons of material to a depth of 100 feet. The Survey recommended that the investigation be extended to determine the graphite reserve and delineate the better quality deposits.

Japan.—In 1958, graphite production totalled 1,508 short tons of crystalline and 2,309 short tons of amorphous graphite, compared with 2,905 tons of crystalline and 2,367 tons of amorphous in 1957.[6]

---

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

[4] Mining World, Austria: Vol. 21, No. 13, December 1959, p. 63.

[5] Moyal, Maurice, Guinea's Mineral Wealth: Min. Jour. (London), vol. 252, No. 6446, Mar. 6, 1959, p. 255.

[6] Ministry of International Trade and Industry, Mining Yearbook of Japan, 1958 (Tokyo): Vol. 33, 1959, p. 225.

TABLE 4.—Graphite (natural and artificial) imported for consumption in the United States

[Bureau of the Census]

	Crystalline				Amorphous				Total	
	Flake		Lump, chip, or dust		Natural		Artificial			
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1950–54 (average)	8,856	$1,283,820	247	$31,098	37,296	$1,280,211	221	[1]$13,143	46,620	[1]$2,608,272
1955	7,706	1,018,600	195	28,703	40,663	1,328,197	236	11,130	48,800	2,386,630
1956	7,264	997,746	171	34,707	40,370	[1]1,555,828	83	5,427	47,888	2,593,708
1957	5,456	636,684	47	14,870	36,019	1,453,051	8	2,197	41,530	2,106,802
1958										
North America:										
Canada	------	------	------	------	------	------	2	203	2	203
Mexico	------	------	------	------	19,569	431,274	------	------	19,569	431,274
Europe:										
France	76	28,285	------	------	------	------	------	------	76	28,285
Germany, West	391	76,602	17	9,986	418	51,764	18	723	844	139,075
Netherlands	17	3,124	------	------	------	------	------	------	17	3,124
Norway	------	------	------	------	946	75,443	------	------	946	75,443
Switzerland	------	------	------	------	------	------	5	2,196	5	2,196
United Kingdom	(2)	119	------	------	------	------	------	------	(2)	119
Asia:										
Ceylon	------	------	84	11,904	1,811	231,019	------	------	1,895	242,923
Hong Kong	------	------	------	------	1,236	27,049	------	------	1,236	27,049
Africa:										
British East Africa	94	13,931	------	------	56	2,662	------	------	150	16,593
Madagascar	2,327	236,819	------	------	------	------	------	------	2,327	236,819
Total	2,905	358,880	101	21,890	24,036	819,211	25	3,122	27,067	1,203,103
1959										
North America:										
Canada	------	------	------	------	39	3,870	1	113	40	3,983
Mexico	------	------	------	------	25,760	497,933	------	------	25,760	497,933
Europe:										
Austria	------	------	------	------	15	599	------	------	15	599
France	17	6,154	------	------	------	------	------	------	17	6,154
Germany, West	402	71,848	66	19,168	759	84,019	------	------	1,227	175,035
Norway	------	------	------	------	1,834	142,095	------	------	1,834	142,095
Switzerland	------	------	------	------	------	------	4	1,507	4	1,507
United Kingdom	1	358	(2)	356	------	------	------	------	1	714
Asia:										
Ceylon	------	------	28	4,444	2,284	281,362	------	------	2,312	285,806
Hong Kong	------	------	------	------	994	28,210	------	------	994	28,210
Turkey	28	2,805	------	------	------	------	------	------	28	2,805
Africa:										
British East Africa	22	3,820	------	------	56	5,889	------	------	78	9,709
Madagascar	4,738	372,328	------	------	------	------	------	------	4,738	372,328
Total	5,208	457,313	94	23,968	31,741	1,043,977	5	1,620	37,048	1,526,878

---

[1] Owing to changes in tabulating procedures by the Bureau of the Census, some data known to be not comparable to other years.

[2] Less than 1 ton.

TABLE 5.—Graphite exported from the United States, by countries of destination

[Bureau of the Census]

Country	Amorphous		Crystalline flake, lump, or chip		Natural, n.e.c.	
	Short tons	Value	Short tons	Value	Short tons	Value
1958						
North America:						
Canada	479	$45,211	97	$24,410	77	$6,399
Cuba	28	4,600	5	2,155	10	1,600
Guatemala					1	1,580
Mexico	25	4,116	19	12,685	(1)	660
Panama	13	2,437	3	570		
South America:						
Argentina	11	4,732				
Brazil					55	9,130
Chile			5	1,013		
Colombia			25	5,260	13	3,233
Venezuela	46	9,498	4	820	22	4,940
Europe:						
Austria	5	952				
Czechoslovakia	22	3,423				
Denmark	11	1,834				
France	27	4,658			6	1,040
Italy					(1)	1,790
United Kingdom	95	14,350			29	6,263
Asia:						
India			1	762	11	1,834
Philippines	5	1,175	3	1,939	5	2,551
Saudi Arabia			2	2,783		
Taiwan					5	896
Oceania: Australia					1	1,560
Total	767	96,986	164	52,397	235	43,476
1959						
North America:						
Canada	556	52,488	35	21,440		
Cuba	11	1,847	4	1,252		
Bahamas					6	2,250
Dominican Republic			3	1,620		
Mexico	5	2,589	29	10,413	17	5,680
Netherlands Antilles					2	1,090
Panama			21	3,990		
South America:						
Brazil	161	23,382			1	580
Chile			2	528		
Colombia	5	692	7	3,490	52	2,875
Venezuela	23	5,666	59	11,449	64	4,725
Europe:						
Austria	5	953				
Czechoslovakia	17	2,695				
France					12	1,793
Germany, West	66	9,900				
Greece					2	2,592
Netherlands			1	1,240		
United Kingdom	130	20,737			11	3,426
Asia:						
India	5	952				
Japan					1	2,160
Philippines	18	3,246	6	1,622	16	5,446
Saudi Arabia			2	3,570		
Turkey	1	528				
Viet Nam					1	105
Africa: Egypt					10	1,780
Oceania: Australia					1	1,350
Total	1,003	125,675	169	60,614	196	35,852

[1] Less than 1 ton.

TABLE 6.—World production of natural graphite, by countries,[1] in short tons[2]

[Compiled by Liela S. Price and Berenice B. Mitchell]

Country [1]	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada	2,625	--------	--------	--------	--------	--------
Mexico	29,582	32,342	32,655	25,938	21,564	30,684
United States	[3] 6,031	(4)	(4)	(4)	(4)	(4)
South America:						
Argentina	76	96	572	451	525	[5] 550
Brazil	757	855	579	890	1,323	[5] 1,300
Europe:						
Austria	18,675	19,637	20,597	20,857	23,318	68,440
Germany, West	9,556	11,556	12,878	12,554	12,021	[5] 12,000
Italy	5,379	2,595	3,191	3,649	4,420	3,412
Norway	3,661	5,970	5,562	6,266	4,905	5,401
Spain	462	349	331	304	557	[5] 550
Sweden	--------	309	441	822	593	[5] 700
U.S.S.R	(6)	(6)	(6)	[5] 50,000	[5] 50,000	[5] 50,000
Yugoslavia	151	1,033	--------	1,102	992	1,102
Asia:						
Ceylon (exports)	10,762	11,064	10,261	9,223	6,342	8,817
China	(6)	(6)	(6)	(6)	[5] 35,000	[5] 45,000
Hong Kong	[7] 456	1,722	2,734	3,703	3,680	3,676
India	1,728	1,807	--------	--------	--------	--------
Japan	4,782	3,441	3,757	5,272	3,817	[5] 4,000
Korea:						
North	(6)	4,288	20,635	34,969	[5] 45,000	[5] 55,000
Republic of	19,499	99,228	67,367	162,703	103,806	91,045
Taiwan	154	--------	2,285	2,756	915	[5] 1,100
Africa:						
Kenya	118	241	619	1,056	739	635
Madagascar	16,832	17,443	17,451	16,989	11,861	11,023
Morocco:						
Northern zone	4	129	137	--------	--------	132
Southern zone	72	--------	--------	--------	--------	--------
Mozambique	53	--------	--------	--------	--------	--------
South-West Africa	1,167	1,011	--------	--------	--------	--------
Tanganyika	10	--------	26	--------	--------	--------
Union of South Africa	565	1,829	1,862	1,750	875	617
Oceania: Australia	79	24	11	--------	--------	--------
World total (estimate) [1] [2]	200,000	290,000	285,000	410,000	350,000	410,000

[1] In addition to countries listed, graphite has been produced in Czechoslovakia, but production data are not available; estimates by senior author of chapter included in total.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Average for 1950–53.

[4] Figure withheld to avoid disclosing individual company confidential data.

[5] Estimate.

[6] Data not available; estimate by senior author of chapter included in total.

[7] Average for 1953–54.

TABLE 7.—Graphite exported from Ceylon, by countries of destination, in short tons[1]

[Compiled by Bertha M. Duggan and Corra A. Barry]

Country	1958	1959	Country	1958	1959
North America:			Asia:		
Canada	56	237	India	332	398
United States	2,077	2,721	Japan	1,238	2,487
Europe:			Pakistan	32	59
France	247	112	Philippines	--------	56
Germany, West	158	198	Oceania:		
Netherlands	40	34	Australia	402	371
United Kingdom	1,727	2,072	Other countries	33	72
			Total	6,342	8,817

[1] Compiled from Ceylon Customs Returns.

TABLE 8.—Exports of graphite from Ceylon to the United States, by grades, in 1959 [1]

Grade	Short tons	Percent of total	Value per ton
97 percent C or higher	859	35.8	$148.39
90–96 percent C	1,316	54.9	112,34
Less than 90 percent C	224	9.3	101.25
Total	2,399	100.0	124.21

[1] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 5, May 1960, p. 13.

Graphite imports from Korea were valued at US$1,221,000 in 1958, compared with US$2,661,000 in 1957.

Korea, Republic of.—In 1959, 90,879 short tons of amorphous graphite and 166 short tons of crystalline graphite were produced, compared with 103,646 tons of amorphous and 160 tons of crystalline in 1958. During 1959, 46 mines reportedly were operating, but more than 70 percent of the production came from 4 mines.[7]

Madagascar.—The ratio of coarse flake (flake) to fine flake (fines) graphite produced in the first 6 months of 1959 was 46:54, compared with 40:60 in the same period in 1958.

TABLE 9.—Graphite exported from Madagascar, by countries of destination, in short tons [1]

[Compiled by Bertha M. Duggan and Corra A. Barry]

Country	1957	1958
North America: United States	5,488	2,923
Europe:		
Belgium-Luxembourg	62	69
France	3,015	2,442
Germany, West	2,847	3,425
Italy	1,049	1,489
Netherlands	72	14
Poland	----------	86
Spain	61	66
United Kingdom	4,164	1,160
Africa: Union of South Africa	----------	244
Asia: Japan	453	112
Oceania: Australia	55	167
Other countries	2	39
Total	17,268	12,236

[1] Compiled from Customs Returns of Madagascar.

Mexico.—The facilities and operations of the San Francisco mine of Grafitera de Sonora, S.A. de C.V., Mexican affiliate of Cummings-Moore Graphite Co., Detroit, Mich., were described.[8]

On October 5, 1959, the Mexican Ministry of the Treasury and Public Credit issued a decree that has the effect of increasing the export tax on graphite 2,000-fold. This was accomplished by increasing the official price of graphite, on which the Mexican export tax of 30 percent ad valorem is based, from 0.0225 pesos to 5.075 pesos per net kilogram and, at the same time, raising the production

---

[7] Bank of Korea, Monthly Statistical Review (Seoul): Vol. 14, No. 2, February 1960, p. 86.

[8] American Chamber of Commerce of Mexico, Sonora Graphite—A Strategic Mineral: Mexican American Rev., July 1959, 3 pp.

tax from 0.0066 to 0.0601 pesos per net kilogram. The increased taxes resulted in complete suspension of graphite mining operations and unemployment for over 1,000 workmen.

Company officials, representatives of the local press and local civic organizations, and the Governor of Sonora (the State where the mines are situated) protested the higher tax to the President of Mexico. Subsequently, a lower tax rate on amorphous graphite was established, effective November 1. This decree distinguished between crystalline and amorphous graphite and continued to apply the October 5 rates to crystalline graphite. The new official price of amorphous graphite on which the ad valorem tax was assessed was fixed at 0.3110 pesos per net kilogram and the production tax was set at 0.0081 pesos per net kilogram.

Graphite mines in Sonora resumed operations but paid the revised export tax rates under protest and continued to try to obtain further tax relief.[9]

Rhodesia and Nyasaland, Federation of.—A crystalline flake graphite occurrence in the Petauke district of the Eastern Province of Northern Rhodesia was described.[10] The graphite occurs as disseminated coarse flakes in weathered granitic gneiss. The ore body extends at least 2 miles along the valley of the Mkonda River and is 600 to 900 feet wide. The ore is weathered to a depth of more than 10 feet. Thirty samples, taken at intervals of one-tenth mile along the strike, averaged 6.8 percent graphite. A crude concentrate was recovered at the site on one sample. The concentrate assayed 90.2 percent C. About 8.5 percent of the graphite was retained on 20-mesh and more than 80 percent was coarser than 52-mesh. Samples of the ore were submitted to the Government Metallurgical Laboratory at Salisbury for comprehensive testing.

Union of South Africa.—Virtually all of the graphite produced in the Union of South Africa was used locally. In 1958, 10 short tons valued at US$616 was exported to Japan, and in 1957, 44 short tons valued at US$2,562 was exported to the United Kingdom.[11] The two leading producers in 1958 were Malanga Grafiet Myn, Messina, and Silica (Pty), Ltd., Johannesburg.

U.S.S.R.—High-grade amorphous graphite occurs in the western part of the Siberian Platform. The best known deposits are the Noginskiy, the Kureiskoe, and the Fatyanikhinskiy, with a combined graphite-ore reserve totaling 14.5 million short tons. The Noginskiy deposit, 175 miles from the mouth of the Nizhnyaya Tunguska River, was discovered in 1859 and has been mined since 1863. The main graphite bed ranges from 5 to 20 feet in thickness and has been traced for 3,800 feet along the strike. The deposit contains three additional beds up to 6 feet wide. The graphite ore reserve is 1.4 million tons.[12]

TECHNOLOGY

New and improved types of manufactured graphite were made available during the year. One of the new materials, a polycrystalline

---

[9] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 4, April 1960, p. 10.

[10] Northern Rhodesia Department of Geological Survey, Annual Report for the Year 1958: January 1959, p. 4.

[11] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 4, October 1959, p. 41.

[12] Work cited in footnote 11, p. 42.

form of graphite deposited from a carbonaceous vapor at temperatures above 2,000° C., had a higher density and greater anisotropic thermal and electrical properties than normal graphite; also, it was more impermeable to gases. This material, marketed under the trade name Pyrographite by Raytheon Co., was expected to be used in missiles and rockets, nuclear reactors, and other applications where strength, impermeability, and chemical inertness at high temperatures are required. Another new type of manufactured graphite was produced in flexible fiber and fabric form by converting organic textiles directly to graphite. The resulting graphite had a purity exceeding 99.9 percent C and tensile strength up to 15,000 p.s.i. National Carbon Co., Division of Union Carbide Corp., developed these graphite fabrics. Suggested uses were to filter hot gases, reinforce plastics and high-temperature refractories, impart thermal and electrical conductance to plastics and ceramics, and in fire retardants, vacuum tube grids, infrared emitters, and self-lubricating, high-temperature packing and gasket materials. Less porous manufactured graphite was made by impregnating the baked material with a hot, concentrated sugar solution[13] or with furfuryl alcohol[14] and subsequent heating to deposit carbon in the pores.

Manufactured graphite continued to be the major material used as a moderator in thermal reactors to reduce neutrons of fission energy to thermal energy. The Atomic Energy Commission signed contracts in August with Philadelphia Electric Co. and General Dynamics Corp. to build a graphite-moderated, helium-cooled nuclear reactor at Peach Bottom, York County, Pa. If feasible, the fuel elements were to be uranium and thorium dispersed in graphite and were to be graphite-clad.

The use of manufactured graphite in nuclear reactors and the effect of radiation on its properties were discussed in numerous reports.[15]

---

[13] South African Mining and Engineering Journal (Johannesburg), Sugar for Nuclear Energy: Vol. 70, No. 3473, pt. 2, Sept. 4, 1959, p. 615.

[14] Chemical Trade Journal and Chemical Engineer (London), Improved Manufactured Graphite: Vol. 145, No. 3769, Aug. 28, 1959, p. 247.

[15] Aleksenko, Yu. N., and Kakushadze, L. Ye. [Radiation-Induced Changes in the Physical Properties of Some Graphites of Various Degrees of Graphitization]: Atomnaya Energiya (Moscow), vol. 6, No. 5, May 1959, pp. 568–569; Scientific Inf. Rept. (CIA) PB 131891 T–26, July 17, 1959, p. 16.

Austerman, S. B., Low-Temperature Irradiation and Annealing Experiments in Graphite: U.S. Atomic Energy Comm. Rept. NAA–SR 2547, 1958, 25 pp.

Chemical Engineering, New Nuclear Grades of Graphite: Vol. 66, No. 3, Feb. 9, 1959, p. 60; Purifying Route to Nuclear-Grade Graphite: No. 4, Feb. 23, 1959, pp. 114–117; What Materials Beat High Nuclear Heat?: No. 8, Apr. 20, 1959, pp. 202, 204, 206.

Chemical and Engineering News, Graphite Leads as Moderator: Vol. 37, No. 30, July 27, 1959, p. 67.

Chemical Trade Journal and Chemical Engineer (London), Nuclear Graphite: Vol. 144, No. 3737, Jan. 16, 1959, p. 139.

Davidson, J. M., and Others, High Temperature Radiation Induced Graphite Contraction: General Electric Co., Hanford Atomic Products Operation, Richland, Wash., Contract W–31–109–eng–52, February 1959, 14 pp.; U.S. Govt. Res. Repts., Off. Tech. Services, U.S. Dept. Commerce, vol. 32, No. 4, Oct. 16, 1959, p. 548.

Davis, T. D., Graphite, A Literary Search: U.S. Atomic Energy Comm., Tech. Inf. Service Rept. TID–3532, October 1959, 80 pp.

Gibb, C. D., Graphite in the World Nuclear Power Program: Eng. Jour. (Quebec), vol. 42, No. 7, July 1959, pp. 43–49, 53.

Smith, J. C.,, and Others, Irradiation of Clad-Graphite in High-Temperature High-Pressure CO_2: Battelle Memorial Inst., Columbus, Ohio, Contract W–7405–eng–92, April 1959, 28 pp.; U.S. Govt. Res. Repts., Off. Tech. Services, U.S. Dept. Commerce, vol. 32, No. 2, Aug. 14, 1959, p. 278.

Snyder, W. A., Radiation Damage to Graphite at 500° C: General Electric Co., Hanford Atomic Products Operation, Contract W–31–109–eng–52, September 1957, 12 pp.; U.S. Govt. Res. Rept., Off. Tech. Services, U.S. Dept. Commerce, vol. 32, No. 2, Aug. 14, 1959, p. 284.

Reports dealing with the properties of graphite were declassified by the Atomic Energy Commission.[16]

Proceedings of conferences on carbon and graphite held in 1957 in London, England,[17] and Buffalo, N.Y.,[18] and a handbook on manufactured graphite[19] were published.

Based on studies of the theory and practice of manufactured graphite technology, it was concluded that small, multicrystalline, manufactured graphite shapes could be made to engineering specifications required in space vehicles and their power plants.[20] Coated and impregnated graphites were being developed to resist corrosion and erosion at the high temperatures encountered by rockets and missiles in space flight.[21]

Platinum-plated titanium anodes were said to offer major savings in power and anode consumption when used to replace graphite anodes in chlorine manufacture.[22]

---

[16] The following references were cited in U.S. Government Research Reports, Office of Technical Services, U.S. Dept. of Commerce (page number in parentheses after each reference):

Vol. 30, No. 4, Oct. 17, 1958:

Fraser, W. A., and Prosen, E. J., Heats of Combustion of Irradiated Graphite and Diamond Samples: Nat. Bureau of Standards, Washington, D.C., project 3203, February 1952, 16 pp. (p. 318).

Hook, A. S., Changes in the Thermal and Electrical Properties of Irradiated Graphite During Pulse Annealing: North American Aviation, Inc., Downey, Calif., Contract AT–11–1–gen–8, January 1952, 48 pp. (p. 318).

Nightingale, R. E., and Fletcher, J. F., Radiation Damage to Graphite From 30° C to 185° C: General Electric Co., Hanford Atomic Products Operation, Richland, Wash., Contract W–31–109–eng–52, June 1957, 16 pp.; September 1957, 22 pp. (p. 317).

Vol. 30, No. 5, Nov. 14, 1958:

Brown, F. W., Lecture on Relaxation Effects in Irradiated Graphite: North American Aviation, Inc., Los Angeles, Calif., Contract AT–11–1–gen–8, Feb. 22, 1949, 30 pp. (p. 471).

Gibson, W. B., Preliminary Investigations into the Preparation of Extruded Graphite: Los Alamos Scientific Lab., Los Alamos, N. Mex., Contract W–7405–eng–36, 1957, 27 pp. (p. 469).

Parkins, W. E., Experimental Techniques in Annealing Bombarded Graphite: North American Aviation, Inc., Los Angeles, Calif., Contract AT–11–1–gen–8, Oct. 15, 1948, 27 pp. (p. 471).

Sanz, M. C., Impregnation of Porous Graphite With Uranium: North American Aviation, Inc., Los Angeles, Calif., Jan. 6, 1947, 14 pp. (p. 471).

Vol. 32, No. 2, Aug. 14, 1959:

Blocher, J. M., Jr., and Others, Carbide Coatings on Graphite: Battelle Memorial Inst., Columbus, Ohio, Contract W–7405–eng–92, June 1957, 58 pp. (p. 277).

Davis, Calvin, Machining Techniques and Procedures for Uranium, Graphite, Titanium, Zirconium, Thorium, Tantalum, Beryllium, Bismuth, Lithium, and Stellite, New York Operations Office, AEC, New York, N.Y., November 1952, 89 pp. (p. 279).

[17] Society of Chemical Engineers, Industrial Carbon and Graphite: London, 1958, 630 pp.

[18] University of Buffalo, Proceedings of the Third Conference on Carbon: Symposium Publications Division, Pergamon Press, New York, N.Y., 1959, 718 pp.

[19] National Carbon Co., Division of Union Carbide Corp., The Industrial Graphite Engineering Handbook: New York, 1959, 156 pp.

[20] Bradstreet, S. W., Graphite Technology: Wright Air Development Center Tech. Rept. 58–503, January 1959, 66 pp.

[21] Blocher, J. M., Jr., and Others, Coating of Graphite With Silicon Carbide by Reaction With Vapor of Controlled Silicon Activity: Battelle Memorial Inst., Columbus, Ohio, Contract W–7405–eng–92, June 1959, 17 pp.; U.S. Govt. Res. Repts., Off. Tech. Services, U.S. Dept. Commerce, vol. 32, No. 4, Oct. 16, 1959, p. 540.

Ceramic Age, New Refractory Material: Vol. 73, No. 4, April 1959, pp. 13–14.

Chemical Engineering, Refractory Metals Mate With Graphite: Vol. 66, No. 26, Dec. 28, 1959, p. 24.

Engle, G. B., and Liggett, L. M., Graphite—How It Compares With Metals, Ceramics: Materials in Design Eng., vol. 49, No. 6, June 1959, pp. 88–90.

Missiles and Rockets, What Can Withstand Re-entry Heat?: Aug. 3, 1959, pp. 24–25.

Whalen, P. T., Effects of Several Impregnants on the Oxidation Resistance of Graphite: Watertown Arsenal, U.S. Army Ordnance Corps, no date, 23 pp.; Off. Tech. Services, U.S. Dept. Commerce Rept. PB 151575.

[22] Chemical Week, Platinum-Plated Route to Chlorine Savings?: Vol. 85, No. 24, Dec. 12, 1959, pp. 67–68, 70.

Patents were issued for producing unctuous graphite,[23] for purifying graphite,[24] and for impregnating manufactured graphite products to increase their resistance to oxidation,[25] to make them more impermeable,[26] or to increase their density.[27] A new method of coating manufactured graphite was developed.[28] An air separator suitable for classifying ground graphite was patented.[29]

---

[23] Mitchell, C. V. (assigned to Union Carbide Corp., New York, N.Y.), Preparation of Graphite from Polynuclear Aromatic Hydrocarbons: U.S. Patent 2,915,370, Dec. 1, 1959.

[24] Beeston, A. W. (assigned to Union Carbide Corp., New York, N.Y.), Purification of Carbon on Graphite Articles: British Patent 798,644, Oct. 29, 1958; Chem. Abs., vol. 53, No. 1, Jan. 10, 1959, col. 617a.

Nedopil, E. (assigned to Seimens-Planiawerke A. G. fur Kohlefabricate, Meitingen bei Augsburg, Germany), Production of High-Purity Graphite: Canadian Patent 587,392, Nov. 17, 1959.

Ulrich, Helmut (assigned to Graphitwerk Kropfmühl A. G. (Munich, Germany), Process of Purifying Graphite: U.S. Patent 2,914,383, Nov. 24, 1959.

[25] Fisher, J. C., Jr. (assigned to Union Carbide Corp., New York, N.Y.), Oxidation Resistant Graphite: U.S. Patent 2,897,102, July 28, 1959.

Johnson, N. J., and Nickerson, J. D. (assigned to Union Carbide Corp., New York, N.Y.), Oxidation Resistant Carbon and Graphite Bodies: U.S. Patent 2,868,672, Jan. 13, 1959.

[26] Melzer, Wolfgang, and Schuster, Wilhelm (assigned to Aktiengesellschaft, Kuhnle, Kopp & Kausch, Frankenthal, Germany), Method of Rendering Porous Graphite Body Impervious to Fluids: U.S. Patent 2,917,404, Dec. 15, 1959.

[27] Sofue, H., and Tabata, Y., Graphite of High Density: Japanese Patent 6,265 (1959), July 18, 1959; Chem. Abs., vol. 53, No. 22, Nov. 25, 1959, col. 22797a.

[28] Gurinsky, D. H. (assigned to the United States of America as represented by the Chairman of the Atomic Energy Commission), Method of Coating Graphite with Stable Metal Carbides and Nitrides: U.S. Patent 2,910,379, Oct. 27, 1959.

[29] Lykken, H. G. (assigned to The Microcyclomat Co., Minneapolis, Minn.), Aerodynamic Classifier: U.S. Patent 2,915,179, Dec. 1, 1959.

Gypsum

By Robert B. McDougal [1] and Nan C. Jensen [2]

◆

THE DOMESTIC gypsum industry reached a new high in 1959 in the output of crude gypsum to meet the needs of the building industry. Several companies were expanding facilities or were building new plants to market their products in new areas.

TABLE 1.—Salient statistics of the gypsum industry

(Thousand short tons and thousand dollars)

	1950-54 (average)	1955	1956	1957	1958	1959
United States:						
Active establishments [1]	88	83	88	84	85	93
Crude gypsum: [2]						
Quantity mined	8,512	10,684	10,317	9,195	9,600	10,900
Value	$24,043	$33,938	$34,099	$29,871	$32,495	$39,141
Imports	3,259	3,977	4,346	4,334	[3] 4,047	6,135
Apparent supply	11,771	14,661	14,663	13,529	[3] 13,647	17,035
Calcined gypsum produced:						
Quantity	7,291	8,848	8,608	7,801	8,122	9,268
Value	$65,755	$88,576	$91,336	$83,455	$91,402	$111,740
Gypsum products sold: [4]						
Uncalcined uses:						
Quantity	2,571	2,938	3,259	3,139	3,471	3,989
Value	$9,476	$11,435	$13,173	$13,120	$14,018	$16,109
Industrial uses:						
Quantity	262	299	334	319	250	311
Value	$5,129	$6,337	$7,310	$6,998	$5,850	$7,087
Building uses:						
Value	$222,065	$301,551	$301,169	$280,977	[5] $309,202	[5] $365,139
Total value	$236,670	$319,323	$321,652	$301,095	$329,070	$388,335
Gypsum and gypsum products:						
Imports for consumption (value)	$4,253	$7,276	$8,546	$8,514	[3] $7,863	$13,204
Exports (value)	$1,488	$1,348	$1,216	$1,345	$2,465	$1,296
World: Production	[3] 27,510	[3] 35,380	[3] 36,460	[3] 37,230	[3] 38,740	42,320

[1] Each mine, calcining plant, or combination mine and plant is counted as 1 establishment.
[2] Excludes byproduct gypsum.
[3] Revised figure.
[4] Made from domestic, imported, and byproduct gypsum.
[5] Excludes tile.

DOMESTIC PRODUCTION

Crude.—Domestic mines produced about 10.9 million short tons of gypsum for an increase of approximately 14 percent above 1958. The production rate was highest during the second and third quarters. Over half the crude gypsum output from Iowa and Texas and about one-third the output in Michigan was calcined, whereas more than

---

[1] Commodity specialist.
[2] Supervisory statistical assistant.

half that produced in California was sold for agricultural purposes. The 67 mines operated included 50 open pit, 15 underground, and 2 combined open pit-underground.

TABLE 2.—Crude gypsum mined in the United States, by States

(Thousand short tons and thousand dollars)

	1958			1959		
	Active mines	Quantity	Value	Active mines	Quantity	Value
California	12	1,423	$3,184	14	1,686	$3,788
Colorado	5	103	341	5	106	385
Iowa	4	1,230	4,491	4	1,318	5,587
Michigan	4	1,331	4,824	5	1,721	6,595
Nevada	3	686	2,306	3	818	2,738
New York	5	834	3,869	5	919	4,663
South Dakota	1	12	49	1	19	78
Texas	6	1,240	4,120	6	1,351	4,770
Wyoming	1	6	19	1	9	30
Other States [1]	21	2,735	9,292	23	2,953	10,507
Total	62	9,600	32,495	67	10,900	39,141

[1] Includes the following States to avoid disclosing individual company confidential data: Arkansas, Idaho, Louisiana, Virginia, and Washington, 1 mine each; Indiana, Kansas, Montana, Ohio, and Utah, 2 mines each; Arizona (1958) 2 mines, (1959) 3 mines; and Oklahoma (1958) 4 mines; (1959) 5 mines.

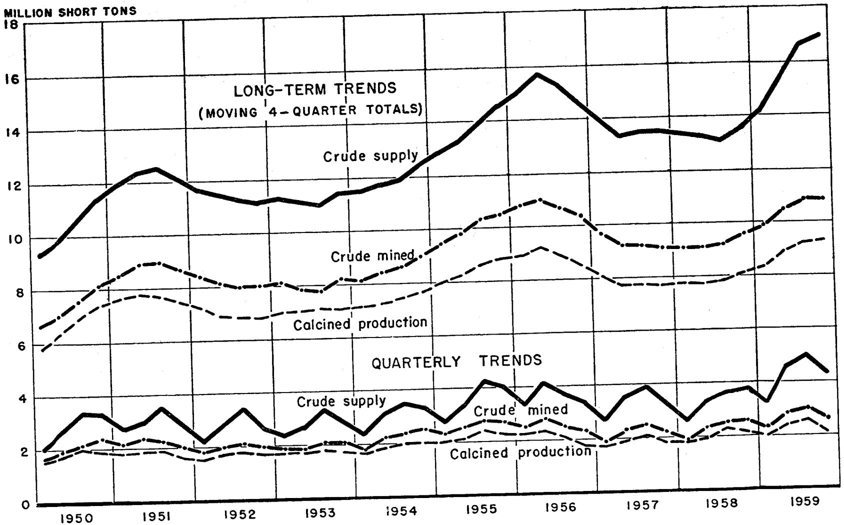

FIGURE 1.—Trends of new crude supply, domestic crude mined, and production of calcined gypsum, 1950–59, by quarters.

Calcined.—Sixty plants, having 271 kettles and other pieces of calcining equipment produced calcined gypsum from domestic and imported ores. Calcined gypsum produced totaled 9.3 million tons 14 percent above the output in 1958 and valued at $111.7 million. Coal, natural gas, oil, and propane were the fuels supplying the heat necessary for converting gypsum to the calcined form in which most gypsum is used.

Mine and Products-Plant Development.—A major expansion program by Bestwall Gypsum Co. including three new plants and improvements at two existing plants was described.[3] A $7 million plant at the Wilmington, Del., Marine Terminal was in the engineering stage and erection of a new $4 million plant at Blue Rapids, Kans., was begun to replace facilities on land to be inundated by the Tuttle Creek dam. Scheduled for completion by July 1960, the new plant capacity will be 100 percent greater and will include facilities to produce gypsum board and lath. A new $5.5 million plant will be built on the Mississippi River–Gulf of Mexico outlet at New Orleans, La. It will be the first industrial plant along the new outlet. Bestwall's new Brunswick, Ga., plant was recently enlarged by a $500,000 addition.

TABLE 3.—Calcined gypsum production in the United States, by States

State	1958					1959				
	Active plants	Short tons (thousands)	Value (thousands)	Calcining equipment		Active plants	Short tons (thousands)	Value (thousands)	Calcining equipment	
				Kettles	Other[1]				Kettles	Other[1]
California	6	710	$6,883	21	10	6	860	$8,197	18	10
Iowa	4	789	8,844	20	4	4	861	10,592	20	4
Michigan	4	511	5,673	17	4	4	524	6,569	18	1
New York	7	1,153	13,556	24	7	7	1,349	16,698	24	6
Texas	5	798	9,742	30	--------	6	962	12,254	31	--------
Other States[2]	31	4,161	46,704	94	36	33	4,712	57,430	103	36
Total	57	8,122	91,402	206	61	60	9,268	111,740	214	57

[1] Includes rotary and beehive kilns, grinding-calcining units, Holo-Flites, and Hydrocal cylinders.

[2] Comprises States and number of plants as follows: Arizona, 1; Colorado, 3; Connecticut, 1; Florida, 1; Georgia (1958) 1, (1959) 2; Illinois (1959) 1; Indiana, 3; Kansas, 2; Louisiana, 2; Maryland, 1; Massachusetts, 1; Montana, 1; Nevada, 2; New Hampshire, 1; New Jersey, 2; Ohio, 2; Oklahoma, 1; Pennsylvania, 1; Utah, 2; Virginia, 2; and Washington, 1.

Heavier demand for wallboard, plaster base, and gypsum sheathing in Florida and the Southeast resulted in a 25-percent increase of capacity at United States Gypsum Co.'s Jacksonville, Fla., plant. At Sperry, Iowa, work progressed on the company's mine. Ore from a tunnel between the main shaft and a ventilating shaft was stockpiled on the surface awaiting the opening of the plant early in 1960.

United States Gypsum Co. opened a new $12 million plant in Galena Park (Houston), Tex., early in 1959. Crude gypsum will be brought in from Jamaica in company-owned ships for manufacturing into wallboard and other products.

Kaiser Gypsum Co. announced that options had been taken on new industrial waterfront sites in Houston, Tex., and Jacksonville, Fla., for new building products plants, and that a plant with an annual

---

[3] Pit and Quarry, vol. 52, No. 5, November 1959, p. 23.

capacity of 120 million square feet of gypsum board would be built near Albuquerque, N. Mex. The plant will be adjacent to a high-grade deposit at Rosario on the Santa Fe Railway between Albuquerque and Santa Fe.

A new firm, American Gypsum Co., reported plans to build a $3 million plant at Albuquerque, N. Mex., to manufacture gypsum building products. Raw material for the plant will come from the White Mesa deposit near San Ysidro, 30 miles to the northwest.

National Gypsum Co. completed a major expansion program at its Savannah, Ga., plant, which the company now claims is the largest products plant in the world. Some ore from its new open-pit mine at Tawas City, Mich., was stockpiled before a plant was opened at Lorain, Ohio. An expansion program at the National Gypsum Co. plant near Shoals, Ind., will boost capacity of the plant by 50 percent and will include enlarging all operations and increasing the output of the mine. Coyote Wells, near El Centro, Imperial County, Calif., will be the site of a new $10 million plant operated by National Gypsum Co.

Big Horn Basin Gypsum Co. announced plans to build a $3 million board plant near Cody, Wyo., with an annual capacity of 100 million feet of gypsum board. The gypsum deposit, containing about 40 million tons, will be mined as an open pit with a 75-foot face.

The Flintkote Co. acquired the Blue Diamond Corp., sixth largest producer of gypsum products in the United States. Beside a gypsum mine and products plant at Blue Diamond, Nev., the company also operates three aggregates plants and eight cement-products plants.

CONSUMPTION AND USES

Private and public spending for new construction in the United States increased 10 percent from about $48.9 billion in 1958 to $54.3 billion in 1959.[4] The nearly $5.4 billion rise in expenditures comprised increases in residential (private and public) building, stores, restaurants, garages, highways, and farms. In terms of physical volume (expenditures adjusted for price changes) 1959 construction showed the largest annual growth since 1950.

Most gypsum building products that were consumed followed the trends of the residential building industry, particularly the high-value prefabricated materials used in residential building.

---

[4] Construction Review, vol. 6, No. 3, March 1960, 56 pp.

TABLE 4.—Gypsum products (made from domestic, imported, and byproduct crude gypsum) sold or used in the United States, by uses

(Thousand short tons and thousand dollars)

Products	1958		1959	
	Quantity	Value	Quantity	Value
Uncalcined:				
Portland-cement retarder	2,416	$10,213	2,757	$11,868
Agricultural gypsum	1,021	3,365	1,188	3,672
Other uses [1]	34	440	44	569
Total	3,471	14,018	3,989	16,109
Calcined:				
Industrial:				
Plate-glass and terra-cotta plasters	48	723	68	982
Pottery plasters	41	870	50	1,062
Orthopedic and dental plasters	9	366	11	416
Industrial molding, art, and casting plasters	75	1,575	100	2,119
Other industrial uses [2]	77	2,316	82	2,508
Total	250	5,850	311	7,087
Building:				
Plasters:				
Base-coat	1,321	22,154	1,403	23,962
Sanded	578	13,950	634	15,335
To mixing plants	3	50	3	51
Gaging and molding	132	2,548	141	2,747
Prepared finishes	13	1,071	13	1,123
Roof-deck	404	6,491	415	6,941
Other [3]	24	2,222	25	2,585
Keene's cement	43	1,098	48	1,184
Total	2,518	49,584	2,682	53,928
Prefabricated products [4]	[5] 6,459	259,618	[5] 7,664	311,211
Total building		309,202		365,139
Grand total, value		329,070		388,335

[1] Includes uncalcined gypsum for use as 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.
[4] Excludes tile.
[5] Includes weight of paper, metal, or other materials.

STOCKS

Producers reported that their stocks of crude gypsum on hand December 31, 1959, totaled 2.5 million short tons, while 2.3 million tons and 2.2 million tons were held by producers at the end of 1957 and 1958, respectively.

TABLE 5.—Prefabricated products sold or used in the United States

(In thousands)

	1958			1959		
	Square feet	Short tons[1]	Value	Square feet	Short tons[1]	Value
Lath:						
⅜-inch[2]	2,121,627	1,593	$55,564	2,305,118	1,732	$60,320
½-inch	32,994	33	1,033	40,999	42	1,281
Total	2,154,621	1,626	56,597	2,346,117	1,774	61,601
Wallboard:						
¼-inch	141,681	79	4,290	152,821	88	4,649
⅜-inch	[3] 2,001,352	[3] 1,530	[3] 69,868	2,195,283	1,677	77,748
½-inch	2,748,830	2,795	111,333	3,505,112	3,554	143,603
⅝-inch	159,067	208	8,862	225,047	294	12,625
1-inch	----------	----------	----------	[4] 1,099	[4] 2	[4] 72
Total	5,050,930	4,612	194,353	6,079,362	5,615	238,697
Sheathing	166,273	173	6,710	209,834	219	8,529
Laminated board	[5] 1,482	2	94	[5] 2,950	3	168
Formboard	44,034	46	1,864	50,540	53	2,216
Grand total[6]	7,417,340	6,459	259,618	8,688,803	7,664	311,211

[1] Includes weight of paper, metal, or other materials.
[2] Includes a small amount of ¼-inch lath.
[3] Includes a small amount of 5/16-inch wallboard.
[4] Includes 5/16-inch and ¾-inch wallboard.
[5] Area of component board and not of finished product.
[6] Excludes tile, for which figures are withheld to avoid disclosing individual company confidential data.

PRICES

The average value of crude gypsum mined in the United States was $3.59 per ton, compared with $3.38 in 1958 and $3.25 in 1957, according to reports from producers. Portland cement retarder was $4.30 per ton, whereas the average value of agricultural gypsum was $3.09 per ton. Industrial plasters declined 3 percent in average value. Building plasters and prefabricated gypsum products increased 2 percent in average values.

Based on 1947–49 averages equaling 100, gypsum products prices, as reported by the U.S. Department of Labor and the U.S. Department of Commerce, showed no changes from 1958 throughout 1959.

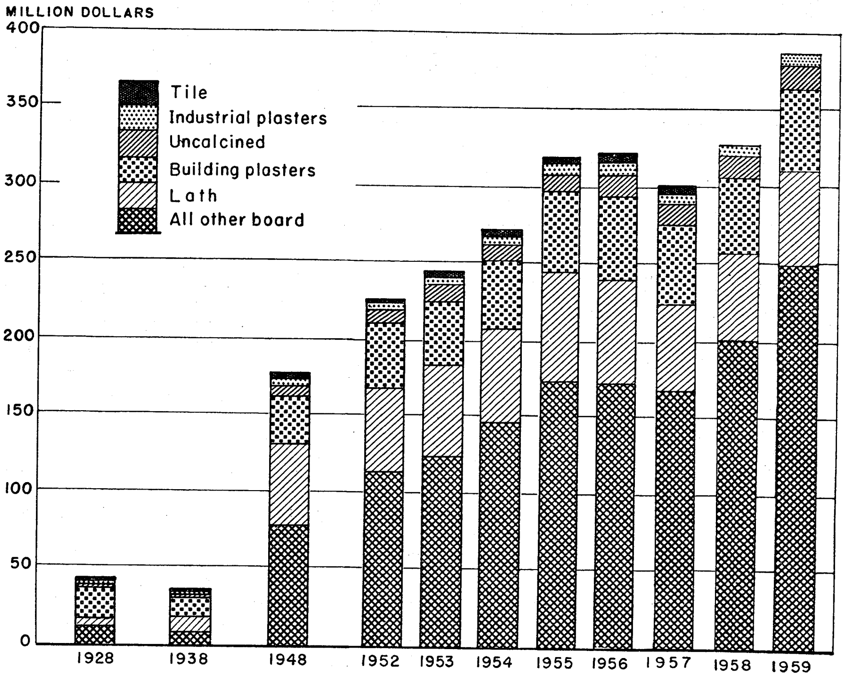

FIGURE 2.—Value of gypsum products sold or used in 1928, 1938, 1948, and 1952–59, by uses.

FOREIGN TRADE[5]

Imports of crude gypsum increased 52 percent from 4.0 million short tons in 1958 to 6.1 million tons. Canada supplied 4.9 million tons, 29 percent of the total United States supply.

TABLE 6.—Gypsum and gypsum products imported for consumption into the United States

[Bureau of the Census]

Year	Crude (including anhydrite)		Ground or calcined		Keene's cement		Alabaster manufactures[1] (value)	Other manufactures, n.e.s. (value)	Total value
	Short tons	Value	Short tons	Value	Short tons	Value			
1950-54 (average)	3,259,307	[2]$3,845,118	851	$28,334	4	$248	[2]$148,141	[2]$230,743	[2]$4,252,584
1955	3,977,105	[2]6,298,410	937	32,674	1	834	[2]346,357	[2]597,340	[2]7,275,615
1956	4,346,135	[2]7,814,223	1,146	39,333	-------	-------	[2]415,973	[2]276,590	[2]8,546,119
1957	4,334,467	[2]7,570,671	870	[2]33,043	-------	-------	[2]577,273	[2]333,510	[2]8,514,497
1958	[3]4,046,999	[3]6,863,779	787	32,680	-------	-------	611,726	354,962	[3]7,863,147
1959	6,134,611	11,870,877	1,025	46,297	-------	-------	945,590	341,524	13,204,288

[1] Includes imports of jet manufactures, which are believed to be negligible.
[2] Data known to be not comparable with other years.
[3] Revised figure.

---

[5] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 7.—Crude gypsum (including anhydrite) imported for consumption into the United States, by countries

(Thousand short tons and thousand dollars)

[Bureau of the Census]

Country	1958		1959	
	Quantity	Value	Quantity	Value
North America:				
Canada	[1] 2,877	[1] $4,626	4,864	$10,001
Dominican Republic	39	106	113	308
Jamaica	668	1,712	437	915
Mexico	459	414	721	647
Total	[1] 4,043	[1] 6,858	6,135	11,871
Europe [2]	4	6	(3)	(3)
Grand total	[1] 4,047	[1] 6,864	6,135	11,871

[1] Revised figure.
[2] 1958: United Kingdom; 1959: Italy.
[3] Less than 1,000.

TABLE 8.—Gypsum and gypsum products exported from the United States

(In thousands)

[Bureau of the Census]

Year	Crude, crushed, or calcined		Plasterboard, wallboard, and tile		Other manufactures n.e.c.[1] (value)	Total value
	Short tons	Value	Square feet	Value		
1950–54 (average)	23	$621	25,097	$748	$119	$1,488
1955	23	738	8,687	412	198	1,348
1956	21	711	7,027	364	141	1,216
1957	24	763	8,867	520	62	1,345
1958	29	921	(1)	(1)	1,544	2,465
1959	14	641	(1)	(1)	655	1,296

[1] Effective Jan. 1, 1958, plasterboard, wallboard, and tile not separately classified, included in "gypsum manufactures, n.e.c."

WORLD REVIEW

NORTH AMERICA

Canada.—Nova Scotia and Ontario, the Commonwealth's two largest producing Provinces in 1958, shipped 3,149,700 and 425,700 short tons, respectively. The remainder of the total shipments of 3,964,100 tons came from Manitoba (176,100 tons), New Brunswick (105,800 tons), British Columbia (70,500 tons), and Newfoundland (36,300 tons).[6] After a prolonged strike at Canadian Gypsum Co., Ltd., mines in Nova Scotia, output of crude gypsum in Canada dropped below that of 1957.[7] Seven firms reported mining at 13 sites, and 73 percent of their output was exported to markets along the United States eastern seaboard. Canada imported 108,000 tons of crude gypsum, mainly from Mexico, for use by a gypsum product plant in British Columbia. Im-

---

[6] Dominion Bureau of Statistics, The Gypsum Industry 1958: Ottawa, Canada, March 1960, 12 pp.
[7] Canada Department of Mines and Technical Surveys, Gypsum and Anhydrite 1958: Ottawa, Canada, April 1959, 9 pp. (preliminary).

ports of finished gypsum products totaled 56,100 tons and were largely from the United States for use in British Columbia, Ontario, and Quebec; whereas, 16 tons of finished gypsum products was exported to New Zealand.

TABLE 9.—Output of gypsum products in Canada

(In thousands)

[Canada Department of Mines and Technical Surveys, Ottawa]

Product	1957		1958	
	Quantity	Value [1]	Quantity	Value [1]
Wallboard..........square feet..	304, 591	Can$12, 004	375, 004	Can$14, 898
Lath..........do....	322, 402	9, 744	395, 449	12, 001
Hard wall plasters..........short tons..	185	3, 912	231	5, 109
Other plasters..........do....	85	2, 285	74	1, 892
All other products [2]..........	----------	1, 682	----------	1, 819
Total..........	----------	29, 627	----------	35, 719

[1] Selling value at works.
[2] Includes tile and blocks, etc.

TABLE 9.—World production of gypsum, by countries [1] [2]

Thousand short tons)

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country [1]	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada [3]..........	3, 857	4, 540	4, 900	4, 707	3, 977	5, 941
Cuba..........	30	[4] 35	24	[4] 45	[4] 45	[4] 45
Dominican Republic..........	17	64	84	80	84	175
Guatemala..........	----------	----------	----------	7	17	[4] 17
Jamaica..........	75	92	140	212	672	432
United States..........	8, 512	10, 684	10, 316	9, 195	9, 600	10, 900
Total [1] [4]..........	12, 571	15, 525	15, 574	14, 356	14, 505	17, 620
South America:						
Argentina..........	156	132	193	169	118	[4] 121
Brazil..........	44	178	175	121	143	[4] 143
Chile [4]..........	74	83	77	77	77	77
Colombia..........	8	24	51	[4] 66	66	77
Peru..........	50	72	70	70	70	[4] 66
Venezuela..........	1	----------	----------	----------	----------	[4] 1
Total [1] [4]..........	333	489	566	503	474	485
Europe:						
Austria [3]..........	247	455	499	579	597	621
Czechoslovakia..........	(5)	233	192	233	[4] 233	[4] 233
France (salable) [3]..........	2, 727	4, 018	3, 933	3, 920	4, 079	[4] 4, 079
Germany:						
East [6]..........	186	233	242	255	249	[4] 249
West [6]..........	868	999	1, 046	982	958	1, 058
Greece..........	22	6	6	6	24	33
Ireland..........	99	139	132	131	116	[4] 116
Italy..........	689	881	966	1, 053	1, 366	[4] 1, 323
Luxembourg..........	10	3	6	8	[4] 9	[4] 9
Poland..........	103	364	390	[4] 390	[4] 390	[4] 390
Portugal..........	46	52	61	71	70	[4] 72
Spain..........	1, 694	1, 093	1, 301	1, 538	2, 104	[4] 2, 094
Switzerland..........	131	[4] 220	266	259	99	[4] 110
U.S.S.R. [7]..........	2, 385	3, 164	3, 329	[4] 3, 860	[4] 3, 860	[4] 3, 860
United Kingdom [3]..........	2, 760	3, 266	3, 734	3, 751	4, 470	[4] 4, 520
Yugoslavia..........	42	85	109	93	84	102
Total [1] [4]..........	12, 210	15, 300	16, 300	17, 220	18, 800	18, 960

See footnotes at end of table.

TABLE 9.—World production of gypsum, by countries[1,2]—Continued

(Thousand short tons)

Country[1]	1950–54 (average)	1955	1956	1957	1958	1959
Asia:						
Ceylon	(8)	(8)	1	1	(8)	(8)
China[4]	112	280	330	390	440	550
Cyprus[4]	155	180	140	160	165	165
India	452	773	956	1,033	884	945
Iran[4,9]	218	739	551	551	551	551
Iraq[4]	275	275	385	440	440	440
Israel[4]	26	56	55	56	44	66
Japan	248	374	417	527	526	595
Pakistan	28	31	41	49	74	109
Philippines	1	----------	----------	----------	2	2
United Arab Republic (Syria Region)[10]	4	1	2	[4] 2	[4] 3	[4] 7
Taiwan	4	11	14	7	11	11
Thailand	(8)	----------	----------	2	10	11
Total[1,4]	1,520	2,720	2,890	3,220	3,150	3,450
Africa:						
Algeria	76	132	84	[4] 84	[4] 84	[4] 84
Angola	8	3	22	8	[4] 11	15
Belgian Congo	7	11	11	12	[4] 11	[4] 11
United Arab Republic (Egypt Region)	163	432	225	1,042	808	[4] 827
Kenya	1	1	2	5	12	15
Morocco: Southern Zone	11	16	28	[4] 28	[4] 28	[4] 28
Sudan	4	3	[4] 2	[4] 2	[4] 2	[4] 2
Tanganyika	[11] 3	9	11	11	10	8
Tunisia	27	38	15	[4] 17	[4] 17	[4] 17
Union of South Africa	153	178	209	180	256	224
Total	453	823	609	[4] 1,390	[4] 1,240	[4] 1,230
Oceania:						
Australia	408	526	524	536	566	[4] 570
New Caledonia	13	----------	----------	----------	----------	----------
Total	421	526	524	536	566	[4] 570
World total (estimate)[1,2]	27,510	35,380	36,460	37,230	38,740	42,320

[1] Gypsum is produced in Bulgaria, Finland, Korea, Mexico and Rumania, but production data are not available; estimates for these countries are included in the totals. Production in Ecuador is negligible.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Includes anhydrite.

[4] Estimate.

[5] Data not available; estimate by senior author of chapter included in total.

[6] Crude production estimates based on calcined figures.

[7] Crude production for use in the construction industries only. In addition, substantial tonnages of gypsum are used in agriculture.

[8] Less than 500 tons.

[9] Year ended March 20 of year following that stated.

[10] Some pure, some 60 percent gypsum and 20 percent limestone.

[11] Average for 1952–54.

Canadian Western Gypsum Corp. was incorporated to develop a group of mineral claims having an estimated 100 million tons of gypsum-bearing material in the Canal Flats section of southeastern British Columbia.[8] The firm was reported to be planning a product plant at Vancouver which would manufacture 40 million square feet of wallboard annually.[9] Canadian Gypsum Co. completed the first phase of a multi-million dollar expansion program at its Hagersville, Ontario, plant, which when finished will double its capacity for product manufacture of plaster base, sheetrock gypsum wallboard, and gypsum sheathing.

Canada's largest producer of gypsum products, Gypsum, Lime, and

---

[8] Mining Magazine (London), vol. 100, No. 3, March 1959, p. 162.

[9] Chemical Engineering, vol. 66, No. 10, May 18, 1959, pp. 204, 206.

Alabastine, Ltd., substantially expanded its productive operations at Calgary.[10] An addition to the plant will increase current production and introduce the manufacture of gypsum wallboard, lath, and sheathing.

An information circular describing the mining and milling technology of gypsum in Canada was issued.[11]

Dominican Republic.—A major development in the mineral industry of the Dominican Republic was a $5 million mechanization plan which the Saly Yeso Co. reported. This reflected in part the increasing interest by Latin American governments in their mineral resources because of the currently poor market for their agricultural products—sugar, cocoa, and coffee.[12] The venture was undertaken to develop gypsum deposits containing an estimated 1 billion tons near Barahona. From Las Salinas, gypsum was moved by conveyor belt to rail sidings for hauling to docks at Barahona. Gypsum could be loaded at the rate of 1,000 tons per hour. With reduced handling costs, exports of gypsum and cement should increase substantially.

Mexico.—The United States Gypsum Co. announced plans to invest approximately $5 million to develop what was reported to be the largest gypsum deposit in the world (2 billion tons) midway between San Luis Potosi and the port of Tampico, in the State of San Luis Potosi.[13] Yeso Mexicano, its Mexican subsidiary, expects to ship about 1 million tons a year to U.S. ports including Houston, Tex., Mobile, Ala., New Orleans, La., and possibly Jacksonville, Fla. Though there are other deposits in this area, the Mexican government discovered bauxite underlying the gypsum and declared the rest of the area to be a national reserve, blocking further development.

SOUTH AMERICA

Uruguay.—Trade with the Soviet Bloc during the first half of 1959 included imports of 7,275 short tons of crude gypsum valued at $62,817 from Poland.[14]

EUROPE

Denmark.—Proposed changes in tariff and import controls in the Danish tariff bill under consideration include the following on gypsum:[15]

Tariff number	Commodity description	Present tariff rate (percent)	Proposed tariff rate (percent)	Import control by license or quota	
				Present	Proposed
68.09	Gypsum or other mineral adhesives	5	7½	Bound-no Q [1]	Free.
68.10	Manufactures of gypsum or mixtures based on gypsum.	5	8	do	Do.

[1] "Bound-no Q" means that the item is subjected to licensing control and that no dollar area allocation for its import appears in the import budget.

---

[10] Canadian Mining Journal, vol. 80, No. 7, July 1959, p. 102.

[11] Collings, R. K., The Canadian Gypsum Industry: Canada Mines Branch, Inf. Circ. 114, Dept. Min. and Tech. Surveys, Ottawa, 1959, 41 pp.

[12] Mine and Quarry Engineering (London), Mining in the Dominican Republic: Vol. 26, No. 2, February 1960, pp. 67–68.

[13] Chemical Week, vol. 85, No. 10, Sept. 5, 1959, p. 31.

[14] U.S. Embassy, Montevideo, Uruguay, State Department Dispatch 529: Nov. 23, 1959, p. 6, encl. 2.

[15] U.S. Embassy, Copenhagen, Denmark, State Department Dispatch 377: Dec. 16, 1959, p. 23, encl. 1.

Finland.—Under a trade agreement with the Soviet Union signed in Moscow on December 22, 1959, imports from the U.S.S.R. in 1960 will include 27,558 short tons of gypsum stones (crude gypsum).[16] In a similar agreement signed in Warsaw, Poland, on December 16, 1959, Poland will export 44,092 tons of gypsum stones and 11,023 tons of building gypsum in 1960 to Finland.[17]

United Kingdom.—The mining of gypsum by trackless methods at the Billingham works of Imperial Chemical Industries, Ltd., was described in an article.[18] The millionth ton of anhydrite was shipped from Long Meg Mine, near Penrith, to the converters in Widnes on May 20.[19] Output of the mine achieved an average of 250,000 tons per year since the project was developed 4 years ago.

Yugoslavia.—A gypsum plant was being constructed in the Jajce District.[20]

ASIA

India.—Large deposits of gypsum were located in the State of Kashmir by the Geological Survey of India.[21] Deposits in the Baramullah District, north of the Jhelum River, contain 15.3 million tons of measured reserves averaging 91.75 percent of gypsum, and a potential reserve of 25.5 million tons to a depth of 100 feet.

The gypsum mined and available for use has been very limited, although the supply in South India is enormous.[22] One of the most serious problems has been lack of a large enough labor force. Consequently, one firm mechanized part of their open-pit operation. A scraper resulted in more efficient use of available manpower, and also in a significant increase of gypsum produced.

At one operation, the scraper removed and stored the top soil, then excavated the gypsum-bearing material. The material was spread and dried. After the dried material was broken with a disc harrow, the gypsum lumps were sorted out by hand. At another location in the mine, the harrowed material was moved by the scraper to an inclined screen, where the lumps of gypsum were separated. The topsoil and waste material at both sites were replaced in the open pits to comply with regulations requiring that the land be restored for agricultural purposes.

The depth of the gypsum-bearing material averaged between 3 and 4 feet, but in some places was 12 feet. The overburden averaged 3 to 4 feet deep.

Philippines.—The United Gypsum & Minerals, Inc., was organized to mine gypsum.[23] Mining was started at gypsum properties on Negros Island. Gypsum was imported from Cyprus and San Marcos Islands, and the hope was that the domestic output would eventually replace imports.

---

[16] U.S. Embassy, Helsinki, Finland, State Department Dispatch 440: Jan. 4, 1960, p. 3, encl. 1.

[17] U.S. Embassy, Helsinki, Finland, State Department Dispatch 516: Feb. 5, 1960, p. 2, encl. 1.

[18] Mining Journal (London), Mining Anhydrite by Trackless Methods: Vol. 252, No. 6458, May 29, 1959, pp. 586–587.

[19] Chemical Age (London), vol. 81, No. 2082, June 6, 1959, p. 936.

[20] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 6, December 1959, p. 42.

[21] Mining Journal (London), vol. 253, No. 6463, July 3, 1959, p. 9.

[22] Indian Mining Journal (Calcutta), vol. 7, No. 1, January 1959, pp. 29–30.

[23] Mining Newsletter (Philippines), vol. 10, No. 5, May–June 1959, p. 225.

United Arab Republic (Syria Region).—As part of a 5-year industrialization plan, a gypsum plant will be built at Lattakia.[24] Costing $137,000, the plant will have an estimated output of 30,000 tons per year.

OCEANIA

Australia.—The Western Australia Geological Survey, Perth, issued a bulletin that described the mining methods, production, and reserves of gypsum in Western Australia.[25]

TECHNOLOGY

Large gypsum deposits of potential commercial value in New Mexico were described in three New Mexico Bureau of Mines bulletins.[26]

The testing of gypsum and gypsum products was covered in a comprehensive standard (C–26), which included both chemical analysis and numerous physical tests.[27] Committee C–11 studied the advisability of separating this into two or more separate standards to facilitate its use.

A method of making a gypsum-base wallboard was patented. The core comprised a uniform admixture of set gypsum, mineral wool fiber, and 20- to 200-mesh wollastonite. Addition of the wollastonite to the core improved fire resistance of the board by delaying calcination of the gypsum content when exposed to flame.[28]

A patent was issued for a method of making laminated gypsum board having staggered edges with interlocking profiles.[29]

A process for the production of calcined gypsum of low consistency and very high strength was patented. Lump gypsum rock was autoclaved under optimum operating conditions in a very dilute solution of, for example, potassium succinate, and the gypsum was then separated and heated in an atmosphere of steam to complete formation of small stubby gypsum crystals, which were recovered, dried, and ground.[30]

---

[24] Chemical Age (London), vol. 81, No. 2076, Apr. 25, 1959, p. 699.

[25] Economic Geology, vol. 54, No. 7, November 1959, p. 1339.

[26] Weber, Robert H., and Kottlowski, Frank E., Gypsum Resources in New Mexico: New Mexico Bureau of Mines Bull. 68, 1959, 68 pp.

Otte, Carel, Jr., Late Pennsylvanian and Early Permian Stratigraphy of the Northern Sacramento Mountains, Otero County, New Mexico: Bull. 50, 1959, 111 pp.

Griswold, George B., Mineral Deposits of Lincoln County, New Mexico: Bull. 67, 1959, 117 pp.

[27] American Society for Testing Materials, Bull. 240, September 1959, p. 7.

[28] Loechl, C. J. (assigned to Celotex Corp.), Gypsum Products and Process of Manufacture: U.S. Patent 2,871,134, Jan. 27, 1959.

[29] Buergin, R. G., and Hovind, J. K. (assigned to National Gypsum Co.), Laminated Gypsum-Core Board: U.S. Patent 2,884,779, May 5, 1959.

[30] Dailey, M. C., and Johnson, E. S. (assigned to United States Gypsum Co.), Process for the Production of High Strength Low Consistency Calcined Gypsum: U.S. Patent 2,913,308, Nov. 17, 1959.

Iodine

❖

By Henry E. Stipp[1] and James M. Foley[2]

UNITED STATES consumption of iodine increased substantially in 1959; however, imports of crude iodine decreased. Significant technical applications for iodine were the preparation of 99.99-percent pure chromium by thermal decomposition of chromium iodide and an incandescent lamp that used iodine to increase output of light.

DOMESTIC PRODUCTION

Production of crude iodine increased 4 percent over that of 1958, and value decreased 2 percent. Domestic producers furnished a substantial part of national requirements. Iodine was extracted from oil-well brines by The Dow Chemical Co., with plants at Seal Beach, Venice, and Inglewood, Calif., and the Deepwater Chemical Co., Ltd., at Compton, Calif. Approximately 36 firms produced refined iodine and iodine compounds from domestic and imported crude iodine.

Radioactive iodine isotopes were recovered and distributed by several firms.

CONSUMPTION AND USES

Domestic consumption of iodine and iodine compounds in 1959 increased about 39 percent as compared with 1958. Crude iodine was resublimed to greater purity or converted to iodine compounds. The principal compound produced was potassium iodide; however, many other inorganic and organic compounds were made. Iodine and

TABLE 1.—Crude iodine consumed in the United States

Compound manufactured	1958			1959		
	Number of plants	Crude iodine consumed		Number of plants	Crude iodine consumed	
		Pounds (thousands)	Percent of total		Pounds (thousands)	Percent of total
Resublimed iodine	4	158	13	3	(1)	(1)
Potassium iodide	12	532	45	10	848	51
Sodium iodide	5	42	3	3	62	4
Other inorganic compounds	12	190	16	13	352	21
Organic compounds	19	273	23	22	402	24
Total	[2] 31	1,195	100	[2] 36	1,664	100

[1] Included with "Other inorganic compounds" to avoid disclosing individual company confidential data.
[2] Nonadditive total because some plants produce more than one product.

---

[1] Commodity specialist.
[2] Supervisory statistical assistant.

iodine compounds were used in medicine as antiseptics, sanitizers, deodorants, drugs, laboratory reagents, aids in X-ray diagnosis, nutrition, and therapeutic agents. Some of the numerous industrial applications were for photographic film processes, analytical reagents, catalysts, chemical synthesis, rubber, dyes, and metallurgy. Among the chief uses for iodine in agriculture were stock-feed supplements, germicides, and anti-inflammatory agents. Radioactive iodine was used for physical therapy and examinations, process control, and research.

PRICES

Prices for iodine and iodine compounds remained steady. The following prices were quoted by the Oil, Paint and Drug Reporter: Crude iodine, in kegs, 95 cents per pound throughout the year; resublimed iodine, U.S.P., drums, $2.00–$2.02 per pound throughout the year; ammonium iodide, N.F., drums, bottles, $4.26–$4.38 per pound from January through April, and 25-pound jars, f.o.b. works, $4.26 per pound from May through December; calcium iodide, jars, $4.52 per pound throughout the year; potassium iodide, U.S.P., crystals, granular or powdered, fiber drums, $1.40 per pound throughout the year; sodium iodide, U.S.P., 300-pound drums, $1.98 per pound throughout the year.

FOREIGN TRADE[3]

Crude iodine imports for consumption decreased for the second consecutive year. Resublimed iodine imported from Czechoslovakia totaled 441 pounds valued at $500.

Exports of iodine, iodides, and iodates were made chiefly to Canada, India, and Brazil, but 17 other countries also received shipments. Re-exports of iodine went to Canada and Colombia.

TABLE 2.—Crude iodine imported for consumption in the United States, by countries[1]

(Thousand pounds and thousand dollars)

[Bureau of the Census]

Country	1950–54 (average)		1955		1956		1957		1958		1959	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Chile	604	$923	868	$1,035	1,002	$1,226	2,149	$2,049	1,401	$1,180	1,243	$892
France	(2)	(2)	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
Japan	250	353	364	478	703	954	536	720	160	149	223	191
Total	854	1,276	1,232	1,513	1,705	2,180	2,685	2,769	1,561	1,329	1,466	1,083

[1] Minerals Yearbook, 1958, vol. I, p. 523, 1954, imports should read: France "less than 1,000."

[2] Less than 1,000.

---

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 3.—Iodine, iodide, and iodates exported from the United States

(Thousand pounds and thousand dollars)

[Bureau of the Census]

Year	Quantity	Value	Year	Quantity	Value
1950–54 (average)	302	$520	1957	233	$335
1955	244	357	1958 [1]	199	314
1956	505	750	1959 [1]	175	249

[1] Data not strictly comparable with earlier years.

TABLE 4.—Iodine, iodide, and iodates re-exported from the United States

(Thousand pounds and thousand dollars)

[Bureau of the Census]

Year	Quantity	Value	Year	Quantity	Value
1950–54 (average)	107	$165	1957	70	$79
1955	41	59	1958 [1]	30	30
1956	96	131	1959 [1]	35	34

[1] Data not strictly comparable with earlier years.

WORLD REVIEW

Chile.—Crude iodine production totaled 2.9 million pounds.[4]

Indonesia.—Iodine of copper (40–46 percent) output in 1958 totaled 981,000 pounds valued at $4.5 million compared with 5.9 million pounds valued at $26.8 million in 1957.[5]

Italy.—Production of iodine totaled 3,307 pounds in 1958.[6]

Japan.—In 1958, elemental iodine production totaled 1.6 million pounds.[7]

TECHNOLOGY

An electric lamp that used iodine was said to produce 50 percent more light during its lifetime than do conventional bulbs. Tungsten evaporated from the filament and reacted with iodine at 250° C. to form tungsten iodide which decomposed depositing tungsten on the filament. The quartz walls of the lamp were not blackened by tungsten, thus more light was produced from a smaller lamp than from present incandescent bulbs.[8]

Chromium reported to be 99.99 percent pure was produced by thermal decomposition of chromium iodide. The chromium showed a high degree of ductility and alloying ability. Alloys of the high-purity metal will be used in nuclear reactors, gas turbines, and jet engines.[9]

---

[4] U.S. Embassy, Santiago, Chile, State Department Dispatch 1106: May 6, 1959, p. 1.

[5] U.S. Embassy, Djakarta, Indonesia, State Department Dispatch 854: May 11, 1959, p. 2.

[6] U.S. Embassy, Rome, Italy, State Department Dispatch 1277: Apr. 28, 1959, p. 2.

[7] U.S. Embassy, Tokyo, Japan, State Department Dispatch 1157: Apr. 8, 1959, p. 3.

[8] Chemical and Engineering News, Iodine Used in Lamp: Vol. 37, No. 25, June 22, 1959, pp. 48, 51.

[9] Chemical and Engineering News, High-purity Chromium: Vol. 36, No. 51, Dec. 22, 1958, p. 27.

A solid material that could be dissolved in water to form a diatomic iodine solution was patented.[10]

It was reported that goiter could be caused by a virus, instead of a body deficiency of iodine.[11]

A process was patented that produced a solution of lower alkyl mercuric iodide in an excess of lower alkyl iodide and a filter cake of mercurous iodide.[12]

The mechanical properties of iodide zirconium alloys were described.[13]

A process was patented for reacting an organic aldehyde and a phosphorous trihalide in the presence of a catalyst containing various metals and iodine or a metal iodide or phosphorus iodide to produce an organic phosphonyl halide.[14]

An article was published that described the preparation of aqueous periodic-acid solutions by electrolysis. Iodine in alkaline solution was oxidized to sodium iodate, which was electrolyzed under acidic conditions to give periodic acid in 96-percent yield. Periodic acid was neutralized to produce sodium periodate and sodium sulfate. Sodium metaperiodate was then isolated by crystallization in 93-percent yield.[15]

A process was patented for recovering iodine from hydrogen iodide by dispersing a liquid aqueous hydrogen iodide solution in an atmosphere of molecular oxygen.[16]

The photo-oxidation of isopropyl iodide was investigated. Products detected in the liquid phase were acetone, carbon dioxide propylene, and possibly carbon monoxide and a viscous oil.[17]

The use of iodine monochloride and iodine monobromide to modify butyl rubber was reported. A portion of the iodine remained in the polymer and probably entered into the metal oxide cure, giving better cure compatibility with natural rubber and improved adhesion.[18]

Electrolyte cells, consisting of tantalum iodide, silver iodide, and silver activated by iodine, gave open-circuit voltage of 0.67, short-circuit currents up to 18 milliamperes, capacity of 10 milliampere-hours, energy output up to 5 milliwatt-hours per cell, and an indefinitely long shelf life from below 150° to 550° C.[19]

Uranium was coated with zirconium by decomposition of zirconium iodide.[20]

---

[10] Carroll, Benjamin, and Kitter, Volda (assigned to Heliogen Products, Inc., Long Island City, N.Y.), U.S. Patent 2,902,405, Sept. 1, 1959.

[11] Science Newsletter, Virus, Not Iodine Lack, May Cause Goiter: Vol. 76, No. 1, July 4, 1959, p. 2.

[12] Baldoni, Andrew A., and Miyashiro, James J. (assigned to Morton Chemical Co., Chicago, Ill.), Preparation of Organo Mercuric Compounds: U.S. Patent 2,914,451, Nov. 24, 1959.

[13] Schwope, A. D., and Chubb, W., Mechanical Properties of Iodide Zirconium Alloys: Battelle Memorial Inst., Columbus, Ohio, May 1957, 21 pp.

[14] Weber, Charles W. (assigned to the M. W. Kellogg Company, Jersey City, N.J.), Preparation of Organic Phosphonyl Halides: U.S. Patent 2,882,314, Apr. 14, 1959.

[15] Industrial and Engineering Chemistry, An Electrolytic Process for Making Sodium Metaperiodate: Vol. 51, No. 4, April 1959, pp. 511–514.

[16] Steinle, Shelton E., and Green, Charles R. (assigned to Shell Development Company, New York, N.Y.), Conversion of Hydrogen Iodide to Iodine: U.S. Patent 2,918,354, Dec. 22, 1959.

[17] McMillan, G. R., The Photo-oxidation of Isopropyl Iodide: Rochester Univ., N.Y., Rept. on Contract A.F. 18(600)1528, Jan. 14, 1959, 9 pp.

[18] Morrissey, R. T., Halogenation of Butyl Rubber with Iodine Monochloride and Iodine Monobromide: Rubber World, vol. 138, No. 5, August 1958, pp. 725–732, 742.

[19] Journal of the Electrochemical Society, Iodine-Activated Solid Electrolyte Cell for Use at High Temperature: Vol. 106, No. 6, June 1959, pp. 475–481.

[20] Robb, W. L., and Shipko, F. J., Iodide Decomposition Process for Coating Uranium with Zirconium: Knolls Atomic Power Lab., Schenectady, N.Y., February 1957, p. 21.

Radioactive Iodine.—A paper that described the recovery and half-life determination of iodine 129 was published.[21]

Industry was reported to be increasing consumption of radioisotopes. A checklist gave the names of suppliers, prices, and forms of radioisotopes such as iodine 131.[22]

A simple radioiodine analysis for use on nuclear submarines was invented. The 15-minute test is based on rapid isotopic exchange between fission-product iodine and iodine atoms in silver iodide.[23]

Reactions between iodine and ethyl iodide induced by radiation were reported.[24]

---

[21] Russel, H. T., Recovery and Half-life Determination of I^{129}: Oak Ridge National Lab., Oak Ridge, Tenn., ORNL-2293, May 1957, 7 pp.

[22] Chemical Engineering, Radioisotopes: Vol. 66, No. 23, Nov. 16, 1959, pp. 100, 102, 104.

[23] Chemical and Engineering News, Quick Check for Radioiodine: Vol. 37, No. 45, Nov. 9, 1959, p. 42.

[24] U.S. Government Research Reports, Chemistry-Radiation & Radio-Chemistry: Vol. 32, No. 4, Oct. 16, 1959, p. 527.

Iron Ore

By Horace T. Reno [1] and Helen E. Lewis [2]

⁂

A STRIKE virtually stopped iron-ore mining in the United States from July 15 to November 7. As a result, domestic mines produced less iron ore in 1959 than in any year since 1938. However, steel mills operated at near capacity during the remainder of the year and consumed more iron ore than in 1958. Iron-ore imports were the highest in history and comprised more than one-third of the new supply. Despite the strike, iron-ore inventory at yearend was 2 million tons greater than at the end of 1958.

TABLE 1.—Salient statistics of iron ore in the United States

(Thousand long tons and thousand dollars)

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Iron ore (usable; [1] less than 5 percent Mn):						
Production [2]	101,718	103,003	97,877	106,148	[3] 67,709	60,276
Shipments [4]	100,702	105,241	96,945	104,157	[3] 66,288	59,164
Value [4]	$604,175	$748,625	$750,354	$865,703	[3] $569,154	$514,067
Average value per ton at mines Dec. 31	$6.00	$7.11	$7.47	$8.31	[3] $8.59	$8.69
Stocks at mines Dec. 31	5,927	4,281	5,465	6,776	[3] 7,033	7,372
Imports	11,010	23,472	30,411	33,651	[3] 27,544	35,613
Value	$80,518	$177,457	$250,490	$285,051	[3] $231,617	$312,367
Exports	3,880	4,517	5,508	5,002	[3] 3,573	2,967
Value	$28,265	$36,993	$48,805	$47,543	[3] $34,898	$33,831
Consumption	107,688	[5] 125,028	125,171	129,375	91,900	93,662
Stocks at consuming plants Dec. 31	41,477	44,358	47,292	53,175	53,599	53,038
Stocks at Lake Erie docks Dec. 31	6,434	4,918	4,558	5,160	5,577	7,575
Manganiferous iron ore (5 to 35 percent Mn):						
Shipments	905	814	[3] 608	[3] 772	465	420
Value	4,999	$5,128	$3,984	$5,413	$3,532	$3,146
World: Production [6]	293,154	[3] 363,421	[3] 388,282	[3] 426,365	[3] 398,439	429,018

[1] Direct shipping ore, washed ore concentrates, agglomerates, and byproduct pyrites cinder and agglomerates.
[2] Includes byproduct ore.
[3] Revised figure.
[4] Byproduct ore excluded.
[5] Includes 1,120,000 tons of manganiferous ore.
[6] Estimate.

Whereas the U.S. iron and steel industry operated near capacity in the first half of the year, the European industry operated much below capacity. On the other hand, the domestic industry was at a standstill most of the last half of the year, whereas the industry in

---

[1] Assistant chief, Branch of Ferrous Metals.
[2] Statistical assistant.

Europe operated at capacity in order to supply its own markets and to ship as much steel as possible to the United States. This boom in the European steel industry stimulated iron-ore production in all countries that normally ship ore to the European markets and enabled the Canadian producers to establish a record output.

The steel strike did not deter U.S. companies from exploring and developing iron-ore deposits in foreign countries. They remained first in the field, although the Japanese steel companies participated in more farflung enterprises.

Minnesota passed a "semi-taconite" tax law to encourage U.S. companies to develop marginal deposits. In response, M. A. Hanna Mining Co. and Oliver Iron Mining Division of U.S. Steel Corp. began research projects to devise means of processing semitaconite-type ore.

Direct reduction continued to be of principal technologic interest. However, progress was greatest in blast-furnace technology, as the Bureau of Mines successfully injected natural gas into the bosh of its experimental blast furnace. Furnace efficiency was increased approximately 30 percent, and the gas replaced about 20 percent of a normal coke charge.

EMPLOYMENT

The record of employment at iron-ore mines in 1958 accentuated the relative stability of the labor force. Although usable iron-ore output in 1958 was 36 percent less than in 1957, the average number of men employed was only 17 percent less. This smaller force, working an average of 18 percent fewer days than in 1957, set a new record in output of crude ore per man-shift, but output of usable ore per man-shift was the lowest since 1954.

Maintenance of a stable labor force obscures advancement in labor's productivity from year to year, but the 15-year record of crude and usable iron-ore output per man-shift presented in table 3 shows the marked increase in productivity. The record also reflects revolutionary changes that have taken place in the industry since World War II. Increasing productivity has essentially paralleled the change in the two interdependent ratios; crude to usable ore output and open pit to underground mine production.

DOMESTIC PRODUCTION

Iron-ore producers, anticipating the steel strike, operated their mines at near capacity through June. They produced almost twice as much ore in the first half of 1959 as in the same period in 1958 and, despite record consumption, built midyear iron-ore stocks at the mills to more than 44 million tons. After the strike the producers not dependent on the Great Lakes transport system again operated at near capacity. However, the loss of 116 days of work during the normal peak production period resulted in less domestic output of iron ore than in any year since 1938.

Mine production of crude ore was only 7 percent less than in 1958. Crude iron ore may have been crushed, screened, or sized but is measured before it has been subjected to any treatment that would remove the waste constituents. The crude ore is classified as hematite, brown

TABLE 2.—Employment at iron-ore mines, quantity and tenor of ore produced, and average output per man in 1958, by districts and States

District and State	Employment					Production[1]									
	Average number of men employed	Time employed				Crude ore (thousand long tons)	Usable ore			Average per man					
		Average number of days	Total man-shifts (thousands)	Man-hours			Thousand long tons	Iron contained		Crude ore		Usable ore			
				Average per shift	Total (thousands)			Thousand long tons	Natural (percent)	Per shift	Per hour	Per shift	Per hour	Iron contained	
														Per shift	Per hour
Lake Superior:															
Minnesota	8,236	252	2,079	8.01	16,644	74,980	42,525	22,916	53.89	36.07	4.50	20.45	2.55	11.02	1.38
Michigan	5,904	163	965	7.97	7,690	9,153	8,515	4,508	52.94	9.49	1.19	8.82	1.11	4.67	.59
Wisconsin	1,003	192	193	7.98	1,540	1,152	1,152	616	53.47	5.97	.75	5.97	.75	3.19	.40
Total	15,143	214	3,237	7.99	25,874	85,285	52,192	28,040	53.72	26.35	3.30	16.12	2.02	8.66	1.08
Southeastern States: Alabama and Georgia	2,409	151	363	8.09	2,937	5,898	3,827	1,460	38.15	16.25	2.01	10.54	1.30	4.02	.50
Northeastern States:															
New York	658	166	109	8.00	872	6,009	2,127	1,320	62.05	55.13	6.89	19.51	2.44	12.11	1.51
New Jersey and Pennsylvania	1,502	232	348	8.10	2,818	2,657	1,285	798	62.10	7.64	.94	3.69	.46	2.29	.28
Total	2,160	212	457	8.07	3,690	8,666	3,412	2,118	62.08	18.96	2.35	7.47	.92	4.63	.57
Western States:															
California, Colorado, and Idaho	313	227	71	8.01	569	2,882	1,939	1,077	55.54	40.59	5.07	27.31	3.41	15.17	1.89
Missouri and Nevada	458	207	95	8.28	787	1,420	1,026	584	56.92	14.95	1.80	10.80	1.30	6.15	.74
Utah and Wyoming	666	224	149	7.99	1,191	4,127	4,127	2,003	48.53	27.70	3.47	27.70	3.47	13.44	1.68
Total	1,437	219	315	8.09	2,547	8,429	7,092	3,664	51.66	26.76	3.31	22.51	2.78	11.63	1.44
Other[2]	184	190	35	8.20	287	2,364	849	394	46.41	67.54	8.24	24.26	2.96	11.26	1.37
Grand total	21,333	207	4,407	8.02	35,335	110,642	67,372	35,676	52.95	25.11	3.13	15.29	1.91	8.10	1.01

[1] Includes manganese-bearing ore in the Lake Superior district. Excludes production of iron oxide pigment materials, also States producing less than 1,000 tons.

[2] Includes Arkansas, Montana, Texas, and Washington.

ore, or magnetite, according to the iron-mineral constituent that predominates; however, the classification is seldom precise, as most iron ores contain several types of minerals.

Since 1943 relatively more crude ore has been mined to obtain an equivalent quantity of iron, because of a steady decrease in the average grade of ore mined. Although this trend continued in 1959, it only partly sustained crude-ore production because output of the taconite mines, which have had more influence on the average grade of crude ore mined than any other identifiable element, decreased in almost direct proportion to the time lost by the strike. The ability of the iron mining industry to expand hematite-ore production rapidly was the principal factor that sustained crude-ore output. Magnetite-ore production was 15 million tons less than in 1958.

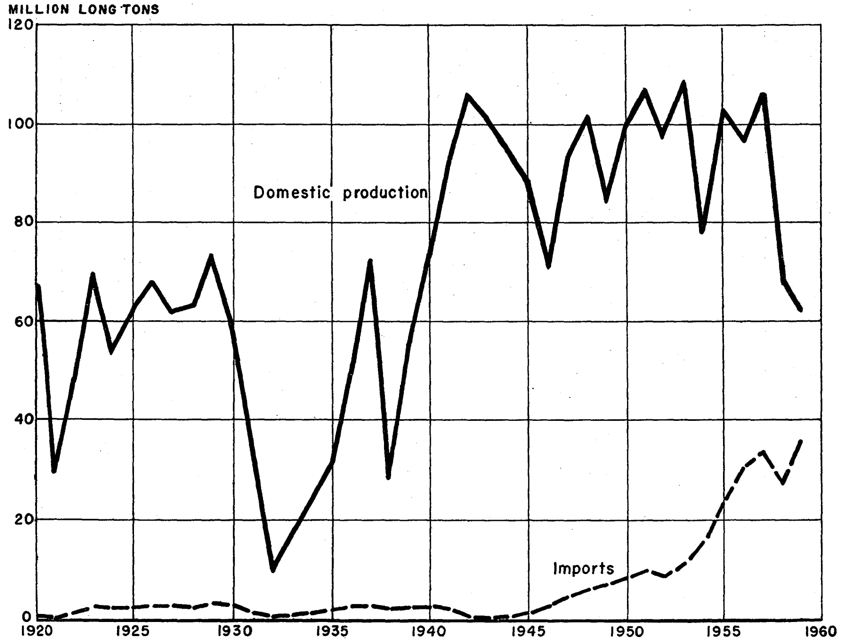

Figure 1.—Production of iron ore in the United States and iron-ore imports for consumption, 1920–59.

TABLE 3.—Average output of crude and usable iron ore per man shift, in long tons

Year	Output per man-shift		Year	Output per man-shift	
	Crude ore	Usable ore		Crude ore	Usable ore
1944	13.7	11.6	1952	16.4	12.5
1945	14.2	11.8	1953	18.9	14.2
1946	13.7	11.5	1954	17.9	12.7
1947	14.3	11.6	1955	24.8	17.8
1948	14.7	11.7	1956	23.4	15.5
1949	13.7	11.1	1957	25.0	16.4
1950	15.4	12.0	1958	25.1	15.3
1951	16.3	12.5			

TABLE 4.—Crude iron ore mined in the United States, by districts and varieties, in thousand long tons

(Exclusive of ore containing 5 percent or more manganese)

District and State	1958					1959				
	Number of mines	Hematite	Brown ore	Magnetite	Total	Number of mines	Hematite	Brown ore	Magnetite	Total
Lake Superior:										
Michigan	29	9,042	-------	-------	9,042	27	8,623	-------	-------	8,623
Minnesota	95	31,627	-------	42,625	74,251	95	40,238	-------	24,276	64,514
Wisconsin	2	1,152	-------	-------	1,152	4	944	-------	-------	944
Total	126	41,821	-------	42,625	84,445	126	49,805	-------	24,276	74,081
Southeastern States:										
Alabama	[1] 30	3,207	1,972	-------	5,179	[1] 31	3,203	4,243	-------	7,446
Georgia	11	-------	719	-------	719	9	-------	748	-------	748
North Carolina	-------	-------	-------	-------	-------	1	-------	-------	(2)	(2)
Tennessee	-------	-------	-------	-------	-------	3	(2)	(2)	-------	(2)
Total	41	3,207	2,691	-------	5,898	44	3,203	4,991	(2)	8,194
Northeastern States:										
New Jersey Pennsylvania	6	2,657	-------	(3)	2,657	5	-------	-------	2,946	2,946
New York	4	-------	-------	6,009	6,009	5	-------	-------	6,078	6,078
Total	10	2,657	-------	6,009	8,666	10	-------	-------	9,024	9,024
Western States:										
Arkansas	1	-------	(2)	-------	(2)	-------	-------	-------	-------	-------
California	2	(3)	(2)	(3)	(2)	2	(2)	-------	(2)	(2)
Colorado	1	-------	(2)	-------	(2)	3	-------	11	-------	11
Idaho	1	-------	-------	6	6	1	-------	-------	1	1
Mississippi	1	-------	(4)	-------	(4)	-------	-------	-------	-------	-------
Missouri	26	(3)	589	-------	589	12	530	(3)	-------	530
Montana	3	(3)	-------	15	15	3	50	-------	(3)	50
Nevada	8	(3)	-------	831	831	11	(3)	-------	962	962
New Mexico	2	-------	-------	(4)	(4)	2	-------	-------	(2)	(2)
Texas	4	-------	(2)	-------	(2)	4	-------	(2)	-------	(2)
Utah	9	2,948	6	616	3,570	11	2,765	(3)	(3)	2,765
Washington	1	4	-------	(4)	4	1	4	-------	-------	4
Wyoming	2	499	-------	58	557	3	471	-------	-------	471
Total	61	3,451	595	1,526	5,572	53	3,820	11	963	4,794
Undistributed	-------	-------	5,221	-------	[5,6] 5,234	-------	3,182	3,215	94	6,491
Grand total [7]	238	51,136	8,507	50,160	[6] 109,815	233	60,010	8,217	34,357	102,584

---

[1] Excludes an undetermined number of small pits. Output of these pits included with tonnage given.

[2] Included with "Undistributed" to avoid disclosing individual company confidential data.

[3] Varieties of ore not shown separately are combined with other varieties in the same State.

[4] Less than 1,000 tons.

[5] Includes 13,000 tons of iron oxide pigment material mined in Georgia, New York, Pennsylvania, Minnesota, and Virginia.

[6] Revised figure.

[7] In some instances data do not add to totals shown because figures have been rounded.

TABLE 5.—Crude iron are mined in the United States, by States and mining methods, in thousand long tons

(Exclusive of ore containing 5 percent or more manganese)

State	1958			1959		
	Open pit	Underground	Total	Open pit	Underground	Total
Alabama	2,052	3,127	5,179	4,384	3,062	7,446
Arkansas	(1)	----------	(1)	----------	----------	----------
California	(1)	----------	(1)	(1)	----------	(1)
Colorado	(1)	----------	(1)	11	----------	11
Georgia	719	----------	719	748	----------	748
Idaho	6	----------	6	1	----------	1
Michigan	(2)	9,042	9,042	1,806	6,817	8,623
Minnesota	72,484	1,767	74,251	63,188	1,326	64,514
Mississippi	(3)	----------	(3)	----------	----------	----------
Missouri	589	(4)	589	530	(4)	530
Montana	15	----------	15	50	----------	50
Nevada	831	----------	831	962	(4)	962
New Jersey Pennsylvania	----------	2,657	2,657	(2)	2,946	2,946
New York	6,009	(4)	6,009	6,078	(4)	6,078
New Mexico	(3)	----------	(3)	(1)	----------	(1)
North Carolina	----------	----------	----------	(1)	(4)	(1)
Tennessee	----------	----------	----------	(1)	----------	(1)
Texas	(1)	----------	(1)	(1)	----------	(1)
Utah	3,570	----------	3,570	2,765	----------	2,765
Washington	4	----------	4	4	----------	4
Wisconsin	----------	1,152	1,152	61	883	944
Wyoming	58	499	557	----------	471	471
Undistributed	5,221	----------	[5,6] 5,234	6,491	----------	6,491
Total	91,558	18,244	[5,6] 109,815	87,079	15,505	102,584

[1] Included with "Undistributed" to avoid disclosing individual company confidential data.
[2] Included with "Underground."
[3] Less than 1,000 tons.
[4] Included with "Open pit."
[5] Revised figure.
[6] Includes 13,000 tons of iron oxide pigment material mined in Georgia, New York, Pennsylvania, Minnesota, and Virginia.

TABLE 6.—Crude iron ore shipped from mines in the United States, by States and disposition, in thousand long tons

(Exclusive of ore containing 5 percent or more manganese)

State	1958			1959		
	Direct to consumers	To beneficiation plants	Total	Direct to consumers	To beneficiation plants	Total
Alabama	2,123	3,051	5,174	2,088	5,351	7,440
Arkansas	-----	(1)	(1)	-----	-----	-----
California	(1)	(1)	(1)	(1)	(1)	(1)
Colorado	(1)	-----	(1)	10	-----	10
Georgia	(2)	719	719	(2)	748	748
Idaho	6	-----	6	6	-----	6
Michigan	8,675	(3)	8,675	5,867	2,466	8,333
Minnesota	19,214	55,224	74,438	16,195	48,024	64,219
Mississippi	-----	(4)	(4)	-----	-----	-----
Missouri	-----	589	589	-----	530	530
Montana	15	-----	15	50	-----	50
Nevada	831	(3)	831	960	(3)	960
New Jersey Pennsylvania	(2)	2,692	2,692	(2)	2,947	2,947
New York	(2)	6,012	6,012	(2)	6,077	6,077
New Mexico	(4)	-----	(4)	(4)	-----	(4)
North Carolina	-----	-----	-----	(4)	-----	(4)
Tennessee	-----	-----	-----	(1)	(1)	(1)
Texas	-----	(1)	(1)	-----	(1)	(1)
Utah	3,514	-----	3,514	2,842	-----	2,842
Washington	4	-----	4	4	-----	4
Wisconsin	1,152	-----	1,152	701	-----	701
Wyoming	499	58	557	471	-----	471
Undistributed	184	5,021	[5][6] 5,218	111	6,465	6,576
Total	36,217	73,366	[5][6] 109,596	29,306	72,608	101,914

[1] Included with "Undistributed" to avoid disclosing individual company confidential data.
[2] Included with ore shipped to beneficiation plants.
[3] Included with direct shipping ore.
[4] Less than 1,000 tons.
[5] Revised figure.
[6] Includes 13,000 tons of iron oxide pigment material mined in Georgia, New York, Pennsylvania, Minnesota, and Virginia.

Usable ore is iron-bearing material produced at mines, benefication plants, and agglomeration plants. It is measured in the form in which it is shipped to the consumer—as direct-shipping ore, iron-ore concentrate, or iron-ore agglomerate. Iron-bearing agglomerates produced at consuming plans are excluded from usable iron-ore production to prevent duplication. The ore in these agglomerates is measured at the mines.

TABLE 7.—Usable iron ore produced in the United States, by districts and varieties, in thousand long tons

(Exclusive of ore containing 5 percent or more manganese)

District and State	1958				1959			
	Hematite	Brown ore	Magnetite	Total	Hematite	Brown ore	Magnetite	Total
Lake Superior:								
Michigan	8,404			8,404	7,129			7,129
Minnesota	33,499		8,722	42,221	27,411		8,465	35,877
Wisconsin	1,152			1,152	944			944
Total	43,055		8,722	51,777	35,484		8,465	43,950
Southeastern States:								
Alabama	3,140	493		3,633	3,098	1,062		4,160
Georgia		194		194		190		190
Tennessee					(1)	(1)		(1)
North Carolina							(1)	(1)
Total	3,140	687		3,827	3,098	1,252		4,350
Northeastern States:								
New Jersey Pennsylvania	1,285		(2)	1,285			1,502	1,502
New York			2,127	2,127			2,167	2,167
Total	1,285		2,127	3,412			3,669	3,669
Western States:								
Arkansas		(1)		(1)				
California	(1)	(1)	(2)	(1)	(1)		(1)	(1)
Colorado		(1)		(1)		11		11
Idaho			6	6			1	1
Mississippi		(3)		(3)				
Missouri	(2)	387		387	174	175		349
Montana	(2)		15	15	37		13	50
Nevada	(2)		639	639	(1)		673	673
New Mexico			(3)	(3)			(1)	(1)
Texas		(1)		(1)		(1)		(1)
Utah	2,948	6	616	3,570	2,765	(2)	(2)	2,765
Washington	4		(3)	4	4			4
Wyoming	499		58	557	503		(2)	503
Total	3,451	393	1,334	5,178	3,483	186	687	4,356
Undistributed		[4] 2,763		[4, 5] 2,776	2,171	943	46	3,160
Total all districts	50,931	[4] 3,843	12,183	[4] 66,970	44,236	2,381	12,867	59,485
Byproduct ore [6]				739				791
Grand total	50,931	[4] 3,843	12,183	[4, 5] 67,709	44,236	2,381	12,867	60,276

[1] Included with "Undistributed" to avoid disclosing individual company confidential data.
[2] Varieties of ore not shown separately are combined with other varieties produced in the same State.
[3] Less than 1,000 tons.
[4] Revised figure.
[5] Includes 13,000 tons of iron oxide pigment material mined in Georgia, New York, Pennsylvania, Minnesota, and Virginia.

Iron-ore agglomerate comprised 20 percent of usable ore production in 1959, compared with 18 percent in 1958. Direct-shipping ore was 50 percent of the usable-ore total. Iron-ore concentrate was only 30 percent of the total, as ore previously sent to consumers as concentrate was agglomerated at the mines. High-grade agglomerate was much in demand to boost blast-furnace output before and after the strike, but little of it reached the open market.

TABLE 8.—Iron ore produced in the United States, by States and types of product, in thousand long tons

(Exclusive of ore containing 5 percent or more manganese)

State	1958				1959			
	Direct shipping ore	Agglomerates [1]	Concentrates	Iron content, natural (percent)	Direct shipping ore	Agglomerates [1]	Concentrates	Iron content, natural (percent)
Alabama	2,687	(2)	947	37.69	3,098	(2)	1,062	38.57
Arkansas	--------	--------	(3)	46.10	--------	--------	--------	--------
California	(3)	--------	(3)	(3)	(3)	--------	(3)	(3)
Colorado	(3)	--------	--------	(3)	11	--------	--------	49.29
Georgia	(2)	--------	194	46.56	(2)	--------	190	45.94
Idaho	6	--------	--------	57.99	1	--------	--------	60.56
Michigan	8,319	(2)	86	53.07	5,562	429	1,138	53.17
Minnesota	19,066	8,857	14,298	53.98	16,276	8,528	11,073	54.11
Mississippi	--------	--------	(4)	--------	--------	--------	--------	--------
Missouri	--------	--------	387	52.48	--------	--------	349	46.70
Montana	15	--------	--------	42.67	50	--------	--------	57.95
Nevada	639	--------	(2)	59.70	673	--------	(2)	59.14
New Jersey Pennsylvania	(2)	(2)	1,285	62.15	(2)	582	920	61.67
New York	(2)	(2)	2,127	62.05	(2)	(2)	2,167	62.60
New Mexico	(4)	--------	--------	--------	(3)	--------	--------	(3)
North Carolina	--------	--------	--------	--------	(3)	--------	--------	(3)
Tennessee	--------	--------	--------	--------	(3)	--------	(3)	(3)
Texas	(3)	(2)	(3)	(3)	(3)	(2)	(3)	(3)
Utah	3,570	--------	--------	49.62	2,765	--------	(4)	50.15
Washington	4	--------	--------	59.99	4	--------	--------	--------
Wisconsin	1,152	--------	--------	53.43	944	--------	--------	53.32
Wyoming	499	--------	58	41.74	503	--------	(2)	45.42
Undistributed	272	--------	[5] 2,491	52.50	88	--------	3,072	54.69
Total	36,229	8,857	[5] 21,873	53.01	29,975	9,539	19,971	53.16
Byproduct ores [6]	--------	739	--------	66.93	--------	791	--------	67.03
Grand total	[7] 36,242	9,596	[5] 21,873	53.16	29,975	10,330	19,971	53.34

[1] Exclusive of agglomerates produced at consuming plants.

[2] Types of ore not shown separately are combined with other types in the same State.

[3] Included with "undistributed" to avoid disclosing individual company confidential data.

[4] Less than 1,000 tons.

[5] Revised figure.

[6] Cinder and sinter obtained from treating pyrites.

[7] Includes 13,000 tons of iron oxide pigment material.

The ratio of crude ore to usable ore (concentration ratio) was 1.7:1 compared with 1.6:1 in 1958, 1.5:1 in 1956 and 1957, and 1.2:1 in 1945. Production from jaspilite and taconite mines was principally responsible for this large increase in ratio from World War II until 1958, but beneficiation of hematite ores was responsible for sustaining the 1958 ratio. As a result, usable ore produced in 1959 contained an average of 53.2 percent iron, slightly more than in 1958. Usable ore averaged only 50.9 percent iron in 1954.

Values of iron-ore shipments, shown in table 9, are as reported by producers at the mines; they exclude transportation costs but include all costs of mining, concentration, and agglomeration. Shipments are classified by use, according to data submitted by the producer. The classification may not be precise, because the shipper does not always control the end use.

TABLE 9.—Shipments of iron ore in the United States, by States and uses, in thousand long tons and thousand dollars

(Exclusive of ore containing 5 percent or more manganese)

State	Iron and steel			Cement	Paint	Miscellaneous	Total	
	Direct shipping ore	Agglomerates[1]	Concentrates				Quantity	Value
Mined ore:								
Alabama	2,088	(2)	2,077				4,165	$23,922
California	(3)		(3)	(2)			(3)	(3)
Colorado					11	(4)	11	78
Georgia	(2)		186				186	945
Idaho	6			(2)		(2)	6	56
Michigan	5,867	398	982		(2)		7,247	62,921
Minnesota	16,195	(2)	19,914	(2)	(4)	(2)	36,109	306,920
Missouri			349				349	3,278
Montana				50		(2)	50	254
Nevada	(2)		(2)			698	698	3,712
New Jersey	(2)		1,406				1,406	26,544
Pennsylvania		(2)			(2)			
New Mexico	(4)						(4)	(3)
New York	(2)	1,733	311	(2)	(2)	(2)	2,044	28,050
North Carolina	(4)						(4)	(3)
Tennessee	21		(2)				21	111
Texas	(3)	(2)	(3)				(3)	(3)
Utah	2,842			(2)		(2)	2,842	19,979
Washington				4			4	5
Wisconsin	701						701	(3)
Wyoming	485					18	503	2,923
Undistributed	140		2,672				[5] 2,822	[5] 34,369
Total	28,345	2,131	27,897	54	11	716	[5] 59,164	[5] 514,067
Byproduct ore[6]							691	8,737
Grand total	28,345	2,131	27,897	54	11	716	59,855	522,804

[1] Exclusive of agglomerates produced at consuming plants.
[2] Combined with other uses in the same State; quantity used cannot be disclosed.
[3] Included with "Undistributed" to avoid disclosing individual company confidential data.
[4] Less than 1,000 tons.
[5] Includes iron oxide pigment materials for Georgia, Oregon, and Virginia, not shown elsewhere in table.
[6] Cinder and sinter obtained from treating pyrites.

TABLE 10.—Iron ore produced in the Lake Superior district, by ranges, in thousand long tons

(Exclusive after 1905 of ore containing 5 percent or more manganese)

Year	Marquette	Menominee	Gogebic	Vermilion	Mesabi	Cuyuna	Total
1854–1954	278, 016	245, 370	290, 016	90, 827	1, 971, 293	53, 829	2, 929, 351
1955	5, 413	4, 126	4, 360	1, 454	64, 860	2, 771	82, 984
1956	5, 869	4, 349	4, 377	1, 285	59, 346	2, 242	77, 468
1957	6, 557	4, 250	4, 437	(1)	65, 886	[2] 2, 400	83, 530
1958	4, 111	2, 896	2, 549	(1)	40, 860	[2] 1, 360	51, 777
1959	2, 851	2, 677	2, 546	(1)	34, 556	[2] 1, 321	43, 950
Total	302, 817	263, 668	308, 285	93, 566	2, 236, 801	63, 923	3, 269, 060

[1] Included with Mesabi Range to avoid disclosing individual company confidential data.
[2] Includes production from the Spring Valley district not in the true Lake Superior district.

TABLE 11.—Average analyses of total tonnages (bill-of-lading weights) of all grades of iron ore from all ranges of Lake Superior district

[American Iron Ore Association]

Year	Long tons	Content (natural), percent				
		Iron	Phosphorus	Silica	Manganese	Moisture
1950–54 (average)	80, 989, 955	50. 44	0. 095	10. 04	0. 75	10. 93
1955	85, 404, 796	50. 63	. 099	10. 11	. 72	10. 81
1956	76, 407, 170	51. 34	. 090	9. 78	. 67	10. 39
1957	83, 264, 900	52. 14	. 089	9. 39	. 65	9. 83
1958	52, 243, 820	53. 78	. 086	8. 76	. 53	8. 49
1959	44, 402, 848	53. 81	. 085	8. 93	. 61	6. 04

TABLE 12.—Beneficiated iron ore shipped from mines in the United States, in thousand long tons

(Exclusive of ore containing 5 percent or more manganese)

Year	Beneficiated	Total	Proportion of beneficiated to total (percent)
1950–54 (average)	29, 612	100, 702	29. 4
1955	36, 182	105, 241	34. 4
1956	38, 260	96, 945	39. 4
1957	42, 027	104, 157	40. 3
1958	[1] 31, 968	[1] 66, 288	48. 2
1959	30, 363	59, 164	51. 3

[1] Revised figure.

CONSUMPTION AND USES

Agglomerating plants consumed 15 percent more iron ore in 1959 than in 1958 and established a new record despite being closed almost one-third of the year by the steel strike. Iron-ore consumption in ferroalloy furnaces almost doubled, but the data from year to year are not a true measure of activity because the furnaces produce ferroalloys only intermittently. Iron-ore consumption in blast furnaces decreased 7 percent because operators obtained a larger percentage of the needed metal from iron-ore agglomerate.

The demand for high-density lump magnetite for special concrete aggregate again exceeded supply in the Eastern United States. In some instances specifications for the aggregate were relaxed to permit substitution of mixtures of ilmenite and magnetite mineral lumps that met density requirements. For several years fluctuating demand for lump magnetite has presented a problem to both consumers and producers. Apparently, future demand for lump magnetite has not been sufficiently assured for anyone to risk stocking large quantities.

TABLE 13.—Consumption of iron ore in the United States in 1959, by States and uses, in long tons

(Exclusive of ore containing 5 percent or more manganese)

State	Metallurgical uses				Miscellaneous			Total
	Iron blast furnaces	Steel furnaces	Agglomerating plants	Ferroalloy furnaces	Cement	Paint	Other	
Alabama	5,752,038	309,973	2,701,595	-------	28,580	-------	-------	8,847,012
Kentucky				-------	-------	-------	-------	
Tennessee				-------	(1)	-------	-------	
Texas				-------	54,826	-------	-------	
California	2,720,121	404,821	1,273,381	-------	47,188	-------	-------	4,445,511
Colorado				-------	(1)	(1)	(1)	
Utah				-------	(1)	-------	(1)	
Delaware	3,253,667	743,992	4,499,401	-------	-------	-------	-------	8,497,060
Maryland				-------	(1)	-------	-------	
West Virginia				-------	(1)	-------	-------	
Illinois	10,719,766	1,165,004	4,909,566	-------	(1)	-------	-------	16,794,336
Indiana				-------	(1)	-------	-------	
Massachusetts	2,527,896	410,128	2,523,897	-------	-------	-------	-------	5,480,498
New York				(1)	18,577	(1)	(1)	
Michigan	3,243,192	431,756	11,384,403	-------	-------	(1)	-------	15,059,351
Minnesota				-------	(1)	(1)	(1)	
Ohio	20,819,635	2,720,040	9,970,799	(1)	(1)	-------	-------	33,554,604
Pennsylvania				(1)	44,130	(1)	-------	
Undistributed [2]	-------	-------	-------	318,137	136,087	19,036	510,041	983,301
Total	49,036,315	6,185,714	37,263,042	318,137	329,388	19,036	510,041	93,661,673

[1] Included with "Undistributed."

[2] Includes States indicated by footnote 1 plus the following: For cement, Florida, Georgia, Idaho, Iowa, Kansas, Louisiana, Missouri, Montana, Oklahoma, Oregon, South Dakota, and Washington; for paint, Georgia, Oregon, and Virginia; for ferroalloy furnaces, New Jersey; and for other uses, Idaho, Montana, Nevada, Wyoming, and Wisconsin.

Agglomerate (Sinter).—The term "agglomerate" includes all iron-bearing fine-grained material that has been massed to form lumps. That formed from iron-ore fines and iron-ore concentrate is designated iron-ore agglomerate. Agglomerates are commonly formed by sintering, nodulizing, pelletizing, or briquetting processes; the lumps so formed are designated individually as sinter, nodules, pellets, and briquets, respectively. Several types of agglomerates produced in 1959 had not yet been given a commonly accepted name.

Agglomerate production and consumption could not be itemized by type and State without disclosing individual company data. Plants at mines in four States produced 11.8 million long tons of agglomerate and plants not directly associated with mines produced 26.9 million tons. Agglomerate produced in foreign countries, shown in table 14, footnote 1, was not reported by type.

TABLE 14.—Production and consumption of agglomerates in the United States in 1959, by States, in thousand long tons

State	Agglomerate produced	Agglomerate consumed[1]	
		In blast furnaces	In steel furnaces
Alabama Kentucky Tennessee Texas	1,418	2,841	21
California Colorado Utah	2,152	2,141	---------
Delaware Maryland West Virginia	4,692	4,764	(2)
Illinois Indiana	5,341	7,320	358
New York	2,533	2,710	(2)
Michigan Minnesota	11,465	3,150	(2)
Ohio Pennsylvania	11,122	15,846	448
Total	38,723	38,772	859

[1] Includes 1,769,000 long tons of agglomerate produced in foreign countries.
[2] Included in total.

TABLE 15.—Agglomerate produced and consumed in blast and steel furnaces in the United States in 1959, by type, in long tons

Type	Agglomerate produced	Agglomerate consumed	
		In blast furnaces	In steel furnaces
Sinter[1]	29,588,693	29,905,972	233,508
Pellets	8,592,687	6,156,386	100,929
Nodules	278,427	208,282	226,788
Briquets	2,228	60,556	16,313
Other	261,630	944,709	7,836
Foreign	------------	1,496,366	272,974
Total	38,723,665	38,772,271	858,348

[1] Includes self-fluxing sinter.

STOCKS

During the steel strike the U.S. stock of usable iron ore at mines, docks, and consuming plants was augmented by large quantities of imported ore stored in emergency yards in anticipation of a winter shortage. This ore was part of the first moved after the strike; thus, by the end of the year the iron-ore inventory, totaling 68 million long tons, was nearly normal. Stocks at consuming plants and the mines totaled 53 million and 7.4 million tons, respectively, and according to the American Iron Ore Association stocks of ore at U.S. docks totaled 7.6 million tons.

TABLE 16.—Stocks of usable iron ore at mines, Dec. 31, by States, in thousand long tons

State	1958	1959	State	1958	1959
Alabama	70	65	New Jersey Pennsylvania	(1)	(1)
California	(1)	(1)	New Mexico		(1)
Colorado	(1)	(1)	New York	(1)	(1)
Georgia		4	North Carolina		(1)
Idaho	5	1	Texas	(1)	(1)
Michigan	[2] 2,515	2,397	Utah	528	451
Minnesota	2,622	2,390	Wisconsin	490	733
Montana	1				
Nevada	[2] 36	(1)	Total	[2] 7,033	7,372

[1] Included in total.
[2] Revised figure.

PRICES

The average value of domestic usable ore per long ton f.o.b. mines, excluding byproduct ore, was $8.69, compared with $8.59 in 1958 and $8.31 in 1957. These data were taken from producers' statements and probably approximated the commercial selling price less the cost of mine-to-market transportation. All of the reported values included the expense of mining, beneficiation, and agglomerating the ore. Lake Erie prices did not change, and the average grade of ore was the same as that in 1958. The slight increase in average value was due to the higher value of ore produced in the smaller mining districts.

TABLE 17.—Average value a long ton of iron ore at mines in the United States in 1959

State	Direct-shipping ore			Iron-ore concentrates			Iron-ore agglomerates
	Hematite	Brown ore	Magnetite	Hematite	Brown ore	Magnetite	
Alabama	$5.71			$6.61	$5.36		$5.60
Michigan	8.37			9.37			11.65
Minnesota	7.65			7.96			10.88
Utah	7.11	(1)	$6.71			(1)	
Other States	7.35	$4.91	8.60	9.84	9.02	$13.49	15.15
Total	7.60	4.91	7.48	8.25	7.09	13.49	11.61

[1] Included with direct shipping magnetite.

E&MJ Metal and Mineral Markets quoted Lake Superior iron ore, 51.5 percent iron, a long ton, lower lake ports, as follows: Mesabi Non-Bessemer $11.45, Old Range Non-Bessemer $11.70, Mesabi Bessemer $11.60, and Old Range Bessemer $11.85. The same publication quoted Eastern ores, foundry and basic, at 17 and 18 cents per long-ton unit, delivered, through February 19 and nominal thereafter; Swedish ore, nominal throughout the year; and Brazilian ore, 68.5 percent iron premium for low-phosphorus ore per gross ton, $14.60 through February 5, $12 (contracts Jan. 1, 1959) through August 6, $11 per ton thereafter and smaller sellers, $11 to $12 throughout the year.

Freight Rates.—Freight charges from the Mesabi Range to the Pittsburgh-Wheeling district via the Great Lakes totaled $6.56 per long ton, unchanged from 1958. The component charges were: $1.47, Mesabi Range to Duluth, including $0.19 dock handling charge; $2.28, Duluth to Lake Erie ports, including $0.28 handling charge for hold to rail of vessel; and $2.81, Lake Erie ports to the Pittsburgh-Wheeling district, including $0.19 handling charge from rail of vessel to car. Rail rates from the Mesabi Range to the Pittsburgh-Wheeling district were also unchanged at $10.12 per long ton.

TRANSPORTATION

The steel strike increased iron-ore ocean shipping, because overall shipments to the United States were not diminished and more foreign ore was needed in Europe to supply the mills that were operated at capacity to make steel for the U.S. market. In contrast, the steel strike and consequent cutback in iron-ore shipments from Canada caused Saint Lawrence Seaway traffic to fall short of that estimated for its first year of deep-draft transit.

Foreign ore that came to the United States through the Seaway did not greatly change the domestic pattern of iron-ore movement. Before and after the strike, the transportation system between the Lake Superior district and its usual markets operated at capacity. On the other hand, domestic use of foreign ore greatly increased traffic on the Mississippi River-Illinois waterway system. More than 200,000 tons of iron ore was transferred from oceangoing vessels to river barges at Burnside, La., and sent up the Mississippi River to the steel mills at Chicago. Previously, the Chicago mills had received less than 10,000 tons of foreign iron ore a year routed in this manner. Some of the ore came from as far away as Liberia, but most of it originated in South American countries.

The steel strike increased the movement of iron ore over the railroads. After the strike a severe car shortage developed. Little ore moved from mine to steel mill by truck, but a substantial quantity was trucked from emergency storage piles to the mills.

Great Lakes.—The Great Lakes shipping season opened April 10 when the first ship was loaded at Escanaba and closed December 20 when the last ship was loaded at Two Harbors. The steel strike and a 4-day wildcat strike of the freighter crews early in July cut Lake shipments to much below normal from July through November. December shipments, however, were the highest on record.

Table 18 gives the carrying capacity of the U.S. Great Lakes iron-ore fleet, by year of construction. Although the aggregate carrying capacity was 2,000 tons more than in 1956 when this information was last presented in the Minerals Yearbook, the fleet numbered 10 less vessels. All ships added to the fleet since 1956 approach the maximum dimensions of 730 feet long and 75 feet in beam allowed on the Lakes.

Saint Lawrence Seaway.—The Saint Lawrence Seaway was officially opened to deep-draft vessels on April 25. Queen Elizabeth II and President Eisenhower formally opened the Seaway on June 26 in a ceremony that marked the beginning of significant changes in the transportation of bulk commodities to and from the Middle West. However, iron-ore transportation was not changed enough to establish a new pattern in this first year of deep-draft shipping, partly because of the steel strike and trouble experienced by ocean freighters unaccustomed to interior waterways. Also retarding the movement of iron ore through the Seaway in 1959 was the fact that many of the Great Lake ports were not yet equipped to handle 27-foot-draft ships.

Seaway tolls, established for bulk cargoes as recommended in 1958 by committees of the United States and Canada, were as follows: On gross registered tonnage, Montreal to Lake Ontario, 4 cents, and on the Welland Canal, 2 cents, plus 40 cents per ton of bulk cargo from Montreal to Lake Ontario and 2 cents per ton on the Welland Canal.

TABLE 18.—Carrying capacity of United States Great Lakes iron-ore fleet, by year of construction

[Lake Carriers Association]

Year built	Number of vessels	Aggregate carrying capacity per trip, long tons	Year built	Number of vessels	Aggregate carrying capacity per trip, long tons
1899	1	7,400	1922	2	27,900
1900	8	58,800	1923	6	78,900
1901	3	17,950	1924	4	50,150
1902	2	13,600	1925	5	68,900
1903	1	7,700	1926	2	26,400
1904	2	18,650	1927	5	71,400
1905	20	197,500	1929	2	27,000
1906	25	247,450	1930	2	26,900
1907	29	296,300	1938	4	55,100
1908	17	150,350	1942	5	88,900
1909	9	86,500	1943	16	249,600
1910	15	149,800	1949	1	20,800
1911	5	55,500	1951	2	30,000
1912	1	12,600	1952	12	222,800
1913	4	45,750	1953	5	98,300
1914	2	19,700	1954	1	24,000
1916	6	69,900	1958	2	50,500
1917	9	103,300	1959	2	48,000
1920	4	51,900			
			Total	241	2,876,200

Source: Burnham, Oliver T. (vice president, Lake Carriers Association). Letter to Bureau of Mines: October 27, 1959.

RESERVES

Iron-ore reserves of Michigan and Minnesota, given in tables 19 and 20, are recalculated each year as deposits are explored and mined and represent only taxable and State-owned reserves, excluding jaspilite and taconite resources.

TABLE 19.—Iron-ore reserves in Michigan, Jan. 1, in thousand long tons

[Michigan Department of Conservation]

Range	1951–55 (average)	1956	1957	1958	1959	1960
Gogebic	31,806	30,810	26,209	25,187	23,547	19,341
Marquette	66,660	63,820	64,464	64,027	58,719	55,575
Menominne	60,935	58,284	63,536	60,877	58,535	53,554
Total Michigan	159,401	152,914	154,209	150,091	140,801	128,471

TABLE 20.—Unmined iron-ore reserves in Minnesota, May 1, in thousand long tons

[Minnesota Department of Taxation]

	1950–54 (average)	1955	1956	1957	1958	1959
Mesabi	864,908	787,992	739,971	697,267	618,606	564,253
Vermilion	12,320	11,307	10,449	9,641	9,044	8,307
Cuyuna	46,150	58,859	54,518	52,337	44,416	42,701
Total Lake Superior district (taxable)	923,378	858,158	804,938	759,245	672,066	615,261
Fillmore County	650	666	926	1,125	2,088	2,638
Morrison County	29	--------	--------	--------	--------	--------
Aitkin County	514	870	825	825	825	825
Mower County	[1] 118	118	118	118	173	152
Olmsted County	--------	--------	--------	--------	28	28
State ore (not taxable)	1,896	117	2,352	2,629	1,134	9,263
Total Minnesota	926,585	859,929	809,159	763,942	676,314	628,167

[1] Figure for 1954 only.

FOREIGN TRADE [3]

The United States imported a record quantity of iron ore in 1959, as most of its trade with foreign countries was little affected by the steel strike. However, exports of iron ore to Canada were more than a million tons below normal, and imports from Canada were slightly less than the record established in 1956. Apparently, iron-ore trade with Japan has leveled off at half a million tons a year, and Brazil has replaced Sweden as the main source of open-hearth ore. Venezuela maintained its position over Canada as the principal supplier by a narrow margin.

---

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 21.—Iron ore[1] imported for consumption in the United States, by countries, in thousand long tons and thousand dollars

[Bureau of the Census]

Country	1950–54 (average)		1955		1956		1957		1958		1959	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
North America:												
Canada	2,203	$17,137	10,077	$79,058	13,723	$117,666	12,537	$111,777	[2] 8,289	[2] $77,329	13,446	$128,798
Costa Rica	1	1	---	---	---	---	---	---	---	---	---	---
Cuba	70	629	43	329	93	910	33	346	---	---	4	40
Dominican Republic	37	442	102	1,173	163	2,043	149	2,025	21	298	50	552
Mexico	172	561	176	574	133	447	236	744	221	739	106	356
Panama	---	---	---	---	(3)	3	---	---	14	164	---	---
Total	2,483	18,770	10,398	81,134	14,112	121,069	12,955	114,892	[2] 8,545	[2] 78,530	13,606	129,746
South America:												
Brazil	761	8,399	1,011	11,216	1,223	15,416	1,431	20,275	832	12,004	1,200	13,613
Chile	2,253	8,773	1,035	5,380	1,564	10,813	2,741	20,641	3,257	25,876	3,577	27,662
Peru	555	4,310	1,559	13,691	1,840	16,405	2,373	20,859	[2] 1,674	[2] 16,785	2,271	21,781
Surinam	---	---	---	---	---	---	---	---	---	---	2	23
Venezuela	1,928	14,291	7,160	45,549	9,254	61,929	12,291	87,733	[2] 12,180	[2] 87,976	13,543	104,358
Total	5,497	35,773	10,765	75,836	13,881	104,563	18,836	149,508	[2] 17,943	[2] 142,641	20,593	167,437
Europe:												
Norway	---	---	---	---	---	---	---	---	---	---	15	147
Spain	18	152	---	---	---	---	---	---	(3)	6	(3)	6
Sweden	2,064	19,277	1,221	12,335	999	11,914	677	9,575	113	1,640	136	1,737
United Kingdom	(3)	27	2	58	1	39	(3)	35	1	[2] 54	19	195
Other Europe	(3)	(3)	---	---	(3)	4	(3)	4	(3)	5	1	15
Total	2,082	19,456	1,223	12,393	1,000	11,957	677	9,614	114	[2] 1,705	171	2,100
Asia:												
Iran	3	162	---	---	4	266	---	---	2	167	3	187
Philippines	1	7	---	---	23	381	---	---	54	1,131	71	1,491
Total	4	169	---	---	27	647	---	---	56	1,298	74	1,678
Africa:												
Algeria	211	1,394	20	245	11	86	---	---	---	---	---	---
British West Africa	230	1,404	138	800	162	1,053	170	1,253	49	351	62	481
Liberia	431	3,156	928	7,049	1,218	11,115	1,013	9,784	837	7,092	1,090	10,762
Other Africa	72	396	---	---	---	---	---	---	---	---	17	163
Total	944	6,350	1,086	8,094	1,391	12,254	1,183	11,037	886	7,443	1,169	11,406
Grand total	11,010	[4] 80,518	23,472	177,457	30,411	250,490	33,651	285,051	[2] 27,544	[2] 231,617	35,613	312,367

[1] In addition, pyrites cinder (byproduct iron ore) were imported as follows: 1950–54 (average), 9,702 long tons ($39,755); 1955, 3,879 tons ($15,801); 1956, 1,430 tons ($5,972); 1957, 567 tons ($2,222); 1958, 2,721 tons ($9,212) all from Canada; 1959, Canada 6,741 tons ($22,988), Italy 3,416 tons ($24,812).

[2] Revised figure.

[3] Less than 1,000.

[4] Data known to be not comparable with other years.

TABLE 22.—Iron ore exported from the United States, by countries of destination, in thousand long tons and thousand dollars

[Bureau of the Census]

Country	1950–54 (average)		1955		1956		1957		1958		1959	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Canada	3,270	$22,343	4,232	$34,077	4,529	$39,272	3,958	$36,871	[1] 3,077	[1] $29,701	2,453	$28,189
Japan	610	5,907	285	2,874	974	9,313	1,041	10,532	493	5,044	507	5,247
Mexico	(2)	1	------	------	3	41	1	8	(2)	4	(2)	2
Philippines	(2)	(2)	(2)	40	------	------	------	------	(2)	2	(2)	3
Union of South Africa	(2)	9	------	------	2	143	2	125	3	140	3	127
Other countries	(2)	5	(3)	2	(3)	36	(3)	7	(3)	[1] 7	4	263
Total	3,880	28,265	4,517	36,993	5,508	48,805	5,002	47,543	[1] 3,573	[1] 34,898	2,967	33,831

[1] Revised figure.
[2] Less than 1,000.
[3] Includes countries receiving less than 1,000 tons each.

WORLD REVIEW

Preliminary figures indicate that world trade in iron ore in 1959 was appreciably larger than that shown for 1958 in table 23. The increase was due principally to business recovery in Europe and to the fact that the European iron and steel industry was greatly stimulated by U.S. demand for steel when it became apparent that the steel strike would not be settled quickly.

Statistical reporting throughout the world greatly improved, and it was again possible to achieve a satisfactory world trade balance within 18 months. The world trade table for the first time gives New Caledonia's fast growing iron-ore trade with Australia.

TABLE 23.—World trade of iron ore, iron-ore concentrates, iron-ore agglomerates, in 1958, in thousand long tons

[Compiled by Corra A. Barry and Berenice B. Mitchell]

Exports by countries of origin	Fe (percent)[1]	Production	Exports	Exports by countries of destination																	
				North America		Europe													Asia	Oceania	
				Canada	United States	Austria	Belgium-Luxembourg	Czechoslovakia	France	Germany, East	Germany, West	Hungary	Italy	Netherlands	Poland	Roumania	Saar	United Kingdom	Japan	Australia	Other countries
North America:																					
Canada	55	14,042	12,391		8,596		26				1,096			[2] 179				2,001	493		
Cuba	62	16	3		3																
Dominican Republic	66	17	21		21																
Mexico	68	[1] 955	220		220																
United States	49	67,709	3,385	2,897															485		3
South America:																					
Brazil	68	5,102	2,779	35	830			329	24		447	21	17	115	339			562	46		14
Chile	64	3,605	3,581		3,365		2	10			167			20					17		
Peru	62	3,532	2,470		1,646						[2] 711								113		
Venezuela	60	15,240	15,325		12,400		82				1,014		548					1,277	4		
Europe:																					
Austria	32	3,357	48					48													
Belgium-Luxembourg	28	6,654	110						93		17										
Finland	36	212	302					17	3	9	31	(3)	27		168			47			
France	33	58,499	23,084				13,401				1,093			51			8,043	496			
Germany, West	27	17,704	326			319	1	(3)	1				2	1							2
Greece	49	275	267			170					[2] 71		21								5
Italy	29	1,272	13		3	6					4										
Norway	65	1,576	1,140			51	27	9	1		644				110			280			18
Portugal	50	228	185				1				61							123			
Spain	45	4,954	2,122			50	6		104		959		55	218	26			575			129
Sweden	60	18,104	14,576		93	77	3,023	110	344	3	6,524	12	230	247	613			3,169			131
Switzerland	40	[1] 77	63								63										
U.S.S.R.	55	87,399	11,731			156		3,642		1,724		1,564			3,940	705					
United Kingdom	30	14,613	3		1						2										
Yugoslavia	45	1,965	157									157									
Other Europe		7,640	(4)																		

Asia:																					
China	50	29, 500	[5] 105	------	------	------	------	(5)	------	------	------	------	------	------	105	------	------	------	------	------	------
Hong Kong	45	105	108	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	108	------	------
India	53	6, 033	1, 866	------	------	------	------	428	1	7	4	------	110	3	39	------	------	------	1, 232	------	42
Korea, North	50	1, 527	186	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	186	------	------
Malaya, Federation of	45	2, 795	2, 591	------	------	------	------	------	------	------	[2] 156	------	------	24	------	------	------	------	2, 397	------	14
Philippines	54	1, 082	1, 024	------	32	------	------	------	------	------	------	------	------	------	------	------	------	------	992	------	------
Portuguese India	55	2, 889	2, 459	------	------	76	------	33	70	------	804	------	382	1	------	------	------	71	1, 015	------	7
Turkey	60	936	254	------	5	------	------	------	------	------	72	------	162	15	------	------	------	------	------	------	------
Africa:																					
Algeria	52	2, 278	2, 287	------	------	7	32	------	162	------	250	------	225	146	------	------	------	1, 465	------	------	------
Angola	65	282	219	------	------	------	------	------	5	------	214	------	------	------	------	------	------	------	------	------	------
Guinea, Republic of	53	408	329	------	------	------	------	------	------	------	10	------	------	------	21	------	------	298	------	------	(3)
Liberia	68	2, 264	2, 035	16	822	------	------	------	------	------	741	------	21	168	------	------	------	267	------	------	------
Morocco	60	1, 514	1, 279	------	------	------	4	------	68	------	435	------	4	129	------	------	------	435	------	------	204
Sierra Leone	60	1, 300	1, 422	------	49	10	------	------	------	------	396	------	------	209	------	------	------	748	------	------	10
Tunisia	53	1, 086	977	------	------	75	------	8	71	------	55	------	153	37	------	------	------	578	------	------	------
Union of South Africa	62	2, 177	8	------	------	------	------	------	------	------	4	------	2	------	------	------	------	------	2	------	------
Oceania:																					
Australia	60	3, 926	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
New Caledonia	55	290	307	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	296	11
Other countries	----	3, 300	(5)	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
Total	----	398, 439	111, 758	2, 948	28, 086	997	16, 605	4, 634	947	1, 743	16, 045	1, 754	1, 959	1, 563	5, 361	705	8, 043	12, 392	7, 090	296	590

---

[1] Estimate.

[2] Imports.

[3] Less than 500 tons.

[4] Data not available.

[5] Trade agreements between China and Czechoslovakia indicate shipments of iron ore from China, but the quantity is unknown.

TABLE 24.—World production of iron ore, iron-ore concentrates, and iron-ore agglomerates, in thousand long tons[1]

[Compiled by Pearl J. Thompson and Berenice B. Mitchell]

Country	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada	4,898	14,539	19,954	19,886	14,042	21,825
Cuba	67	129	135	177	16	---------
Dominican Republic	[2] 74	99	111	124	17	12
Guatemala	[3] 2	[3] 3	[3] 3	4	5	[3] 4
Mexico	486	705	801	[3] 935	[3] 955	[3] 875
United States	101,718	102,999	97,877	106,148	67,709	60,276
Total	107,245	118,474	118,881	127,274	82,744	82,992
South America:						
Argentina	58	74	64	66	64	[3] 60
Brazil	2,804	3,329	4,011	4,898	5,102	[3] 5,600
Chile	2,683	1,512	2,624	2,638	3,605	4,587
Colombia	[4] 82	344	388	584	543	399
Peru	[5] 1,589	1,703	2,604	3,522	3,532	3,478
Venezuela	2,196	8,306	10,930	15,054	15,240	16,929
Total	9,412	15,268	20,621	26,762	28,086	31,053
Europe:						
Albania	(6)	(6)	(6)	(6)	88	[3] 160
Austria	2,433	2,793	3,207	3,441	3,357	3,329
Belgium	87	104	142	136	121	140
Bulgaria	[3] 80	111	232	267	288	370
Czechoslovakia	1,856	2,451	2,499	2,766	2,755	2,917
Finland	[5] 75	181	203	207	212	190
France	37,852	49,517	51,872	56,865	58,499	59,935
Germany:						
East	[3] 875	1,638	1,729	1,455	1,482	1,417
West	13,162	15,436	16,661	18,031	17,704	17,778
Greece	75	189	323	424	275	177
Hungary	350	347	344	327	365	432
Italy	773	1,372	1,648	1,556	1,272	1,217
Luxembourg	5,861	7,091	7,474	7,719	6,533	6,406
Norway	724	1,236	1,526	1,478	1,576	1,451
Poland	1,090	1,672	1,774	1,757	1,931	1,982
Portugal	[7] 72	187	233	281	228	237
Rumania	549	627	683	634	731	1,047
Spain	2,614	3,709	4,410	5,155	4,954	[3] 4,800
Sweden	15,403	17,080	18,648	19,609	18,104	17,999
Switzerland	90	127	129	114	[3] 77	[3] 60
U.S.S.R.[8]	51,406	70,727	76,846	82,963	87,399	92,909
United Kingdom	15,069	16,175	16,245	16,902	14,613	14,872
Yugoslavia	767	1,376	1,698	1,846	1,965	2,062
Total[8]	151,263	194,146	208,526	223,933	224,529	231,887
Asia:						
Burma	[4] 3	4	4	4	6	4
China[3]	4,500	6,900	8,900	14,800	29,500	44,300
Hong Kong	134	115	123	94	105	120
India	3,744	4,678	4,898	5,074	6,033	7,810
Iran[9]	[7] 9	[3] 10	10	[3] 10	11	[3] 10
Japan[10]	1,311	1,492	1,882	2,204	2,056	2,422
Korea:						
North	(6)	(6)	(6)	(6)	1,527	2,650
Republic of	[7] 30	29	62	182	257	277
Lebanon	[2] 29	42	41	41	23	[3] 25
Malaya, Federation of	935	1,466	2,445	2,972	2,795	3,761
Philippines	1,046	1,410	1,417	1,325	1,082	1,211
Portuguese India	665	2,176	2,505	2,901	2,889	2,999
Thailand (Siam)	5	5	6	9	15	6
Turkey	398	760	915	1,146	936	901
Total[8]	12,949	20,077	24,198	31,752	47,235	66,496
Africa:						
Algeria	2,914	3,541	2,587	2,746	2,278	1,893
Angola	---------	---------	---------	104	282	343
United Arab Republic (Egypt Region)	---------	---------	130	250	175	[3] 180
Guinea, Republic of	[5] 488	640	834	1,074	408	353
Liberia	[7] 890	1,870	2,108	1,935	2,264	2,647
Morocco:						
Northern Zone	933	1,017	1,356	1,839	1,514	1,245
Southern Zone	466	305	482			

See footnote at end of table.

TABLE 24.—World production of iron ore, iron-ore concentrates, and iron-ore agglomerates, in thousand long tons [1]—Continued

[Compiled by Pearl J. Thompson and Berenice M. Mitchell]

Country	1950–54 (average	1955	1956	1957	1958	1959
United Arab Republic—Continued						
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	2	2	----------	----------	----------	----------
Southern Rhodesia	59	83	114	133	142	128
Sierra Leone	1,131	1,332	1,311	1,324	1,300	[11] 1,596
Tunisia	918	1,122	1,151	1,156	1,086	966
Union of South Africa	1,621	1,967	2,031	2,047	2,177	2,845
Total	9,422	11,879	12,104	12,608	11,626	12,196
Oceania:						
Australia	2,860	3,573	3,924	3,806	3,926	[3] 4,100
Fiji	----------	----------	----------	----------	3	12
New Caledonia	3	----------	28	230	290	282
Total	2,863	3,573	3,952	4,036	4,219	4,394
World total (estimate)[1] [6]	293,154	363,417	388,282	426,365	398,439	429,018

[1] This table incorporates some revisions.
[2] Average for 1952–54.
[3] Estimate.
[4] 1 year only as 1954 was the first year of commercial production.
[5] Average for 1953–54.
[6] Data not available for Albania and North Korea; estimates included in the total for North Korea.
[7] Average for 1951–54.
[8] U.S.S.R. in Asia included with U.S.S.R. in Europe.
[9] Year ending Mar. 21 of year following that stated.
[10] Includes iron sand production as follows: 1950–54 (average), 320,240 tons; 1955, 541,890 tons; 1956, 846,153 tons; 1957, 1,067,088 tons; 1958, 898,913 tons; and 1959, 1,266,463 tons.
[11] Exports.

NORTH AMERICA

Canada.—Canadian iron-ore mines established a record output of 21.8 million tons in 1959, almost 2 million tons more than the previous record established in 1956. The record was possible because (1) Canadian consumers operated at capacity during and after the steel strike in the United States, (2) shipments to the United States were only slightly curtailed during the steel strike as storage facilities at U.S. docks were increased, and (3) a strong demand for Canadian iron ore developed in Europe during the last half of the year.[4]

British Columbia.—Texada Mines, Ltd., and the Empire Development Co., Ltd., were the only iron-ore producing companies in British Columbia. However, the British-Columbia concerns, Cascade Load Mines, Ltd., and Silver Standard Mines, Ltd., negotiated with the Japanese for the sale of high-grade iron ore and concentrates.

Newfoundland-Quebec.—The Iron Ore Company of Canada produced a record tonnage of iron ore at its Labrador-Quebec property. In addition, the company cooperated with the Wabush Iron Co. in developing deposits on the west side of Wabush Lake. These deposits reportedly contain 1.5 billion tons of 37- to 38-percent iron ore.

The Wabush Iron Co. was developing iron deposits on the east side of Wabush Lake, which are estimated to contain more than a billion tons of 37-percent iron ore. Hilton Mines, Ltd., operated its 600,000-

---

[4] Eluer, R. B., Iron Ore: Canadian Min. Jour., vol. 81, No. 2, February 1960, pp. 143–147.

ton-capacity beneficiation plant at capacity and began installing equipment to increase capacity to 800,000 tons a year. The Quebec Iron and Titanium Corp. resumed operations in March after a 6-month shutdown caused by poor markets.

Quebec Cartier Mining Co. continued developing deposits in the Mount Reed area at Lac Jeannine. The company was building a deep-water terminal and a new town at Port Cartier, 193 miles of rail line from the port to the mine, a new town at the mine, a 60,000-hp. powerplant, and a beneficiation plant that will treat 20 million tons of crude ore to yield 8 million tons of concentrate.

Ontario.—Steep Rock Iron Mines, Ltd., completed the Hogarth shaft and began underground development.

Lowphos Ore, Ltd., began shipping iron-ore concentrate in June. The Lowphos company completed its 550,000-ton beneficiation plant in 1958 but did not start operating at the time because of an adverse market for ore.

Marmoraton Mining Co., Ltd., was the only Canadian iron-ore producer directly affected by the U.S. steel strike. Its mines were closed 119 days from July 15 to November 10.

Anaconda Iron Ores (Ontario), Ltd., continued exploring its iron prospect 35 miles north of Nakina and installed a 100-ton-per-day mill at the property.

Mexico.—The Government of Mexico transferred all iron-ore deposits in the National Mineral Reserve that were not covered by mining concessions into the property of the Comision de Fomento Minero.[5] This act was intended to ensure that iron-ore deposits in Mexico would be developed jointly by private capital and Fomento Minero in the future.

Altos Hornos de Mexico, the Government-controlled integrated steel company, bought the La Perla iron-ore deposit from La Consolidada, S. A. La Perla was operated on a daily schedule of about 800 long tons of washed iron ore per day for Altos Hornos' account after the company built 114 miles of railroad to the main line of the Ferrocarriles Nacionales.[6]

La Perla, Cerro de Mercado, Golodrinas, and a small deposit near Torreon, Coahuila, were the only iron properties in Mexico worked on a regular schedule.

SOUTH AMERICA

Argentina.—The Argentine Government through its Direccion General de Fabricaciones Milatares invited bids for developing iron-ore deposits in Sierra Grande in Rio Negro Territory. The Government had proved 70,000 tons of 55- to 60-percent iron ore in the area.[7]

Brazil.—The Director of Internal Revenue of the National Treasury of Brazil published a schedule of unit values for computing taxes of Brazilian minerals at the mouth of the mine. The schedule was effective for 1960 mine output. Iron ore was valued per ton as follows:

---

[5] U.S. Embassy, Mexico, D.F., State Department Dispatch 253, Sept. 2, 1959.

[6] U.S. Embassy, Mexico, D.F., State Department Dispatch 264, Sept. 4, 1959.

[7] Engineering and Mining Journal, Argentina Invites Bids to Develop Iron Mine: Vol. 160, No. 4, April 1959, p. 138.

Canga, $0.26; itabirite, $0.52; hematite-magnetite, $1.04; and friable itabirite and fines, $0.31.[8]

Minerais e Metais Gruner, Ltd., of Rio de Janeiro, shipped 1,390 long tons of iron ore from the port of São Roque.[9] Apparently this was the start of exploitation of the iron-ore deposits in the State of Bahia.

Chile.—Compañía Minera Santa Fe displaced Bethlehem Chile Iron Mines Co. as the principal iron-ore producer. The Santa Fe company produced about 1.5 million tons of ore from its own mines and bought about half a million tons from numerous small operators.

Compañía de Acero del Pacifico, a Chilean company, bought the Algarrobo iron-ore deposit from William P. Mueller and Co.[10] Algarrobo contains 50 to 70 million tons of high-grade ore. Therefore, its ownership by Compañía de Acero del Pacifico assures Chile enough iron ore for its needs for several decades.

Peru.—Marcona Mining Company completed a 5,000-ton-per-day gravity-magnetic concentrating plant early in the year. The Marcona Company had been Peru's only iron-ore producer; however, Panamerican Commodities S. A., a Peruvian company financed partly by American Overseas Corp., began producing iron ore at its newly developed Acarí mine in August. Acarí's first shipment of iron was high-grade ore destined for the United States through the port of San Juan.[11]

Venezuela.—The Government of Venezuela, by Decree 97, dated July 6, 1959, placed the District of San Fernando and a strip of land 19 miles (30 km.) wide on the left bank of the Orinoco River in the national iron-ore reserve. The strip was bounded by the river and extended from the northern boundary of the District of Fernando to the western boundary of the Federal Territory of Delta Amacuro.[12] It covered parts of the Districts of Miranda, Infante, and Zaraza, in the State of Guárico; Monagas and Independencia, in the State of Anzoátegui; and Sotillo, in the State of Monagas.

Orinoco Mining Company opened a new ship channel through the delta of the Orinico River for shipping iron ore from its Cerro Bolivar mine.[13] The new channel, in the Boca Grande arm of the river, is 139 miles long and has a minimum width of 400 feet and a minimum depth of 30 feet.

EUROPE

Member nations of the European Coal and Steel Community produced a record 85 million tons of iron ore.

Germany, West.—Iron ore was discovered at depths of 2,400 to 3,600 feet in northwest Germany, about 30 miles south of Bremen. The Federal Geological Research Office in Hanover, on the basis of a preliminary investigation, estimated that the deposit contained 400 million tons of 42- to 48-percent iron ore.[14]

---

[8] U.S. Embassy, Rio de Janeiro, Brazil, State Department Dispatch 764, Jan. 27, 1960.

[9] U.S. Consul, Salvador, Bahia, Brazil, State Department Dispatch 19, Jan. 14, 1960.

[10] U.S. Embassy, Santiago, Chile, State Department Dispatch 524, Jan. 21, 1960.

[11] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 2, August 1959, p. 17.

[12] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 4, October 1959, p. 20; No. 6, December 1959, pp. 14–18.

[13] Engineering and Mining Journal, Venezuela: Vol. 160, No. 7, July 1959, p. 138.

[14] Bureau of Mines, Mineral Trade Notes: Vol. 48, No. 5, May 1959, p. 7.

Sweden.—Sweden exported iron ore at about the 1958 rate until the last quarter of the year, when the rate increased markedly owing to more ore being sent to steel mills in West Germany and Belgium.[15]

The price of Swedish iron ore was reduced approximately 10 percent in January by agreement between Luossavaara Kiirunavaara, a.-b. (LKAB), and West German consumers.[16] LKAB is a government-owned mining company acquired by purchase from the Grängesberg Company in 1957. The managing director of LKAB reported that iron-ore deposits in Arctic Sweden contain at least 31 billion tons, and that Swedish output of iron ore could be increased from the current 14 to 15 million tons annually to 22 to 23 million tons by the late 1960's. However, such an increase would depend upon the export market and the expansion of existing railway and port capacities.[17]

The Grängesberg Company officially reopened the Strassa iron mine which had been idle for nearly four decades. The Strassa mine produced iron ore for more than three centuries before it was closed when the market declined after World War I. The reopening was one phase of the company's plan to invest the money received from nationalization of LKAB in a fully integrated steelmaking facility in Sweden.

U.S.S.R.—The Russians began developing an iron-ore mine in the Krivoi Rog basin, south Ukraine, which was reported to be the world's largest underground iron mine.[18] The shaft was expected to be ready to hoist ore in 1961. It is 25 feet in diameter, and the first operating depth will be between 1,970 and 2,950 feet. Ore reserves in Dzerzhinskiy district were estimated at 507 million long tons to a depth of 2,950 feet. The ore averages 57 to 59 percent iron.

ASIA

China.—Communist China reportedly discovered 600 iron-ore deposits, thus increasing its reserve to an estimated 100 million tons to suport its campaign of rapid industrialization.[19] However, most of the small iron works authorized to support this program in 1958 apparently were failures.

The first blast furnace of a new steel plant at Paotow, Inner Mongolia, was lit. The Paotow plant is one of three Communist Chinese steel centers; the others are at Anshan and Wuhan.[20]

India.—The National Metallurgical Laboratory of India ignited a 15-ton-per-day low-shaft furnace pilot plant at Golmuri, Jamshedpur.[21] The plan was designed to determine the possibilities of obtaining commercial grades of pig iron from iron ore and noncoking fuels. It is one of the largest of its kind in existence. India's Council of Scientific and Industrial Research participated in the project through its Metal Committee.

---

[15] U.S. Embassy, Stockholm, Sweden, State Department Dispatch 314, Nov. 10, 1959.

[16] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 5, November 1959, p. 14.

[17] Mining Journal (London), Iron Ore in Arctic Sweden: Vol. 253, No. 6468, Aug. 7, 1959, p. 122.

[18] Bureau of Mines, Mineral Trade Notes: Vol. 48, No. 6, June 1959, pp. 11–12.

[19] Mining World, vol. 21, No. 3, March 1959, p. 83.

[20] Blast Furnace and Steel Plant, vol. 47, No. 11, November 1959, p. 1196.

[21] Journal of Mines, Metals and Fuels (Calcutta), Low-Shaft Furnace Pilot Plant: Vol. 7, No. 2, February 1959, pp. 22–23.

Japan.—The Japanese steel industry resumed its rapid rate of expansion and as in 1957 negotiated to buy iron ore throughout Asia and the Western Hemisphere. Members of the industry investigated the possibility of further exploiting, for Japan's future needs, iron-ore resources in Malaya, Philippines, and India. For current needs, Japan stepped up its purchase of ore in these countries, the United States, and Canada and offered to buy iron ore in Brazil.

Malaya, Federation of.—Iron-ore output in the Federated Malay States exceeded 3 million tons in 1959, breaking all records. Bukit Besi, Malaya's largest iron mine, developed an estimated 20 million tons of new reserve. Perak, with five mines operating near Ipoh and two being developed, surpassed Johore and challenged Kelontan as Malaya's principal iron-ore-producing State. Perak reserves were estimated at more than 10 million tons.[22] Iron-ore reserves at a large open-pit mine being developed near Rompin in Pahang were estimated at 30 million tons containing 50 to 60 percent of iron.[23]

AFRICA

Algeria.—Strengthened security measures reportedly virtually eliminated terrorism of Algerian iron-ore producers.[24] Thereafter, output was limited only by the market. However, 1959 production declined 17 percent from that of 1958. According to the head of the mining association, iron ore sold by West Germany reduced the market for Algerian ore.

The French Government, Bureau des Recherches Minieres de l'Algerie, reported an iron-ore deposit containing 400 to 500 million tons of 57-percent iron at Gara Djebilet, 85 miles southeast of Tindouf. Although the Bureau was studying this deposit, its location made early exploitation unlikely.

Cameroun.—The Bureau of Mines of Overseas France began drilling in April to explore the Chaines des Mamelles iron deposits 25 miles south of Kribi and 4 miles from the coast.[25] The reserve was estimated at 100 million tons, averaging 40 percent iron.

Gabon.—The Sydicat du Fer de Mekambo, formed in 1956 to explore the Mekambo group of iron-ore deposits in Gabon, was reorganized as Société des Mines de Fer de Mekambo. The new organization will explore and exploit these deposits.

The Mekambo group of iron-ore deposits lies in a 50-mile area between Makokou and Mekambo along the upper Ivindo River in northeastern Gabon. Boka-Boka, Belinga, and Batoala, three large iron-bearing massifs, are the principal deposits of the group. Boka-Boka, which is the largest, crops out over a length of 5 miles. It was completely explored to a depth of 180 feet by the Syndicat du Fer de Mekambo. To that depth it contains 25 to 300 million tons of 63-percent iron ore.

Société des Mines de Fer de Mekambo planned to continue exploring the Mekambo group, first on the Belinga and then on the Batoala and smaller massifs. Concurrently, the company was to make a pre-

---

[22] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 2, February 1960, p. 8.
[23] Mining Journal (London), vol. 253, No. 6479, Oct. 23, 1959, p. 401.
[24] U.S. Consul General, Algiers, Algeria, State Department Dispatch 114, Nov. 16, 1959.
[25] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 2. August 1959, p. 17.

liminary survey of a rail route to a proposed port at Owendo, opposite Libreville at the mouth of the Gabon Estuary.[26]

Liberia.—All iron ore produced in Liberia in 1959 was mined by Liberian Mining Co., Ltd., at its Bomi Hills concession in northwest Monrovia. The high-grade iron-ore reserve at Bomi Hills was estimated at 50 million tons of 68- to 70-percent iron ore. The total reserve was estimated at 300 million tons. Liberian-American-Swedish Minerals Co. (LAMCO) and Bethlehem Steel Corp. continued preliminary development of iron deposits on Nimba Mountain in the Nimba Range where core drilling had already proved more than 200 million tons of 60- to 70-percent iron ore.

National Iron Ore Co. and Liberian Iron Ore Co. explored iron-ore deposits near the Mano River, north of Bomi Hills, and in the Bong Hills north of Katata.[27]

Mauritania.—Société des Mines de Fer de Mauretanie (Miferma) was developing iron-ore deposits estimated at 120 million tons of 65- to 68-percent iron ore. To exploit these deposits, the company would need haulage facilities which would extend 390 miles to the sea.[28]

Sierra Leone.—Sierra Leone Development Corp. (DELCO) reported proved reserves at its Marampa mine of 400 million tons containing more than 60-percent iron. The company finished an ore beneficiation plant in March that was expected to increase Marampa iron-ore-concentrate capacity to a total of 2 million tons annually.[29]

Rhodesia and Nyasaland, Federation of.—The Mesina (Transvaal) Development Co., Ltd., proved a reserve of 80 million tons of hematite iron ore at Bukwe in Southern Rhodesia.[30]

TECHNOLOGY

Judging solely from the number of publications on the scientific aspects of the iron-ore industry, iron-ore research and development was not as active in 1959 as in 1958. However, if the activity is measured by the number of patents issued and by papers on iron-ore reduction that were scheduled for presentation at scientific meetings in 1960, iron-ore technology advanced substantially.

The scientists remained principally interested in direct-reduction processes, but their principal accomplishments were in blast-furnace operating techniques and iron-ore agglomerating practice. Research was continued on mineral dressing, mining, and geology in the search for better methods and new knowledge.

Geologists sought a key in primary mineralogy to the environment existing when the iron formation of Michigan and Wisconsin was deposited.[31] They found no unaltered minerals because the formation had been oxidized to depths of more than 4,000 feet, but they determined the approximate primary-mineral composition by studying areas that were only slightly altered. From the minerals in these

---

[26] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 2, February 1960, pp. 7–8.
[27] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 3, September 1959, pp. 18–19.
[28] Iron and Coal Trades Review (London), vol. 179, No. 4757, Sept. 18, 1959, p. 319.
[29] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 5, November 1959, pp. 12–13.
[30] Bureau of Mines, Mineral Trade Notes: Vol. 48, No. 2. February 1959, pp. 15–16.
[31] Huber, N. K., Some Aspects of the Origin of the Ironwood Iron-Formation of Michigan and Wisconsin: Econ. Geol., vol. 54, No. 1, January–February 1959, pp. 82–118.

areas, geologists showed that the iron formation probably was formed by dominantly chemical sedimentation and that the differing facies of the formation reflect small fluctuations in physical and chemical conditions at the time.

Geologists also studied the hard hematite ores in itabirite (taconite) to determine their origin.[32] They concluded that the ores fall into two principal classes: (1) Those formed by normal weathering processes, and (2) those formed by migration and rearrangement of the iron minerals during regional metamorphism.

Iron-ore producers looked for safer mining methods and more efficient equipment. A mining company on the Mesabi Range began testing a 55-ton-payload diesel-electric truck that had power transmitted to each wheel by an integrated electric-motor gear drive. The truck was designed to negotiate 15-percent grades at speeds greater than the conventional diesel-powered trucks. If the test proves successful, this type of truck may have a marked influence on iron-ore open-pit mining methods.[33]

A safer, more efficient way of undercutting was developed at the Cleveland-Cliffs' Iron Company Mather "A" mine at Ishpeming, Mich.[34] Iron-ore blocks at the Mather "A" were developed for caving to the point of undercut by the conventional systematic arrangement of draw drifts and crosscuts, and miners using the new system then developed the undercuts in safety from finished and supported draw drifts.

Beneficiation research was stimulated by a "semi-taconite" law, enacted by the State of Minnesota, which permitted preferential tax levies on iron-ore companies producing from low-grade, altered-iron formations. Semitaconite was identified as iron-bearing material, in which iron oxide is finely disseminated in particles less than 20-mesh, that is not merchantable in its natural state and cannot be made merchantable by simple beneficiation methods.

Simple beneficiation was defined as involving only crushing, washing, and drying; jig, heavy-medium, spiral, or cyclone concentration; or any combination thereof. Therefore, investigators again became interested in washing and heavy-medium separation followed by a reducing roast and magnetic concentration. This method had long been proposed as a classic process for treating the low-grade Lake Superior ores, but heretofore it had not been seriously investigated because it was deemed by concerns operating in the district too expensive under the prevailing iron-ore tax structure.

Rotary scrubbers were added to several iron-ore heavy-medium beneficiation plants on the Mesabi Range. The scrubbers were essentially ball mills without grinding elements. They proved their worth in reducing medium viscosity problems and in removing loosely-bonded siliceous material to produce high-grade medium concentrates.[35]

---

[32] Park, C. F., Jr., The Origin of Hard Hematite in Itabirite: Economic Geology, vol. 54, No. 4, June–July 1959, pp. 573–587.

[33] Mining World, Electric Truck Slated for Delivery to Iron Range: Vol. 21, No. 13, December 1959, p. 51.

[34] Hakala, O. W., Undercutting From Draw Drift Pays Off at Cleveland Cliffs' Mather "A" Mine: Eng. Min. Jour., vol. 160, No. 12, December 1959, pp. 104–105.

[35] Erickson, S. E., Trends in Iron Ore Beneficiation: Skillings' Min. Rev., vol. 48, No. 28, Oct. 10, 1959, p. 4.

Atomized spheroidal material imported from West Germany was tested on a large scale for use as the medium in heavy-medium processes. Compared with conventional ground ferrosilicon, the spheroids gave higher operating specific gravity, less medium loss, and lower pumping costs. However, they were not proved equally applicable in all types of heavy-medium vessels.

Researchers at Minnesota University tested 40 fatty-acid collectors of different degrees of saturation in iron-ore laboratory flotation tests.[36] Saturated fractions of fish-oil fatty acids showed technical promise in floating iron oxide minerals from siliceous gangue. Conversely, the unsaturated fractions effectively floated calcium activated quartz and chert from the iron oxides.

The Bureau of Mines and St. Joseph Lead Co. developed a magnetic-separation flotation flowsheet for treating iron ore from the Pea Ridge deposit in Missouri to produce a high-grade iron concentrate with an apatite mineral byproduct. In some tests the apatite concentrate contained 71 percent tricalcium phosphate (bone phosphate of lime), which could be used as raw material for the fertilizer industry.[37]

Bureau of Mines laboratories continued mineral dressing studies of the southeastern brown ores and ferruginous sandstones in the Birmingham, Ala., district. Most of the work was on desliming processes and possible methods of removing phosphorus. The phosphorus-bearing mineral in most of the investigated ores was identified as collophanite, a hydrated calcium phosphate. A satisfactory process for removing it was not found.

The Allis-Chalmers Co. opened a one-fiftieth-scale agglomeration pilot plant at Carrollville, Wis., to study and demonstrate agglomerating techniques.[38] The plant was designed principally to process iron concentrates and featured a completely instrumented, double-pass, traveling-grate, rotary-kiln tempering system.

An ultra-high-pressure blast furnace was designed by engineers of Koppers Co., Inc. Theoretically, the furnace, having a hearth diameter of 28 feet and operating on beneficiated raw materials with a top pressure of 40 p.s.i., would produce 4,000 tons of hot metal per day.[39] The proposed top pressure was nearly four times that of any existing commercial blast furnace.

Natural gas injected directly into the smelting zone of the Bureau of Mines experimental blast furnace at Bruceton, Pa., increased metal production 30 percent and cut coke requirements 36 percent. Anthracite coal also was injected into the smelting zone as a partial substitute for coke. When 20 percent of the normal coke requirement was replaced with anthracite and the hot blast temperature was raised 30 percent, the rate of metal output in the experimental furnace was increased 21 percent.

---

[36] Cooke, S. R. B., Iwasaki, I., Choi, H. S., Effects of Structure and Unsaturation of Collector on Soap Flotation of Iron Ores: Min. Eng., vol. 11, No. 9, September 1959, pp. 920–927.

[37] Fine, M. M., and Frommer, D. W., Experiments in Concentrating Iron Ore From The Pea Ridge Deposit, Missouri: Min. Eng., vol. 11, No. 3, March 1959, pp. 325–328.

[38] Mining World, Agglomeration Tests Start at A–C Plant: Vol. 21, No. 11, October 1959, p. 35.

[39] Iron and Steel Engineer, Proposed Furnace Design Should Double Iron Output: Vol. 36, No. 11, November 1959, pp. 160, 163.

The Bureau's furnace was also used to study the possibility of producing high-alumina slag used in manufacturing refractory cement. Slag meeting the desired composition specification (47 to 52 percent Al_2O_3, 37 to 41 percent CaO, maximum 7.5 percent SiO_2, and maximum 2.5 percent combined MgO, TiO_2 and S) was produced using Surinam bauxite, selected iron ore, and limestone.

A study of research on the scientific aspects of blast-furnace operation conducted by the Bureau of Mines from 1918 to 1958, which was begun in 1958, was continued but not completed. Results of the study were to be published.

Direct-reduction processes were not applied commercially in the United States, despite the success of pilot-plant operations in 1958. However, the R–N, Strategic-Udy, and H-iron processes were moved closer to commercial application through negotiations with patent holders for licenses to use them.

A 200-ton-per-day sponge-iron plant at Monterrey, Mexico, which started operating in 1958 with natural gas as the reductant, apparently proved a commercial success, as the company began building facilities to increase the capacity by 500 tons per day.[40] The reduction process used at this plant is known as the HyL (Hojalata y Lamina). It was developed by engineers of M. W. Kellogg Co., who were first consulted to develop a system of gas re-forming. Sponge iron from a HyL plant can be melted in electric furnaces without undue difficulty using techniques developed at Monterrey.

Scientists of the Republic Steel Corp. made steel strip from iron ore, without melting, in direct-iron-reduction laboratory experiments.[41] They first purified the ore and reduced it to metallic iron powder which they rolled to produce a thick, "green" porous strip. Then, they passed this strip through a 2,200° F. reducing-atmosphere furnace to a series of rolls from which it emerged as a dense metallic material, indistinguishable from conventional strip rolled from low-carbon steel.

---

[40] Starratt, F. W., Sponge Iron by the HyL Process: Jour. Metals, vol. 11, No. 5, May 1959, pp. 315–318.

[41] Iron Age, Direct Reduction Moves Closer: Vol. 183, No. 26, June 25, 1959, p. 54.

Iron and Steel

By James C. O. Harris[1]

◆

Contents

THE IRON and steel industry experienced the longest steel strike in its history. Although consumers anticipated the strike and built up large stocks of steel, the 116-day work stoppage caused shortages in many industries. Workers were idled in the automotive, railroad, construction, and other fields, curtailing the output of many finished products.

Despite the strike, pig iron and steel productions were greater than in 1958. Pig-iron output totaled 60.2 million short tons, a 5.3-percent increase over 1958. Steel output by ingot producers was 93.4 million tons, up 9.6 percent. Steel castings made by independent steel foundries (1.4 million short tons) were 30.4 percent above 1958, and shipments of gray and malleable iron castings (13.2 million tons) increased 20 percent. As a result of a high ratio of scrap to pig iron (average 68 to 32) during the steel strike, the overall ratio increased. The ratio of scrap to pig iron in 1959 was 51 to 49, compared with 50 to 50 in 1958 and 49 to 51 in 1957.

At the end of 1959 blast- and steel-furnace capacities reached new peaks of 96.5 million and 148.6 million tons. Steelmaking capacity increased 0.9 million tons, compared with 6.9 million in 1958, and blast-furnace capacity increased 1.9 million tons, compared with 3.6 million in 1958. New steelmaking capacities, by type of process and gain or loss during 1959, in million tons, were: Open hearth, 126.6 (plus 0.1); electric, 14.4 (plus 0.9); oxygen, 4.2 (plus 0.1); and Bessemer, 3.4 (minus 0.2).

Advances in technology included increased unit blast-furnace output through the improved preparation of raw materials and the use of natural gas in the blast furnace. Algoma Steel Corp., Ltd., used iron-ore agglomerates to replace over 50 percent of the scrap used in its basic oxygen converters, without any apparent loss in metallic yield. At an experimental oxygen converter installation in Donawitz, Austria, the scrap charge was increased from 30 to 50 percent

---

[1] Commodity specialist.

TABLE 1.—Salient iron and steel statistics in the United States, in short tons

	1950–54 (average)	1955	1956	1957	1958	1959
Pig iron:						
Production	65, 777, 443	76, 848, 509	75, 030, 249	78, 404, 266	57, 154, 909	60, 210, 257
Shipments	65, 611, 366	77, 300, 681	75, 109, 714	76, 886, 551	56, 017, 037	61, 245, 263
Imports	626, 411	283, 559	326, 700	225, 387	209, 743	701, 775
Exports	11, 307	34, 989	269, 477	882, 342	103, 348	10, 444
Steel: [1]						
Production of ingots and castings:						
Open-hearth:						
Basic	88, 007, 971	104, 804, 570	102, 167, 989	101, 027, 725	75, 501, 789	81, 225, 013
Acid	607, 386	554, 847	672, 596	630, 051	377, 605	443, 984
Bessemer	3, 870, 598	3, 319, 517	3, 227, 997	2, 475, 138	1, 395, 985	1, 380, 283
Oxygen converter	(2)	307, 279	506, 338	611, 508	1, 323, 361	1, 864, 338
Electric [3]	6, 539, 112	8, 049, 872	8, 641, 229	7, 970, 574	6, 656, 145	8, 532, 514
Total	99, 025, 067	117, 036, 085	115, 216, 149	112, 714, 996	85, 254, 885	93, 446, 132
Capacity, annual Jan. 1	110, 817, 600	125, 828, 310	128, 363, 090	133, 459, 150	140, 742, 570	147, 633, 670
Percent of capacity	89. 4	93. 0	89. 8	84. 5	60. 6	63. 3
Production of alloy steel:						
Stainless	923, 064	1, 222, 316	1, 255, 725	1, 046, 919	895, 629	1, 130, 972
Other	8, 147, 036	9, 437, 775	9, 072, 343	7, 864, 904	5, 768, 560	7, 776, 511
Total	9, 070, 100	10, 660, 091	10, 328, 068	8, 911, 823	6, 664, 189	8, 907, 483
Shipments of steel products:						
For domestic consumption	69, 730, 755	81, 134, 367	79, 628, 741	75, 325, 782	57, 485, 284	67, 968, 448
For export	2, 763, 140	3, 583, 077	3, 622, 427	4, 568, 795	2, 429, 149	1, 408, 619
Total	72, 493, 895	84, 717, 444	83, 251, 168	79, 894, 577	59, 914, 433	69, 377, 067

[1] American Iron and Steel Institute.
[2] Data not available,
[3] Includes a very small quantity of crucible steel.

by the addition of coke breeze. Ford Motor Company made a low-alloy steel with an ultimate strength of 500,000 p.s.i. by heavy mechanical working between 800° and 1,050° F.

Shipments of steel in 1959 including exports totaled 69.4 million tons, compared with 59.9 million in 1958 and 79.9 million in 1957. Although domestic shipments increased 10.5 million tons, the receipts of several consuming industries decreased slightly. The automotive industry continued to be the largest consumer, receiving 14.2 million tons or 21 percent of the domestic shipments (40.4 percent more than in 1958). Steel exports totaled 1.4 million tons, compared with 2.4 million in 1958.

Weekly hours per employee in the steel industry averaged 39.3, compared with 37.5 in 1958. The average number of employees was 417,000 compared with 437,000 in 1958, and the average hourly wage was $3.08 compared with $2.88 in 1958.

The average composite price of finished steel, as published by Iron Age, was 6.20 cents a pound compared with 6.06 cents in 1958.

PRODUCTION AND SHIPMENTS OF PIG IRON

U.S. production of pig iron, exclusive of ferroalloys, was 5.3 percent above 1958 but 8.5 percent below the 1950–54 average. Except for January and February and the months affected by the steel strike, blast furnaces operated above 90 percent of capacity. Record monthly tonnages of more than 7 million were produced in March–June and December. During the steel strike, blast furnaces operated at 44.9 percent of capacity in July, 11.8 to 12.7 percent for August–October, and 54.3 percent in November. The average operating rate for the year was 64.2 percent of capacity. Pig-iron production increased in 11 of the 17 States listed in table 2. Pennsylvania, Ohio, Indiana, and Illinois were the leading producing States and supplied 25, 19, 10, and 9 percent, respectively, of the pig iron, compared with 25, 17, 14, and 7 percent in 1958.

Blast furnaces also produced 25.6 million short tons of blast-furnace slag, or 849 pounds per ton of pig iron (887 pounds in 1958 and 1,040 in 1957); 5 million tons of flue dust was recovered, or 166 pounds per ton of pig iron (185 pounds in 1958).

The number of blast furnaces in the United States decreased from 266 to 263; 2 were taken out of operation at Clairton, Pa., by United States Steel Corp. and 1 by Bethlehem Steel Corp., at Johnstown, Pa. Despite the resulting loss of 646,300 tons of pig-iron capacity, overall blast-furnace capacity increased 1.9 million tons. The entire increase

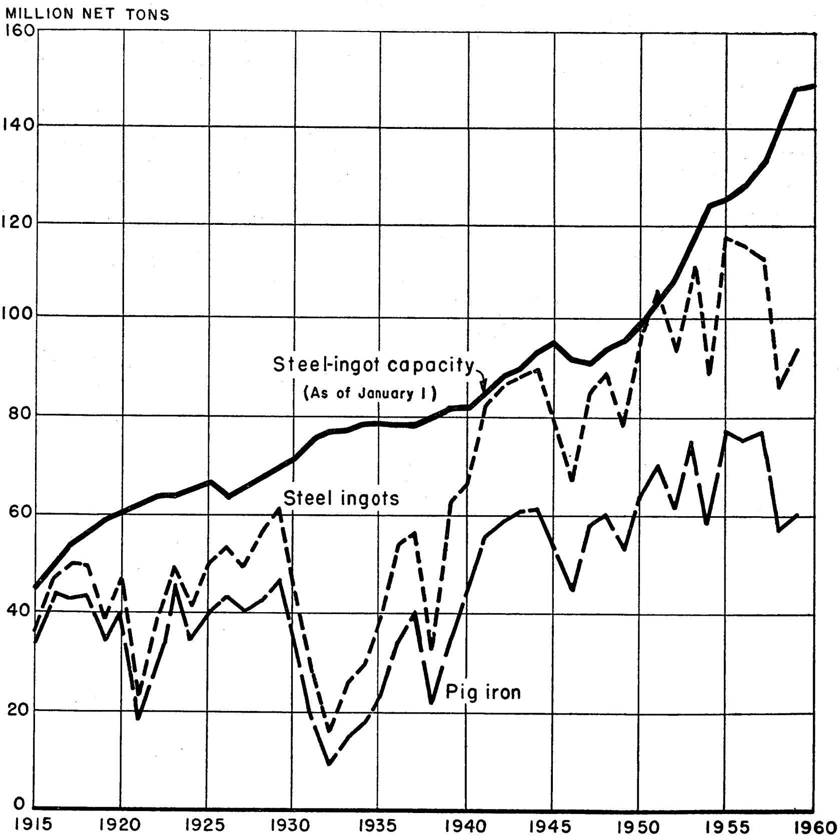

FIGURE 1.—Trends in production of pig iron and steel ingots and steel-ingot capacity in the United States, 1915–59.

was attributed to technological advances; no enlargement of furnaces was reported. United States Steel Corp., Republic Steel Corp., Ford Motor Co., Armco Steel Corp., and McLouth Steel Corp. accounted for 75 percent of the increase.

Shipments of pig iron (including on-site transfers) were 7.6 percent above 1958. As over 90 percent of all pig iron made in the United States was used in the molten state for making steel ingots, castings, and iron castings, the values of pig iron shown in tables 2 and 4 are largely estimated and do not agree with prices published in trade journals.

Metalliferous Materials Used.—The production of pig iron, excluding coke and fluxes, required 100.2 million short tons of iron, manganiferous ores, and agglomerates; 6.5 million tons of scrap; 0.2 million tons of flue dust; and 3.3 million tons of miscellaneous materials—1.819 tons of material per ton of pig iron made. The scrap charge consisted of 2,566,288 tons of home and purchased scrap, 133,430 tons of offgrade pig iron, and 676,756 tons of slag scrap. Consumption of miscellaneous materials included 3 million tons of mill cinder and scale, 3.4 million tons of open-hearth and Bessemer slag, 36,174 tons of other metalliferous materials, and 148,642 tons of nonmetalliferous materials. Net totals shown in table 6 were computed by deducting 5 million tons of flue dust recovered and 700,000 tons of scrap produced at blast furnaces.

The agglomerate charge consisted of 34,721,122 tons of sinter, 7,601,491 tons of pellets, 233,276 tons of nodules, 67,823 tons of briquets, and 801,231 tons of other agglomerates; 1,675,430 tons came from foreign sources. Canada, Venezuela, Chile, and Peru supplied 42, 38, 11, and 9 percent, respectively, of foreign iron and manganiferous ores used in blast furnaces. According to the American Iron and Steel Institute (AISI), 4.5 million cubic feet of oxygen was used at blast-furnace plants, compared with 5.9 million in 1958.

TABLE 2.—Pig iron produced and shipped in the United States, by States

State	Produced		Shipped from furnaces			
	1958	1959	1958		1959	
	Short tons		Short tons	Value (thousands)	Short tons	Value (thousands)
Alabama	3, 414, 901	3, 658, 287	3. 411, 954	$188, 150	3, 634, 322	$206, 449
Illinois	4, 200, 153	5, 267, 526	4, 217, 898	258, 661	5, 327, 003	320, 243
Indiana	7, 773, 794	6, 630, 339	7, 757, 011	453, 049	6, 635, 598	390, 329
Ohio	9, 562, 739	11, 563, 896	9, 609, 594	556, 662	11, 858, 775	705, 553
Pennsylvania	14, 502, 484	15, 133, 520	14, 348, 322	869, 097	15, 593, 140	933, 035
California Colorado Utah	3, 341, 253	3, 067, 238	3, 291, 070	189, 352	3, 120, 466	188, 703
Kentucky Tennessee Texas	1, 581, 311	1, 463, 396	1, 622, 598	87, 602	1, 446, 051	79, 213
Maryland West Virginia	6, 086, 534	5, 718, 573	6, 044, 353	391, 937	5, 754, 911	348, 224
Michigan Minnesota	3, 316, 851	4, 048, 867	3, 274, 239	182, 647	4, 108, 647	232, 302
New York Massachusetts	3, 374, 889	3, 658, 615	3, 340, 898	215, 151	3, 766, 350	229, 875
Total	57, 154, 909	60, 210, 257	56, 917, 937	3, 392, 308	61, 245, 263	3, 633, 926

TABLE 3.—Foreign iron ore and manganiferous iron ore consumed in manufacturing pig iron in the United States, by sources of ore, in short tons

Source	1958	1959	Source	1958	1959
Africa	34,547	(1)	Peru	814,328	1,132,643
Brazil	(1)	59,399	Venezuela	4,542,104	4,861,766
Canada	4,795,894	5,438,401	Other countries	9,039	63,476
Chile	593,829	1,405,884			
Mexico	107,456	(1)	Total	10,897,197	12,961,569

[1] Included with "Other countries."

TABLE 4.—Pig iron shipped from blast furnaces in the United States, by grades [1]

Grade	1958			1959		
	Short tons	Value		Short tons	Value	
		Total (thousands)	Average a ton		Total (thousands)	Average a ton
Foundry	1,619,453	$92,387	$57.05	1,854,321	$111,438	$60.10
Basic	47,674,412	2,847,545	59.73	52,735,479	3,118,433	59.13
Bessemer	3,701,059	218,973	59.16	3,136,915	186,950	59.60
Low-phosphorus	1,363,387	78,283	57.42	394,905	24,872	62.98
Malleable	2,302,762	140,629	61.07	2,827,592	174,812	61.82
All other (not ferroalloys)	256,864	14,491	56.42	296,051	17,421	58.84
Total	56,917,937	3,392,308	59.60	61,245,263	3,633,926	59.33

[1] Includes pig iron transferred directly to steel furnaces at same site.

TABLE 5.—Number of blast furnaces (including ferroalloy blast furnaces) in the United States

[American Iron and Steel Institute]

State	Jan. 1, 1959			Jan. 1, 1960		
	In blast	Out of blast	Total	In blast	Out of blast	Total
Alabama	13	9	22	16	6	22
California	3	1	4	2	2	4
Colorado	3	1	4	4	----	4
Illinois	15	7	22	21	1	22
Indiana	22	1	23	21	2	23
Kentucky	2	1	3	2	1	3
Maryland	7	3	10	9	1	10
Massachusetts	1	----	1	----	1	1
Michigan	8	1	9	8	1	9
Minnesota	3	----	3	2	1	3
New York	11	6	17	15	2	17
Ohio	35	17	52	46	6	52
Pennsylvania	54	25	79	70	6	76
Tennessee	1	2	3	1	2	3
Texas	2	----	2	2	----	2
Utah	4	1	5	5	----	5
Virginia	1	1	2	1	1	2
West Virginia	4	1	5	4	1	5
Total	189	77	266	229	34	263

TABLE 6.—Iron ore and other metallic materials, coke, and fluxes consumed and pig iron produced in the United States, by States, in short tons

State	Metalliferous materials consumed							Net coke	Fluxes	Pig iron produced	Metalliferous materials consumed per ton of pig iron made				Coke and fluxes consumed per ton of pig iron	
	Iron and manganiferous ores		Agglomerates	Net ores and agglomerates [1]	Net scrap [2]	Miscellaneous [3]	Net total				Net ores and agglomerates [1]	Net scrap [2]	Miscellaneous [3]	Total	Net coke	Fluxes
	Domestic	Foreign														
1958																
Alabama	4, 534, 478	374, 600	2, 146, 754	6, 743, 410	192, 210	146, 966	7, 082, 586	3, 229, 665	1, 023, 042	3, 414, 901	1. 975	0. 056	0. 043	2. 074	0. 946	0. 300
Illinois	5, 391, 397	20, 304	1, 686, 385	6, 640, 345	219, 755	565, 076	7, 425, 176	3, 376, 176	1, 173, 797	4, 200, 153	1. 581	. 052	. 135	1. 768	. 804	. 279
Indiana	10, 329, 382	241, 674	2. 957, 005	12, 606, 964	121, 112	1, 045, 729	13, 773, 805	6, 103, 794	2, 281, 182	7, 773, 794	1. 622	. 015	. 135	1. 772	. 785	. 293
Ohio	6, 990, 217	2, 199, 395	6, 095, 204	14, 659, 746	494, 086	1, 247, 330	16, 401, 162	7, 715, 347	2, 979, 320	9, 562, 739	1. 533	. 052	. 130	1. 715	. 807	. 312
Pennsylvania	9, 908, 844	3, 708, 069	9, 650, 162	22, 042, 168	698, 116	1, 994, 660	24, 734, 944	11, 652, 032	4, 612, 568	14, 502, 484	1. 520	. 048	. 138	1. 706	. 803	. 318
California Colorado Utah	(4)	(4)	2, 595, 681	6, 033, 467	55, 568	128, 562	6, 217, 597	2, 465, 909	685, 351	3, 341, 253	1. 806	. 017	. 038	1. 861	. 738	. 205
Kentucky Tennessee Texas	582, 773	447, 691	1, 399, 195	2, 376, 940	104, 862	240, 096	2, 721, 898	1, 211, 445	531, 436	1, 581, 311	1. 503	. 066	. 152	1. 721	. 766	. 336
Maryland West Virginia	(4)	(4)	5, 115, 993	9, 287, 947	99, 258	635, 214	10, 022, 419	4, 472, 274	1, 402, 635	6, 086, 534	1. 526	. 016	. 105	1. 647	. 735	. 230
Michigan Minnesota	(4)	(4)	2, 190, 762	5, 843, 919	30, 522	163, 191	6, 037, 632	2, 836, 978	1, 128, 906	3, 316, 851	1. 762	. 009	. 049	1. 820	. 855	. 340
New York Massachusetts	2, 588, 131	438, 124	2, 749, 972	5, 411, 527	88, 613	339, 872	5, 840, 012	2, 712, 553	998, 004	3, 374, 889	1. 603	. 026	. 101	1. 730	. 804	. 296
Total	49. 224, 350	10, 897, 197	36, 587, 113	91, 646, 433	2, 104, 102	6, 506, 696	100, 257, 231	45, 776, 173	[5] 16, 816, 241	57, 154, 909	1. 603	. 037	. 114	1. 754	. 801	. 294
1959																
Alabama	4, 320, 268	1, 264, 452	1, 879, 646	7, 213, 533	175, 336	66, 305	7, 455, 174	3, 458, 812	1, 095, 826	3, 658, 287	1. 972	. 048	. 018	2. 038	. 945	. 300
Illinois	5, 486, 398	183, 499	3, 310, 947	8, 489, 753	287, 081	580, 149	9, 356, 983	4, 169, 395	1, 407, 970	5, 267, 526	1. 612	. 054	. 110	1. 776	. 792	. 267
Indiana	6, 293, 213	142, 815	4, 887, 966	10, 648, 807	103, 761	887, 394	11, 639, 962	5, 057, 707	1, 644, 956	6, 630, 339	1. 606	. 016	. 134	1. 756	. 763	. 248
Ohio	7, 678. 017	2, 867, 409	7, 653, 380	17, 352, 067	746, 090	1, 442, 566	19, 540, 723	9, 097, 557	3, 330, 416	11, 563, 896	1. 501	. 064	. 125	1. 690	. 787	. 288
Pennsylvania	9, 673, 731	4, 162, 644	10, 094, 926	22, 703, 314	866, 582	2, 046, 853	25, 616, 749	11, 936, 579	4, 194, 137	15, 133, 520	1. 500	. 057	. 135	1, 692	. 789	. 277
California Colorado Utah	(4)	(4)	2, 398, 021	5, 294, 686	77, 899	69, 485	5, 442, 070	2, 277, 526	584, 910	3, 067, 238	1. 726	. 025	. 023	1. 774	. 743	. 191

Kentucky Tennessee Texas	611, 287	263, 130	1, 301, 579	2, 220, 891	70, 381	173, 329	2, 464, 601	1, 155, 685	470, 555	1, 463, 396	1. 518	. 048	. 118	1. 684	. 790	. 322
Maryland West Virginia	([4])	([4])	5, 335, 565	8, 701, 300	154, 195	602, 378	9, 457, 873	4, 165, 544	1, 076, 041	5, 718, 573	1. 522	. 027	. 105	1. 654	. 728	. 188
Michigan Minnesota	([4])	([4])	3, 527, 364	6, 838, 548	60, 993	208, 915	7, 108, 456	3, 277, 228	1, 199, 156	4, 048, 867	1. 689	. 015	. 052	1. 756	. 809	. 296
New York Massachusetts	2, 595, 593	560, 496	3, 035, 549	5, 900, 168	166, 279	370, 782	6, 437, 229	2, 964, 032	1, 156, 530	3, 658, 615	1. 613	. 045	. 101	1. 759	. 810	. 316
Total	43, 826, 061	12, 961, 569	43, 424, 943	95, 363, 067	2, 708, 597	6, 448, 156	104, 519, 820	47, 560, 065	[6] 16, 160, 497	60, 210, 257	1. 584	. 045	. 107	1. 736	. 790	. 268

---

[1] Net ores and agglomerates=ores+agglomerates+flue dust used—flue dust recovered.

[2] Excludes home scrap produced at blast furnaces.

[3] Does not include recycled material.

[4] Included in total.

[5] Excludes 1,761,527 tons of limestone used in agglomerate production at or near steel plants and an unknown quantity of limestone used in making agglomerates at mines.

[6] Fluxes consisted of 11,846,103 tons of limestone and 4,314,394 tons of dolomite, excluding 1,975,121 tons of limestone and 1,197,652 tons of dolomite used in agglomerate production at or near steel plants and an unknown quantity used in making agglomerates at mines.

PRODUCTION AND SHIPMENTS OF STEEL

Domestic steel production was 93.4 million short tons or 63.3 percent of capacity; the AISI index was 111.6 (1947–49=100). The corresponding figures for 1958 were 85.3, 60.6, and 101.8, respectively. Except for January, February, and the months affected by the steel strike, record or near record tonnages were produced. A record, 11,989,000 tons, was produced in December, and outputs in March, April, and May exceeded the previous record of 11,049,000 tons produced in October 1956.

The percentages of steel made by the several processes were as follows: Open hearth, 87.4; electric, 9.1; basic oxygen converter, 2.0; and Bessemer, 1.5. Corresponding figures for 1958 were 89.0, 7.8, 1.6, and 1.6, respectively. Pennsylvania led in steel production and Ohio, Indiana, and Illinois ranked second, third, and fourth, supplying 25, 19, 12, and 9 percent, respectively, compared with 24, 16, 15, and 8 percent in 1958.

New steelmaking capacities by type of process at yearend, in millions of short tons, were: Open hearth, 126.6; electric, 14.4; oxygen converter, 4.2; and Bessemer, 3.4. Electric-furnace capacity increased 900,000 tons, and Bessemer capacity decreased 200,000 tons. The combined capacity of open hearths and oxygen converters increased 200,000 million tons. Figures for steelmaking capacity represent net-steel capacity after the producers deducted an average of 8.7 percent for operating time lost for rebuilding, relining, repairing, and holiday shutdowns (AISI). Steel casting output by independent steel foundries, not included in the production data, totaled 1,366,328 short tons.

Expansion included three electric-furnace works at Borg-Warner Corp., Calumet Steel Div., Chicago Heights, Ill.; Ceco Steel Products Corp., Lemont, Ill.; and H. M. Harper Co., Morton Grove, Ill. New oxygen steelmaking facilities planned or under construction included converters at Jones & Laughlin Steel Corp.'s Cleveland works and Colorado Fuel and Iron Corp.'s Pueblo works. Detroit Steel Corp. and Granite City Steel Co. equipped open-hearth furnaces for oxygen lancing. Although the number of open-hearth furnaces decreased from 920 to 906, capacity increased through enlargement, modernization, and advancements in technology. Several plate, hot and cold strip, and blooming and roughing mills were under construction.

Table 10 shows that shipments of steel products increased 9.5 million tons. All categories or components of categories increased, except construction, including maintenance (rail transportation and all other), shipbuilding and marine equipment, containers (cans and closures, barrels, drums, and shipping pails), and ordnance and other military. The greatest increases were in the automotive and warehouses and distributors industries.

Alloy Steel.[2]—Domestic alloy-steel production was 8,907,483 short tons—8,857,847 tons of ingots and 49,636 tons of castings—an increase

---

[2] The Bureau of Mines uses the American Iron and Steel Institute specifications for alloy steels, which include stainless and any other steel containing one or more of the following elements in the designated percentages: Manganese in excess of 1.65 percent, silicon in excess of 0.60 percent, and copper in excess of 0.60 percent. It also includes steel containing the following elements in any quantity specified or known to have been

of 34 percent over 1958. Alloy steel supplied 9.5 percent of the steel output, compared with 7.8 percent in 1958.

Stainless-steel ingot production (12.7 percent of the total alloy-steel output) was 1,128,518 tons, 26.4 percent above 1958 and 7.3 percent above 1957. The production of austenitic stainless steel AISI 300 (nickel-bearing) and 200 series (manganese-nickel-bearing), representing 63.5 percent of stainless-steel production, was 28.4 percent above 1958; output of ferritic and martensitic, straight chromium types, AISI 400 series, increased 24.6 percent. Production of AISI 200 series (28,170 tons) decreased 4.9 percent. The output of type 501, 502, and other high-chromium, heat-resisting steels, included in the stainless-steel-production figure, decreased 0.8 percent.

Output of all grades of carbon steel increased.

Production of all grades of alloy steel, other than stainless, increased 35 percent. Production of chromium steels (1.5 million tons) increased 52.3 percent, nickel-chromium-molybdenum steels (1.3 million tons) 34.3 percent, chromium-molybdenum steels (800,000 tons) 29.8 percent, and high-strength steels (800,000 tons) 24.5 percent.

The percentages of alloy steel produced in the basic open hearth, acid open hearth, and electric furnaces were 58, 1, and 41 percent, respectively, compared with 59, 1, and 40 percent in 1958.

Metalliferous and Other Materials Used in Steelmaking.—Pig iron and scrap consumed in steelmaking furnaces totaled 104.5 million short tons; the percentage of each was 52 and 48, respectively, compared with 54 and 46 in 1958. Consumption of foreign iron ore increased and was the second highest quantity ever used in steel furnaces. The principal foreign sources of iron ore were: Chile, 50 percent; Brazil, 19 percent; Liberia, 13 percent; and Venezuela, 11 percent. According to AISI, other materials used in steelmaking, excluding inde-

TABLE 7.—Steel capacity, production, and percentage of operations, in the United States, in thousand short tons[1]

[American Iron and Steel Institute]

Year	Annual capacity, Jan. 1	Production					
		Open hearth	Bessemer	Oxygen converter	Electric[2]	Total	Percent of capacity
1950–54 (average)	110,818	88,615	3,871	(3)	6,539	99,025	89.4
1955	125,828	105,359	3,320	307	8,050	117,036	93.0
1956	128,363	102,841	3,228	506	8,641	115,216	89.8
1957	133,459	101,658	2,475	611	7,971	112,715	84.5
1958	140,743	75,880	1,396	1,323	6,656	85,255	60.6
1959	147,634	81,669	1,380	1,864	8,533	93,446	63.3

[1] Includes only that steel for castings produced in foundries operated by companies manufacturing steel ingots. Omits about 2 percent of total steel production.

[2] Includes a very small quantity of crucible steel.

[3] Data not available.

---

added to obtain a desired alloying effect: Aluminum, boron, chromium, cobalt, columbium, molybdenum, nickel, titanium, tungsten, vanadium, zirconium, and other alloying elements.

Stainless steel includes all grades of steel that contain 10 percent or more of chromium with or without other alloys or a minimum combined content of 18 percent of chromium and other alloys. Valve or bearing steels, high-temperature alloys, or electrical grades with analyses meeting the definition for stainless steels are included. All tool-steel grades are excluded.

Heat-resisting steel includes all steel containing 4 percent or more but less than 10 percent of chromium (excluding tool-steel grades).

pendent foundries, included 5.1 million tons of limestone, 1.3 million tons of lime, 202,000 tons of fluorspar, and 284,778 tons of other fluxes. Oxygen consumption at steel plants, exclusive of blast furnaces, reached a record 30 million cubic feet, used as follows: Steelmaking, 18.3 million cubic feet; conditioning, 8.1 million; scrap preparation, 1.3 million; other burning and welding, 1.3 million; and all other, 1 million.

TABLE 8.—Production of steel by States and processes,[1] in thousand short tons

[American Iron and Steel Institute]

State	Open hearth	Bessemer	Basic oxygen process	Electric	Total
New York	4,526	----------	----------	124	4,650
Pennsylvania	21,054	(2)	(2)	[3] 1,576	23,456
Rhode Island, Connecticut, New Jersey, Delaware, and Maryland	5,871	----------	----------	169	6,040
Virginia, West Virginia, Georgia, Florida	(2)	----------	----------	(2)	3,393
Kentucky	(2)	----------	----------	(2)	1,178
Alabama, Tennessee, and Mississippi	(2)	----------	----------	(2)	3,169
Ohio	14,572	(2)	----------	(2)	17,663
Indiana	(2)	----------	----------	(2)	11,610
Illinois	6,916	----------	(2)	(2)	8,175
Michigan	(2)	----------	(2)	773	5,637
Minnesota, Missouri, Oklahoma, and Texas	2,206	----------	----------	702	2,908
Arizona, Colorado, Utah, Washington, and Oregon	(2)	----------	----------	(2)	2,958
California	1,766	----------	(2)	(2)	2,609
Total: 1959	81,669	1,380	1,864	8,533	93,446
1958	75,880	1,396	1,323	6,656	85,255
1957	101,658	2,475	611	7,971	112,715
1956	102,841	3,228	506	8,641	115,216
1955	105,359	3,320	307	8,050	117,036

[1] Includes only that steel for castings produced in foundries operated by companies manufacturing steel ingots. Omits about 2 percent of total steel production.
[2] Figure withheld to avoid disclosing individual company confidential data.
[3] Includes production of crucible steel.

TABLE 9.—Steel electrically manufactured in the United States, in thousand short tons[1]

[American Iron and Steel Institute]

Year	Ingots	Castings	Total [2]	Year	Ingots	Castings	Total [2]
1950–54 (average)	6,457	82	6,539	1957	8,514	68	8,582
1955	8,307	50	8,357	1958	7,929	51	7,980
1956	9,090	57	9,147	1959	8 477	56	8,533

[1] Includes only that steel for castings produced in foundries operated by companies manufacturing steel ingots. See table 7.
[2] Includes a very small quantity of crucible steel and, for 1954–58, oxygen converter steel.

TABLE 10.—Shipments of steel products by market classifications, all grades including carbon, alloy, and stainless, in thousand short tons

[American Iron and Steel Institute]

Market classification	1958		1959	
	Shipments	Percent of total	Shipments	Percent of total
Steel for converting and processing [1]	2,855	5.0	3,133	4.6
Forgings	767	1.3	957	1.4
Bolts, nuts, rivets, and screws	879	1.5	1,071	1.6
Warehouses and distributors:				
Oil and gas industry	1,004	1.8	1,890	2.8
All other	9,898	17.2	11,159	16.4
Total	10,902	19.0	13,049	19.2
Construction, including maintenance:				
Rail transportation	43	.1	40	.1
Oil and gas	2,100	3.7	2,262	3.3
All other	6,580	11.4	6,212	9.1
Total	8,723	15.2	8,514	12.5
Contractors' products	3,467	6.0	3,573	5.3
Automotive:				
Passenger cars, trucks, parts, etc	9,850	17.1	13,792	20.3
Forgings	275	.5	422	.6
Total	10,125	17.6	14,214	20.9
Rail transportation:				
Railroad rails, trackwork, and equipment	584	1.0	763	1.1
Freight cars, passenger cars, and locomotives	867	1.5	1,572	2.3
Street railways and rapid-transit systems	21	.1	22	----------
Total	1,472	2.6	2,357	3.4
Shipbuilding and marine equipment	797	1.4	642	1.0
Aircraft	62	.1	71	.1
Oil and gas drilling	306	.5	541	.8
Mining, quarrying, and lumbering	179	.3	235	.3
Agriculture:				
Agricultural machinery	903	1.6	964	1.4
All other agricultural	290	.5	301	.5
Total	1,193	2.1	1,265	1.9
Machinery, industrial equipment, and tools	3,181	5.5	4,158	6.1
Electrical machinery and equipment	1,772	3.1	2,052	3.0
Appliances, utensils, and cutlery	1,590	2.8	1,829	2.7
Other domestic and commercial equipment	1,716	3.0	1,833	2.7
Containers:				
Cans and closures	5,252	9.1	5,010	7.4
Barrels, drums, and shipping pails	800	1.4	773	1.1
All other containers	516	.9	535	.8
Total	6,568	11.4	6,318	9.3
Ordnance and other military	239	.4	127	.2
Shipments of nonreporting companies	692	1.2	2,029	3.0
Total domestic	57,485	100.0	67,968	100.0
Export	2,429	----------	1,409	----------
Total shipments	59,914	----------	69,377	----------

[1] Net total after deducting shipments to reporting companies for conversion or resale.

TABLE 11.—Alloy-steel ingots and castings manfactured in the United States, by processes, in thousand short tons[1]

[American Iron and Steel Institute]

Process	1950–54 (average)	1955	1956	1957	1958	1959
Open hearth:						
Basic	5,852	6,735	6,289	5,746	[2] 3,926	5,144
Acid	179	186	201	170	[2] 85	89
Electric [3]	3,039	3,739	3,838	2,996	2,653	3,674
Total	9,070	10,660	10,328	8,912	6,664	8,907

[1] Includes only that steel for castings produced in foundries operated by companies manufacturing steel ingots. See table 7.

[2] Revised figure.

[3] Includes a very small quantity of crucible steel and, for 1954–58, oxygen converter steel.

CONSUMPTION OF PIG IRON

Although all the States used some pig iron, 92 percent was consumed in steelmaking centers in the East North Central, Middle Atlantic, and East South Central States. Pennsylvania (the leading consumer) used 25 percent of the total; Ohio (second), 19 percent; and Indiana (third), 12 percent; corresponding figures for 1958 were 25, 16, and 14 percent respectively.

TABLE 12.—Metalliferous materials consumed in steel furnaces in the United States, in short tons

Year	Iron ore		Sinter [1]	Pig iron	Ferro-alloys [2]	Iron and steel scrap
	Domestic	Foreign				
1950–54 (average)	3,516,024	2,708,794	1,517,454	57,801,845	1,434,000	53,112,304
1955	3,352,182	4,615,966	1,751,663	67,957,207	1,620,000	61,774,897
1956	3,398,359	4,741,062	1,516,936	66,437,573	1,630,000	62,276,019
1957	2,836,650	5,592,024	[3] 1,934,038	68,767,530	1,530,000	56,764,655
1958	2,092,340	4,741,751	[4] 1,260,763	51,299,102	1,115,000	43,023,625
1959	1,690,030	5,238,060	[5] 961,349	54,698,928	1,380,000	49,793,577

[1] Includes consumption of pig iron and scrap by ingot producers and iron and steel foundries.

[2] Includes ferromanganese, spiegeleisen, silicomanganese, manganese briquets, manganese metal, ferrosilicon, and ferrochromium alloys.

[3] Includes other agglomerates (nodules, pellets, etc.) and 106,602 tons of foreign origin.

[4] Includes 601,509 tons of sinter, 238,040 tons of pellets, 281,390 tons of nodules, and 139,824 tons of other agglomerates. (325,268 tons of foreign origin.)

[5] Includes 271,736 tons of sinter, 215,109 tons of pellets, 255,448 tons of nodules, 32,039 tons o fbriquets, and 87,017 tons of other agglomerates. (314,507 tons of foreign origin.)

TABLE 13.—Consumption of pig iron in the United States, by type of furnace

Type of furnace or equipment	1958		1959	
	Short tons	Percent of total	Short tons	Percent of total
Open hearth	48,407,537	84.5	51,250,472	83.0
Bessemer	2,635,906	4.6	1,482,885	2.4
Oxygen converter	(1)		1,574,261	2.6
Electric	[2] 255,659	.5	[3] 391,310	.6
Cupola	3,709,415	6.5	4,412,116	7.1
Air	189,672	.3	250,732	.4
Direct castings	2,064,147	3.6	2,411,415	3.9
Total	57,262,336	100.0	61,773,191	100.0

[1] Data not available.
[2] Includes a very small quantity of crucible steel and oxygen converter steel for 1958.
[3] Includes a small quantity of pig iron consumed in crucible furnaces.

TABLE 14.—Consumption of pig iron in the United States, by districts and States, in short tons

District and State	1958	1959
New England:		
Connecticut	27,310	34,047
Maine	5,447	4,195
New Hampshire		
Massachusetts	87,269	77,114
Rhode Island	33,706	45,792
Vermont	4,852	8,329
Total	158,584	169,477
Middle Atlantic:		
New Jersey	158,293	149,673
New York	2,702,089	2,988,093
Pennsylvania	14,355,285	15,489,188
Total	17,215,667	18,626,954
East North Central:		
Illinois	4,190,537	5,141,524
Indiana	7,960,282	7,296,402
Michigan	3,321,133	4,138,861
Ohio	9,446,795	11,574,983
Wisconsin	191,935	255,452
Total	25,110,682	28,407,222
West North Central:		
Iowa	71,767	93,718
Kansas	4,033	5,251
Nebraska		
Minnesota	405,532	432,814
North Dakota		
South Dakota		
Missouri	36,257	73,518
Total	517,589	605,301
South Atlantic:		
Delaware	4,133,280	3,554,242
District of Columbia		
Maryland		
Florida	13,737	13,850
Georgia		
South Atlantic—Con.		
North Carolina	21,793	24,732
South Carolina	13,116	17,846
Virginia	2,120,942	2,449,489
West Virginia		
Total	6,302,868	6,060,159
East South Central:		
Alabama	2,981,431	3,125,492
Kentucky	866,548	771,705
Mississippi		
Tennessee		
Total	3,847,979	3,897,197
West South Central:		
Arkansas	6,393	7,222
Louisiana		
Oklahoma		
Texas	773,124	768,110
Total	779,517	775,332
Mountain:		
Arizona	110	142
Nevada		
New Mexico		
Utah and Colorado	2,044,046	1,846,990
Montana	412	309
Idaho		
Wyoming		
Total	2,044,568	1,847,441
Pacific:		
California	1,280,159	1,379,104
Oregon	4,723	5,004
Washington		
Total	1,284,882	1,384,108
Total United States	57,262,336	61,773,191

PRICES

Pig iron and steel prices remained virtually constant during 1959. The weighted average annual price of pig iron, as published by Iron Age, was $59.29 per short ton, compared with $59.33 in 1958. The Iron Age composite price of finished steel for 1959 was 6.196 cents per pound, compared with 6.060 cents per pound in 1958.

TABLE 15.—Average value of pig iron at blast furnaces in the United States, by States, per short ton

State	1950–54 (average)	1955	1956	1957	1958	1959
Alabama	$44.31	$47.89	$50.23	$53.94	$55.14	$56.81
California Colorado Utah	49.40	53.82	50.67	57.44	57.53	60.47
Illinois	47.38	51.21	54.52	58.04	61.32	60.12
Indiana	47.41	50.79	53.09	58.33	58.41	58.82
New York	48.18	51.54	54.54	63.09	64.48	61.01
Ohio	46.84	49.35	52.42	55.88	57.93	59.50
Pennsylvania	48.03	51.30	55.01	59.25	62.45	59.84
Other States [1]	47.97	50.78	54.19	60.37	60.53	58.38
Average	47.49	50.68	53.58	58.43	59.60	59.33

[1] Comprises Kentucky, Maryland, Massachusetts, Michigan, Minnesota, Tennessee, Texas, and West Virginia.

TABLE 16.—Average prices of chief grades of pig iron, per short ton [1]

[Metal Statistics]

Month	Foundry pig iron at Birmingham furnaces		Foundry pig iron at Valley furnaces		Bessemer pig iron ar Valley furnaces		Basic pig iron at Valley furnaces	
	1958	1959	1958	1959	1958	1959	1958	1959
January–December	$55.80	$55.80	$59.38	$59.38	$59.82	$59.82	$58.93	$58.93

[1] Prices did not change during 1958 and 1959.

TABLE 17.—Free-on-board value of steel-mill products in the United States, in cents per pound [1]

	1958				1959			
	Carbon	Alloy	Stainless	Average	Carbon	Alloy	Stainless	Average
Ingots	4.570	8.834	50.076	16.001	4.432	9.135	27.629	5.688
Semifinished shapes and forms	5.673	10.135	39.627	6.508	5.912	10.410	40.388	6.724
Plates	6.468	14.651	62.093	7.265	6.333	12.606	61.850	7.114
Sheets and strips	7.095	14.121	51.183	8.131	7.146	14.341	46.678	8.261
Tin-mill products	8.930			8.930	9.176			9.176
Structural shapes and piling	6.268	8.521		6.288	6.406	8.079		6.424
Bars	7.502	13.658	64.902	8.882	7.752	13.836	63.526	9.406
Rails and railway-track material	7.360			7.360	7.779			7.779
Pipes and tubes	10.412	20.187	165.622	11.587	10.766	19.642	163.464	12.118
Wire and wire products	[2] 12.613	37.186	81.276	[2] 13.629	12.870	37.497	82.895	13.549
Other rolled and drawn products	[2] 10.018	43.370	60.820	[2] 15.312	9.460	43.810	69.493	8.432
Average total steel	[2] 7.768	14.437	59.325	[2] 8.643	7.894	14.223	54.387	8.857

[1] Computed from figures supplied by the U.S. Department of Commerce, Bureau of the Census. This table represents the weighted average value based on the quantity of each type of steel shipped, therefore, it reflects shifts in the distribution of the 3 classes of steel.

[2] Revised figure.

FOREIGN TRADE [3]

Lower priced foreign steels and spot shortages created by the steel strike were partly responsible for the importation of a record 4.6 million short tons of iron and steel products. Pig-iron imports were the highest since 1951.

Imports of iron and steel products were 154 percent above 1958 and 101 percent above 1951, the previous record year. Imports of all classes of products increased. Wire and wire products (1,282,185 short tons), concrete reinforcement bars (851,950), structural iron and steel (871,477), pipes and tubes (575,930), and boiler and other plates (381,945) furnished 86 percent of imports, excluding advanced manufacturers. Exports of iron and steel products dropped 39 percent and were the lowest since 1938.

TABLE 18.—Pig iron imported for consumption in the United States, by countries, in short tons

[Bureau of the Census]

Country	1950-54 (average)	1955	1956	1957	1958	1959
North America: Canada	242,637	260,741	303,121	221,166	182,128	437,095
South America:						
Brazil	6,787	----------	19,621	----------	2	----------
Chile	13,480	----------	----------	----------	----------	----------
Total	20,267	----------	19,621	----------	2	----------
Europe:						
Austria	30,067	----------	----------	----------	----------	----------
Belgium-Luxembourg	5,547	----------	----------	----------	----------	----------
Finland	34	----------	----------	----------	----------	10,253
France	15,061	----------	----------	----------	----------	----------
Germany [1]	121,594	----------	----------	34	13,933	[2] 43,336
Netherlands	76,349	1,232	112	----------	1,125	35,078
Norway	6,652	224	339	----------	334	168
Portugal	----------	----------	----------	----------	----------	4,395
Spain	15,128	3,000	----------	----------	7,867	78,499
Sweden	23,710	2,466	1,852	3,135	1,615	1,071
U.S.S.R.	----------	----------	----------	----------	----------	1,550
Other Europe	1,380	----------	----------	----------	----------	51
Total	295,522	6,922	2,303	3,169	24,874	174,401
Asia:						
India	12,291	11,217	336	----------	----------	56
Japan	----------	----------	----------	----------	----------	10,674
Turkey	7,442	----------	----------	----------	----------	----------
Total	19,733	11,217	336	----------	----------	10,730
Africa:						
Rhodesia and Nyasaland, Federation of [3]	1,710	241	----------	----------	----------	4,863
Union of South Africa	5,212	1,425	128	----------	----------	70,519
Total	6,922	1,666	128	----------	----------	75,382
Oceania: Australia	41,330	3,013	1,191	1,052	2,739	4,167
Grand total: Short tons	626,411	283,559	326,700	225,387	209,743	701,775
Value	$26,907,341	$14,563,612	$17,842,357	$13,527,813	[4] $12,026,015	$35,592,871

[1] Effective 1952 classified as West Germany.

[2] Includes 110 tons from East Germany.

[3] Classified as Southern Rhodesia through June 30, 1954; 1,562 short tons January through June 1954.

[4] Revised figure.

---

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

Exports of pig iron, 10,444 tons, valued at $549,324, were the lowest since 1936. Cuba received 75 percent of the exports. Pig-iron imports increased 235 percent and were the highest since 1951.

TABLE 19.—Major iron and steel products imported for consumption in the United States

[Bureau of the Census]

Products	1958		1959	
	Short tons	Value	Short tons	Value
Semimanufactures:				
Steel bars:				
Concrete reinforcement bars	[1] 473,705	[1] $35,015,218	851,950	$68,697,236
Solid and hollow, n.e.s	80,405	7,193,567	215,536	22,714,724
Hollow and hollow drill steel	674	193,400	1,697	578,891
Bar iron, iron slabs, blooms, or other forms	68	19,942	81	30,222
Wire rods, nail rods, and flat rods up to 6 inches in width	181,283	18,481,263	447,967	45,150,098
Boiler and other plate iron and steel, n.e.s	27,528	2,942,576	381,904	40,352,901
Steel ingots, blooms, and slabs; billets, solid and hollow	17,938	1,786,182	91,771	9,025,204
Die blocks or blanks, shafting, etc	300	111,621	1,263	361,395
Circular saw plates	36	31,255	41	51,670
Sheets of iron or steel, common or black and boiler or other plate iron or steel	4,660	517,586	178,188	27,805,179
Sheets and plates and steel, n.s.p.f	2,268	611,848	26,083	3,232,925
Tinplate, terneplate, and taggers' tin	57	26,003	66,989	12,949,433
Total	[1] 788,922	[1] 66,930,461	2,263,470	230,949,878
Manufactures:				
Structural iron and steel	304,127	35,406,108	871,477	90,480,017
Rails for railways	4,626	328,267	8,194	735,878
Rail braces, bars, fishplates, or splice bars and tie plates	175	20,060	650	61,201
Pipes and tubes:				
Cast-iron pipe and fittings	12,181	2,066,257	22,791	4,333,028
Other pipes and tubes	200,045	30,767,614	553,139	87,982,850
Wire:				
Barbed	59,253	7,951,961	78,287	10,251,360
Round wire, n.e.s	[1] 133,694	[1] 20,042,698	236,480	37,218,921
Telegraph, telephone, etc., except copper, covered with cotton jute, etc	1,424	736,127	2,875	1,082,778
Flat wire and iron and steel strips	30,472	7,386,783	80,579	16,267,399
Rope and strand	16,932	7,168,465	41,855	14,258,070
Galvanized fencing wire and wire fencing	39,825	5,744,792	79,040	11,373,461
Iron and steel used in card clothing	(2)	471,388	(2)	533,817
Hoop and band iron and steel, for baling	15,941	2,143,307	29,094	3,933,149
Hoop, band and strips, or scroll iron or steel, n.s.p.f	5,555	674,870	10,828	1,759,375
Nails	201,225	[1] 30,274,853	315,102	48,822,612
Castings and forgings, n.e.s	5,290	1,788,808	19,009	3,888,030
Total	[1] 1,030,765	[1] 152,972,358	2,349,400	332,981,946
Advanced manufactures:				
Bolts, nuts, and rivets	[1] 28,744	[1] 9,118,270	53,869	15,772,886
Chains and parts	3,699	2,533,711	6,998	4,465,750
Hardware, builders'		619,574		831,742
Hinges and hinge blanks		1,003,906		1,721,929
Screws (wholly or chiefly of iron or steel)		[1] 1,191,476		2,020,965
Tools		[1] 12,179,263		17,106,508
Other		222,465		289,586
Total		[1] 26,868,665		42,209,366
Grand total		[1] 246,771,484		606,141,190

[1] Revised figure.
[2] Weight not recorded.

TABLE 20.—Major iron and steel products exported from the United States

[Bureau of the Census]

Products	1958		1959	
	Short tons	Value	Short tons	Value
Semimanufactures:				
Steel ingots, blooms, billets, slabs, and sheet bars	28,001	$3,560,670	14,719	$2,261,733
Iron and steel bars and rods:				
Carbon-steel bars, hot-rolled, and iron bars	76,199	12,585,733	39,399	7,091,515
Concrete reinforcement bars	24,729	3,619,983	13,775	2,057,893
Other steel bars	22,170	7,377,157	13,917	5,551,294
Wire rods	16,711	2,380,484	4,189	464,651
Iron and steel plates, sheets, skelp, and strips:				
Plates, including boiler plate, not fabricated	248,709	39,112,479	65,585	13,649,810
Skelp iron and steel	79,614	9,990,415	15,742	1,915,143
Iron and steel sheets, galvanized	84,166	17,081,025	40,577	8,830,719
Steel sheets, black, ungalvanized	[1] 683,957	[1] 122,529,936	437,028	91,478,276
Strip, hoop, band, and scroll iron and steel:				
Cold-rolled	19,919	9,478,100	17,778	8,592,523
Hot-rolled	20,457	5,786,104	21,892	6,674,977
Tinplate and terneplate	371,630	65,376,290	368,355	62,954,269
Tinplate circles, cobbles, strip, and scroll shear butts	17,615	1,691,368	16,892	1,774,146
Total	[1] 1,693,877	[1] 300,569,744	1,069,848	213,296,949
Manufactures—steel-mill products:				
Structural iron and steel:				
Water, oil, gas, and other storage tanks (unlined), complete and knockdown material	41,110	14,490,092	30,206	11,745,510
Structural shapes:				
Not fabricated	[1] 291,990	40,816,934	225,958	29,594,976
Fabricated	112,687	40,879,147	57,704	18,426,091
Plates, sheets, fabricated, punched, or shaped	66,485	13,887,930	30,372	6,949,496
Metal lath	1,625	594,989	1,362	501,742
Frames, sashes, and sheet piling	14,899	3,518,299	14,918	2,832,062
Railway-track material:				
Rails for railways	[1] 121,143	[1] 14,912,584	61,356	7,393,938
Rail joints, splice bars, fishplates, and tie plates	40,439	8,558,110	20,429	3,958,268
Switches, frogs, and crossings	3,138	1,296,260	1,665	806,435
Railroad spikes	2,550	569,439	1,006	231,196
Railroad bolts, nuts, washers, and nut locks	1,063	482,229	416	227,215
Tubular products:				
Boiler tubes	13,024	[1] 8,138,445	6,298	3,932,547
Casing and line pipe	[1] 474,559	[1] 112,998,074	161,117	47,565,393
Seamless black and galvanized pipe and tubes, except casing, line and boiler, and other pipes and tubes	32,775	8,508,287	19,048	6,354,533
Welded black pipe	44,210	10,345,605	35,583	7,891,539
Welded galvanized pipe	4,470	1,139,776	2,396	690,057
Malleable-iron screwed pipe fittings	1,733	1,757,906	1,317	1,391,406
Cast-iron pressure pipe and fittings	17,737	3,621,782	15,485	2,920,187
Cast-iron soil pipe and fittings	10,269	2,199,020	11,439	2,252,625
Iron and steel pipe, fittings, and tubing, n.e.c.	58,527	[1] 43,422,422	28,661	13,495,969
Wire and manufactures:				
Barbed wire	1,179	239,049	625	119,078
Galvanized wire	5,894	1,736,098	5,311	1,507,682
Iron and steel wire, uncoated	17,993	5,588,495	12,925	4,563,915
Spring wire	1,470	892,530	1,921	1,100,147
Wire rope and strand	12,042	7,385,694	10,217	6,212,575
Woven-wire fencing and screen cloth	2,499	[2] 1,917,630	1,301	[2] 1,630,450
All other	24,835	11,797,929	19,038	10,510,034
Nails and bolts, iron and steel, n.e.c.:				
Wire nails, staples, and spikes	3,645	2,703,669	3,060	2,736,449
All other nails, staples, spikes, and tacks	1,341	841,936	1,034	666,763
Bolts, screws, nuts, rivets, and washers, n.e.c.	14,453	14,509,732	14,475	15,290,146
Castings and forgings: Iron and steel, including car wheels, tires, and axles	91,477	26,707,724	89,728	25,258,889
Total	[1] 1,531,261	[1] 406,466,816	886,371	238,757,313

See footnotes at end of table.

TABLE 20.—Major iron and steel products exported from the United States—Continued

[Bureau of the Census]

Products	1958		1959	
	Short tons	Value	Short tons	Value
Advanced manufactures:				
Buildings (prefabricated and knockdown)	------------	$7,141,606	------------	$15,111,272
Chains and parts	8,971	10,378,384	9,800	10,757,618
Construction material	8,313	6,053,079	6,065	4,661,866
Hardware and parts	------------	22,495,919	------------	23,739,298
House-heating boilers and radiators	------------	9,660,059	------------	9,135,741
Oil burners and parts	------------	8,035,405	------------	8,915,323
Plumbing fixtures and fittings	------------	[3] 5,402,902	------------	4,879,980
Tools	------------	[1] 48,299,806	------------	49,613,574
Utensils and parts (cooking, kitchen, and hospital)	1,160	3,833,850	958	3,218,988
Other	------------	34,771,002	------------	35,837,151
Total	------------	[1] 156,072,012	------------	165,870,811
Grand total	------------	[1] 863,108,572	------------	617,925,073

[1] Revised figure.

[2] Includes wire cloth as follows—1958: $1,088,675 (5,442,270 square feet); 1959: $1,103,761 (5,037,493 square feet).

[3] Revised to exclude other metal plumbing fixtures and fittings.

WORLD REVIEW

World production of pig iron, including ferroalloys, and steel reached a new peak with a 14-percent increase in pig iron and a 13-percent increase in steel. The United States, the European Coal and Steel Community, and the Soviet Union ranked first, second, and third in both pig-iron and steel production. The United States produced 25 percent of the pig iron and 28 percent of the steel, compared with 28 and 29 percent, respectively, in 1958 and 35 percent of both in 1957.

TABLE 21.—World production of pig iron (including ferroalloys), by countries,[1] in thousand short tons [2]

[Compiled by Pearl J. Thompson and Berenice B. Mitchell]

Country [1]	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada	2,745	3,405	3,808	3,923	3,172	4,311
Mexico	289	356	455	473	547	617
United States	67,837	79,263	77,670	80,920	58,867	62,135
Total	70,871	83,024	81,933	85,316	62,586	67,063
South America:						
Argentina	33	39	32	37	32	39
Brazil	952	1,198	1,291	1,400	1,513	[3] 1,540
Chile	267	282	406	421	336	320
Colombia	[4] 97	109	128	158	164	[3] 165
Total	1,349	1,628	1,857	2,016	2,045	[3] 2,064
Europe:						
Austria	1,275	1,660	1,915	2,161	2,004	2,024
Belgium	4,892	5,941	6,350	6,160	6,084	6,575
Bulgaria	[5] 8	9	11	62	93	[3] 100
Czechoslovakia	2,620	3,287	3,618	3,928	4,160	4,679
Denmark	43	61	62	65	49	64
Finland	94	126	114	142	111	106
France	9,766	12,198	12,831	13,310	13,381	13,763
Germany:						
East	823	1,672	1,735	1,840	1,957	2,090
West	12,614	18,168	19,375	20,236	18,363	20,275
Hungary	697	973	847	923	1,200	[3] 1,200
Italy	1,269	1,911	2,200	2,431	2,388	2,416
Luxembourg	3,143	3,401	3,655	3,713	3,621	3,793
Netherlands	600	739	730	773	1,011	1.259
Norway	280	392	388	624	575	672
Poland	2,208	3,430	3,865	4,059	4,259	4,822
Rumania	422	630	650	756	812	933
Saar	2,532	3,174	3,341	3,492	3,420	3,540
Spain	856	1,093	1,100	1,030	1,479	1,874
Sweden	1,084	1,375	1,555	1,701	1,559	1,548
Switzerland	42	60	45	50	[3] 40	[3] 50
U.S.S.R.[6]	27,230	36,720	39,410	40,830	43,700	47,400
United Kingdom	11,906	13,966	14,750	16,024	14,531	14,100
Yugoslavia	314	585	713	812	860	995
Total [6]	84,718	111,571	119,260	125,122	125,657	134,278
Asia:						
China	2,270	4,000	5,265	6,060	[7] 10,470	[7] 22,600
India	2,034	2,122	2,194	2,141	2,389	3,491
Japan	4,082	5,981	6,905	7,864	8,510	10,851
Korea, North	[3] 14	[3] 120	205	300	350	[3] 765
Taiwan (Formosa)	8	11	20	22	19	36
Thailand	6	2	4	4	6	8
Turkey	196	223	244	239	251	260
Total [6]	8,610	12,459	14,837	16,630	21,995	38,011
Africa:						
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	40	63	66	88	94	[3] 80
Union of South Africa	1,121	1,433	1,495	1,574	1,745	1,992
Total	1,161	1,496	1,561	1,662	1,839	2,072
Oceania: Australia	1,767	2,013	2,324	2,472	2,550	2,804
World total (estimate)	168,500	212,200	221,800	233,200	216,700	246,300

---

[1] Pig iron is also produced in Belgian Congo and Indonesia, but production is believed insufficient to affect the estimated world total.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Estimate.

[4] 1 year only, as 1954 was the first year of commercial production.

[5] Average for 1952–54.

[6] U.S.S.R. in Asia included with U.S.S.R. in Europe.

[7] Based on figures from Chinese sources. 1958 does not include approximately 4,000,000 tons of substandard iron produced at small plants. 1959 production probably includes pig iron obtained from reworking the low-grade product of 1958 and an unreported quantity (probably relatively small) of substandard iron from small plants, most of which were shut down early in the year.

TABLE 22.—World production of steel ingots and castings, by countries, in thousand short tons[1]

[Compiled by Pearl J. Thompson and Berenice B. Mitchell]

Country	1950-54 (average)	1955	1956	1957	1958	1959
North America:						
Canada	3,593	4,535	5,301	5,068	4,359	5,922
Mexico	559	838	969	1,136	1,144	1,442
United States [2]	99,025	117,036	115,216	112,715	85,255	93,446
Total	103,177	122,409	121,486	118,919	90,758	100,810
South America:						
Argentina [3]	165	240	[4] 340	[4] 400	270	240
Brazil	1,070	1,402	1,640	1,523	1,672	[3] 2,000
Chile	245	320	420	428	384	457
Colombia	7	85	99	126	133	120
Total	1,487	2,047	2,499	2,477	2,459	2,817
Europe:						
Austria	1,316	2,010	2,291	2,766	2,638	2,769
Belgium	5,148	6,504	7,035	6,917	6,626	7,096
Bulgaria	[5] 21	82	143	175	233	254
Czechoslovakia	4,182	4,932	5,381	5,695	6,074	6,724
Denmark	193	261	265	289	281	320
Finland	154	195	217	230	207	260
France	10,977	13,831	14,727	15,540	16,111	16,776
Germany:						
East	1,969	2,765	3,020	3,291	3,354	3,532
West	16,377	23,519	25,561	27,014	25,116	28,464
Greece	41	73	83	[3] 83	125	100
Hungary	1,506	1,796	1,571	1,521	1,793	1,939
Ireland [3]	22	33	33	28	31	44
Italy	3,674	5,947	6,512	7,481	6,913	7,454
Luxembourg	3,090	3,555	3,820	3,850	3,725	4,038
Netherlands	778	1,080	1,157	1,306	1,585	1,841
Norway	110	188	320	386	403	457
Poland	3,535	4,879	5,527	5,847	6,242	6,789
Rumania	714	844	859	952	1,030	1,027
Saar	2,825	3,489	3,719	3,791	3,814	3,983
Spain	1,055	1,427	1,365	1,526	1,734	2,150
Sweden	1,809	2,342	2,644	2,737	2,659	3,132
Switzerland [6]	162	183	188	247	256	[3] 275
U.S.S.R.[7]	38,074	49,903	53,680	56,412	60,485	66,028
United Kingdom	18,922	22,165	23,137	24,303	21,918	22,597
Yugoslavia	537	887	978	1,156	1,233	1,432
Total [7]	117,191	152,890	164,223	173,443	174,586	189,481
Asia:						
China	1,511	3,145	4,922	5,897	8,820	14,720
India	1,726	1,909	1,947	1,920	2,030	2,726
Japan	7,438	10,371	12,242	13,856	13,358	18,330
Korea:						
North [3]	33	150	210	310	400	500
Republic of	2	12	11	19	22	44
Philippines	-------	-------	-------	63	73	[3] 70
Taiwan (Formosa)	20	69	87	98	118	175
Thailand	6	4	4	6	6	7
Turkey	161	207	213	194	176	236
Total [7]	10,897	15,867	19,636	22,363	25,003	36,808
Africa:						
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	32	55	64	72	83	88
Union of South Africa	1,230	1,742	1,769	1,915	2,019	2,092
United Arab Republic (Egypt region) [3]	28	95	120	110	190	190
Total	1,290	1,892	1,953	2,097	2,292	2,370
Oceania: Australia	1,961	2,465	2,844	3,377	3,534	3,788
World total (estimate)	236,000	297,600	312,650	322,700	298,600	336,100

---

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

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

[3] Estimate.

[4] Including castings.

[5] Average for 1953-54.

[6] Including secondary.

[7] U.S.S.R. in Asia included with U.S.S.R. in Europe.

NORTH AMERICA

Canada.—Canada continued to expand its steel industry by constructing new plants and increasing capacities at existing plants. The opening of the Saint Lawrence Seaway encouraged the expansion of existing plants and the building of new plants at locations previously not accessible to markets and raw material.

Dominion Foundries and Steel Ltd., Hamilton, Ohio, added a third oxygen plant with a capacity of 150 tons per day. The company, first in North America to produce steel by the basic oxygen converter process, expanded steelmaking capacity from 750,000 to 1,000,000 short tons. Cost of expansion was $25 million. Hot- and cold-rolling facilities also were being enlarged. This enlargement included the installation of four additional stands to the existing hot-strip mill, a second continuous pickling line, and a second 56-inch cold-rolling mill.

Dominion Steel and Coal Corp., in partnership with Sogemines Ltd., a Belgian holding company, was planning to build hot- and cold-rolling facilities for making sheets, wire, strip, and plate in the Montreal, Quebec, area. The expansion also included a new pipe mill capable of producing pipe up to 15 inches in diameter. A blooming mill was to be added at the Sydney Works to produce slabs for the 500,000-ton Quebec rolling mill. The expenditures for this venture were estimated at $75 million.[4]

Quebec South Shore Steel Corp., Montreal, was constructing a $12 million plant at Varennes, Quebec, which will use the Strategic-Udy steelmaking process discussed in the Technology Section of the 1958 Chapter on Iron and Steel. Construction was scheduled for completion early in 1961. The plant will have an annual capacity of 140,000 short tons and will have about 150 employees.[5]

The construction of the first iron and steel plant in western Canada was begun at Kimberley, British Columbia, by Consolidated Mining and Smelting Company. Furnace facilities, with a capacity of 100,000 tons of steel per year, were to include an electric furnace for making 36,500 tons of pig iron. The addition of a second and larger furnace and oxygen-blown converters, as well as fabricating facilities, were to follow, according to company plans. The cost of the integrated iron and steel installation was to exceed $20 million.[6]

Interprovincial Steel Corp. Ltd., Regina, Saskatchewan, was building a rolling mill at Regina at a cost of $15 million. The 100,000-ton-capacity plant will produce plate primarily for pipeline use. The company also was adding a third electric furnace and widening its plate mill.

Canadian Steel Wheel, Ltd., formally opened a $12 million steel-wheel plant in Montreal in July. The rated capacity is 200,000 wrought steel wheels per year.

Algoma Steel Corp. completed a new blooming and plate mill in March and reported excellent operation of its two 95-ton oxygen

---

[4] Engineering Journal, vol. 42, No. 7, July 1959, p. 97.
Blast Furnace & Steel Plant, vol. 47, No. 8, August 1959, pp. 817–836.

[5] Steel, vol. 144, No. 16, Apr. 20, 1959, p. 53.

[6] Iron and Steel Engineer, vol. 36, No. 5, May 1959, p. 184.

converters. The mill was designed to make beams as large as 24 by 12 inches and weighing 190 pounds per linear foot.

The Steel Company of Canada (STELCO) planned to increase steelmaking capacity at its Hamilton works almost 25 percent within 2 years. A new 400-ton open-hearth furnace, a galvanizing and aluminized-coating line, improvement of mill-plant docks, ore and coal supplies, and improvements in rolling and other processing equipment, were to call for a capital expenditure of $80 million. Of this amount, some $49 million was spent in 1959 and the balance was to be spent in 1960. The company reported that pellets from the Erie and Hilton mines and self-fluxing sinter greatly increased blast-furnace output. STELCO, in partnership with Page-Hersey, Ltd., planned to construct a new steel-pipe mill at Camrose, Alberta. The mill was to cost approximately $10 million and to make 40-foot lengths of steel pipe 16 to 40 inches in diameter. The annual capacity will be 325,000 tons.[7]

Atlas Steel, Ltd., Canada's leading stainless-steel producer, added a second Sendzimer cold-reduction mill at its Welland, Ontario, plant. Strip down to gages as low as 0.002 inch can be rolled within close tolerances.[8]

Crucible Steel of America, through a subsidiary, purchased Sorel Industries, Ltd., Sorel, Quebec. This firm had a steel plant with an annual capacity of 40,000 tons of electric-furnace ingots, a 16-inch bar mill, forging presses, annealing furnaces, and other auxiliary equipment. Crucible Steel planned to increase production of titanium slag and high-grade pig iron. Tool and alloy steels were to be produced.[9]

Cuba.—Compania Antillana de Acero, at El Cotorro, produced Cuba's first steel ingots in May 1959. The plant was built by the Engineering & Construction Division, Koppers Co., Inc., Pittsburgh, Pa., in cooperation with Republic Steel Corp. of Cleveland. The plant comprises two open hearths (each 77 short tons heat capacity), a blooming mill, and a rod mill. The plant operated about 1½ months in 1959 but was forced to shut down because of inventory buildup and low demand for concrete reinforcing bars. Raw materials for the open hearth will consist of iron and steel scrap; approximately 45,000 short tons of pig iron from Europe, ferrosilicon from Canada, ferromanganese from Belgium, and fluorspar from Mexico. Fuel oil from a local refinery was to be used for firing the open hearth. This company formerly imported steel billets from Europe and processed them into concrete reinforcing bars.

Metalurgica Basica Nacional, S. A., began producing cast-iron pipe in 1957. This company can produce approximately 20,000 tons of centrifugal cast-iron pipe annually. Belgian cupolas (hot blast), similar to those used at Acme Steel Co., Ford Motor Co., and Phoenix Steel Corp., are used to produce molten metal for the centrifugal cast-iron-pipe machine, which produces pipe up to 12 inches in diameter.[10]

Mexico.—The world's largest direct iron unit (500-tons-per-day) was under construction at the Hojalata y Lamina, S. A., (HyL) steel

---

[7] U.S. Embassy, Toronto, Canada, State Department Dispatch No. 19: Oct. 6, 1959.

[8] Metal Bulletin (London), No. 4373, Feb. 23, 1959, p. 13.

[9] Northern Miner (Canada), vol. 45, No. 33, Nov. 5, 1959, p. 9.

[10] U.S. Consul, Habana, Cuba, State Department Dispatch 1091, Mar. 30, 1959. Foreign Trade (Ottawa, Canada), vol. 112, No. 11, Nov. 21, 1959, p. 29.

plant in Monterrey. HyL had units for producing 200 tons of sponge iron per day by reducing iron ore with re-formed natural gas. Hot sponge was refined in electric furnaces, and the resulting steel was used for sheets and welded tubes. Aceros del Norte, S. A., a new company, was constructing a small steel plant in Mexicali. The company expected to manufacture reinforcing bars, angles, channels, cotton ties, and plate. The Atlas Hormos de Mexico, S. A., of Monclova, was increasing blast-furnace capacity and installing a 22-inch reversing mill for rolling billets.[11]

SOUTH AMERICA

A major development in South American steel industry was the formation of the Latin American Iron and Steel Federation during a September meeting in Chile. The objective of the 28 company federation was to establish a system of coordinating their industry for better growth. At this meeting it was estimated that Latin American steel production would reach 6 million short tons in 1960.

Argentina.—Two additional blast furnaces were expected to start producing pig iron at Zapla. These furnaces were built by the German firm Demag, A. G., at a cost of $1.1 million. With the opening of the new furnaces, annual production will reach 165,000 short tons. The $280 million San Nicolas plant on the Parana River, with a planned capacity of 2 million short tons, was expected to begin producing pig iron in 1960 and steel in the first part of 1961.[12]

Brazil.—Brazil has expanded its steel production tenfold in less than 20 years. Between 1939 and 1941, production increased at an average annual rate of 25.5 percent, and between 1945 and 1948 the rate accelerated to 32 percent. Steel output was 425,000 short tons in 1947 and 1,760,000 tons in 1957. Expansion plans underway were expected to raise output of steel ingots to 2.5 million tons in 1960 and 4 million tons by 1963. Half of the expansion at Cia Siderurgica Nacional (Volta Redonda) was completed; this will raise output to 900,000 tons. In March a seventh blast furnace was blown in, and work was begun on the eighth. The program, to be completed by the end of 1960, will increase ingot capacity to 1.4 million short tons.

In 1958, work was completed on an oxygen plant at Cia. Belgo-Mineira, which raised the steelmaking capacity to 27,000 short tons a month. In response to a government appeal, the company was also increasing capacity of the Monlevade plant to 550,000 short tons annually. Blast furnaces were being remodeled and amplified, and a new sintering plant had been added.

Another big mill, Usinas Siderurgicas de Minas Gerais (USIMINAS) was to be built at Ipatinga in the State of Minas Gerais, the heart of Brazil's largest iron-ore holdings. This company will specialize in extra large plates for new ship construction. USIMINAS capital outlays approximated $200 million; 60 percent was Brazilian, and 40 percent was furnished by three Japanese steel companies. An agreement was reached with the Japanese group to

---

[11] Bureau of Mines, Mineral Trade Notes: vol. 49, No. 2, August 1959, pp. 22–23.

[12] Madsen, I. E., Developments in the Iron and Steel Industry During 1959: Iron and Steel Eng., vol. 37, No. 1, January 1960, pp. 93–145.
Iron and Coal Trades Review (London), vol. 178, No. 4751, June 12, 1959, p. 1349.

use the Linz Donawitz oxygen process. The agreement also stipulated that USIMINAS would receive technical assistance from the Austrian firm Bot Grassert Oxygen Technik, A. G., of Vienna and that the company would have the right to place any product made by this process in any market. USIMINAS annual steelmaking capacity was to be 550,000 tons of ingots.

Companhia Siderurgica Paulista (COSIPA) was building a 5.5-million-ton plant in the State of Sao Paulo near the port of Santos. The company's rolling mills were to be geared to meet the needs of the domestic automobile industry, most of which was in the Sao Paulo area.

Cia Ferro e Aco de Vitoria, with the aid of Ferrostaal, A. G. Essen, Germany, planned to produce 130,000 short tons of ingots in 1961 and to increase output to 275,000 tons in 1964. By then the company expected to have a new 800-ton-per-day blast furnace utilizing coke and an oxygen steelmaking plant with two 30-ton converters.

The proposal to build steel works in the State of Santa Catarina was revived. This plant was to have an initial steelmaking capacity of 110,000 short tons in 1963 and 225,000 tons by 1966. The plant was to be located on the Tubarao River near the Capivari coal mines and a thermal-electric power station. Metallurgical coal was to be obtained from the nearby coal washery. The State-owned Cia. Vale do Rio Doce guaranteed a supply of 230,000 tons of iron ore.

Companhia Acos Especiais Itabira (Acesita) and Companhia Metalurgica Barbara utilized charcoal in their blast furnaces. It was reported that other steel companies in Brazil also utilized charcoal.[13]

Chile.—The Huachipato plant of Compania de Acero del Pacifico (CAP) was the second largest steel plant in South America. Two smaller plants were Industrias de Estano y Acero (INDAC), a private company, and Fabricas y Maestranza del Ejercito (FAMAE), a Government organization operated by the Chilean Army. The smaller plants had rolling-mill installations and made bars and structural and strip steel, mainly for their own needs. CAP produced semifinished steel products for domestic and foreign markets. Most of the raw materials consumed, such as iron ore, coal, dolomite, manganese ore, and silica rock and sand, were obtained locally. However, coking coal was imported from the United States for blending with local coals in making metallurgical coke.

CAP bought about 2,500 tons of steel scrap per year from domestic sources to supplement home-plant scrap. Other smaller foundries consumed about 20,000 tons a year, and The Anaconda Co. used about 10,000 tons for copper precipitation. The exportation of iron and steel scrap, not imported into Chile, was prohibited by law. The company recently installed a new rolling mill that can produce steel sheets and plate. Another significant improvement was the semicontinuous hot-strip mill which processed slabs directly from the blooming mill. This mill reportedly saved $15 a ton in processing costs.

Allied industries had grown rapidly around CAP's activities and included a chemical plant that utilized waste gases from the steel

---

[13] Foreign Trade (Ottawa, Canada), vol. 113, No. 1, Jan. 2, 1960, pp. 14–16.
Iron and Coal Trades Review (London), vol. 178, No. 4,747, May 15, 1959, pp. 1115–1116.
Iron and Steel Works of the World, 2d ed., 1956–57, 799 pp.

plant and a cement plant that utilized blast-furnace slag. In addition, over 200 metallurgical plants, including work shops and foundries, had been established since CAP began producing in 1950.

Chile continued to import structural steels, rails, alloy steel, and a few specialized items, mostly from the United States. The domestic market for these items was not large enough to justify the addition of steelmaking and rolling facilities.[14]

Colombia.—Acerias Paz del Rio, S.A., signed a contract with a U.S. firm to increase steelmaking capacity and rolling-mill facilities. The agreement also included alteration of coke ovens and byproduct plants and alterations needed for the production of steel sheets and skelp. Work was expected to be completed in 1962. According to the Iron and Steel Works Directory of the World, this company was operating a blast furnace, an electric-arc furnace, and three Bessemer converters. Rolling-mill equipment included a blooming, structural, merchant, and wire mill. There was also a 43-oven byproduct coke battery plant.[15]

Venezuela.—The production of iron and steel in Venezuela was limited to concrete reinforcing wire and steel castings produced by Siderurgica Venezuela, S. A. (SIVENSA), and about 6,614 short tons of iron castings.

Construction of the Government's Matanzas steel mill near Puerto Ordaz in eastern Venezuela continued despite labor and contract difficulties. The plant is situated on the bank of the Orinoco River, 155 miles from the Atlantic Ocean. The Venezuela Government selected this site for several reasons: (1) Nearness of iron-ore mines, (2) availability of hydroelectric power, and (3) navigability of the Orinoco River. Part of the mill had been scheduled for operation by March 1958, and all units were to be operating by 1960. Initial capacity was to be 825,000 short tons of steel ingots, and capacity was to be expanded to 1.7 million tons. Pig iron was to be made with low-shaft electric furnaces (Thysland-Hole type) instead of the conventional blast furnace. This type of equipment was selected because of the lack of coking coal and the availability of electrical power. Other equipment at the plant included open hearths for steelmaking, a 44-inch blooming mill, roughing mills for rolling semifinished steel for the wire mill, pipe and tube mill, and a foundry. Future expansion called for blast furnaces, oxygen-converter plant, plate mill, small capacity strip mill, and a cold-rolling mill. Iron ore for the electric pig-iron furnaces was to come from United States Steel's Cerro Bolivar mine and Bethlehem Steel's El Pao mine.[16]

EUROPE

The European Coal and Steel Community.—Industrial production in the community increased 6.4 percent, and orders for rolled-steel products were 20 percent above the previous record of 1956. Orders totaled

---

[14] Bureau of Mines, Mineral Trade Notes: vol. 49, No. 4, October 1959, pp. 23–24. Blast Furnace and Steel Plant, vol. 47, No. 2, February 1959, pp. 171–189.

[15] Madsen, I. E., Developments in the Iron and Steel Industry During 1959: Iron and Steel Eng., vol. 37, No. 1, January 1960, pp. 93–145.

[16] Bureau of Mines, Mineral Trade Notes: vol. 49, No. 6, December 1959, pp. 20–21. Iron and Steel Engineer, vol. 26, No. 5, May 1959, pp. 71–93. Skillings' Mining Review, vol. 48, No. 30, Oct. 24, 1959, p. 8.

55.6 million short tons of rolled-steel products and deliveries amounted to 50.8 million tons.

The following import and export data are for the first 9 months of 1958 and 1959. Steel imports totaled 1.5 million short tons, or 7 percent above 1958. Exports were 8.7 million tons, compared with 7.5 million tons in 1958. Exports to North America more than tripled and totaled 1.8 million short tons.

Steel Community pig iron (including ferroalloys) and crude steel production were at new peaks, totaling 51.4 million tons and 69.6 million tons, respectively. Steel furnaces operated at 89.8 percent of capacity and exceeded 90 percent of capacity in all countries except West Germany (87.4 percent) and Italy (83.8 percent). Record outputs were established in all countries except Italy, where output was slightly below the 1957 level.

The percentages of total steel made by the several processes during the first 9 months were as follows. Basic Bessemer, 51.3; acid Bessemer, 0.3; open hearth, 36.9; electric, 10; and other (including L–D Rotor and Kaldo), 1.5. Corresponding figures for all of 1958 were 50.5, 0.4, 38.1, 9.9, and 1.1, respectively.

The ratio of pig-iron production to steelmaking capacity increased from 1,462 pounds per short ton in 1958 to 1,488 in 1959. This improvement was due to projects completed since 1955 and the use of more sintered iron ore. Production of sintered iron ore increased from 24.9 million short tons in 1958 to 31.3 million tons in 1959. Paralleling the use of more sinter in blast furnaces, coke consumption per ton of pig iron decreased from 1,940 pounds per ton in 1955–57 to 1,820 pounds by mid-1959.

The supply of scrap in the common market continued to improve despite the record steel output. Imports were less than 1 million tons, whereas during the recession year 1958 they totaled 2.6 million tons. Steel Community collection rose from 11 million to 13.8 million tons. The price compensation scheme for imported scrap ended November 30, 1959; that is, the High Authority would no longer pay the difference between the domestic price of purchased scrap and imported scrap.

Construction projects declared for iron and steel plants in 1959 were valued at $495 million compared with $905 million in 1958. A breakdown of the 1959 investments are: Coke plants, $12 million; burden preparation, $60 million; blast furnaces, $43 million; steel furnaces, $17 million ($6 million, L–D and similar processes), rolling mills, galvanizing and tinning, etc., $302 million; power generation, $24 million; and miscellaneous $37 million.[17]

Czechoslovakia.—Ground was broken at Kosice, eastern Slovakia, for one of the largest integrated steel plants in Europe. The plant was part of a development program, which includes expansion of the older Bohemian and Moravian mills. Upon completion of the program, estimated for 1965, the country's steelmaking capacity will be 10 million short tons. Kosice was selected because it is situated midway between the Soviet iron mines at Krivoi Rog in the Ukraine and the Czechoslovakia coal region of Morava Ostrava. It was planned to

---

[17] European Coal and Steel Community, Eighth General Report on the Activities of the Community, Feb. 1, 1959, 455 pp.

load the ore cars with coking coal in Morava Ostrava and unload them at Kochitza on their return trip to Krivoi Rog. In 1959, ore cars returned empty from the older steel mills to Krovoi Rog.[18]

Denmark.—Norden Cement Iron Syndicate, the only pig-iron producer in Denmark which uses the Basset Rotary Kiln process, announced that operations would soon be suspended at its plant at Aalborg. The company, which employed 300 persons at Aalborg, reportedly was unable to meet the low prices of the freely imported Swedish pig iron.[19]

Poland.—Poland's largest and most modern steel mill, the Nowa Huta Steelworks, near Cracow, had three blast furnaces, eight open-hearth furnaces, hot and cold rolling mills, and an annual steel-ingot capacity of 1.6 million short tons. Plans called for increasing capacity to 3.8 million tons by 1965; this would be 40 percent of Poland's steel output. Two new blast furnaces, a 1.1-million-ton oxygen converter plant from U.S.S.R. and three new rolling mills were to be installed. Employment at the plant will increase to 24,000 workers in 1965.[20]

Spain.—Empresa National Siderrgica, S. A., Spain's largest steelworks, at Alviles on the Asturian coast, began operating with the commissioning of a 42-inch reversing mill in the spring. The blast furnace had been operating since 1957, and the pig iron was sold domestically or exported. The three 385-ton tilting-type open hearths were operating at the end of 1958. A structural mill was to be commissioned at end of 1959.[21]

Sweden.—The largest single private investment ($105–$115 million) ever undertaken in Sweden was the steelworks being constructed at the east-coast port of Oxelösund. The old coke-oven plant was being extended; and in addition, a sinter plant, blast furnace, open hearth, Kaldo oxygen steelmaking converter, and rolling mill were under construction. The plant was expected to be in operation in 1960. Coke capacity will be increased to 375 short tons per year. Annual blast- and steel-furnace capacities will be 375,000 tons each.

At the Domnarfvets Jernverk plant, owned by Stora Kopparbergs, a.-b., a 63-inch cold-rolling mill, with an annual capacity of 132,000 short tons of sheet steel for automobile bodies, was under construction. Steel sheet for the Swedish Volvo and Saab automobiles has been supplied mainly by imports from the United States and Belgium.[22]

Turkey.—In December three U.S. firms, Westinghouse Electrical International, Blaw Knox Co., and Koppers Co., signed a letter of intent with the Turkish Government for constructing a modern integrated steel plant at Eregli on the Black Sea coast, near Turkey's largest coalfield. The plant would consist of coke ovens, blast furnaces, oxygen steelmaking converters, rolling mills for flat-rolled products, and a 20,000-kilowatt powerplant. Initial annual output was

---

[18] Blast Furnace and Steel Plant, vol. 47, No. 9, September 1959, p. 993.
[19] Metallurgia (Manchester), vol. 59, No. 353, March 1959, pp. 139–140.
[20] Warsaw, Wiedra i Zycie, July 1959, pp. 441–443.
Iron and Coal Trades Review (London), vol. 178, No. 4,749, May 29, 1959, p. 1,248.
Iron and Coal Trades Review (London), vol. 178, No. 4,728, Jan. 2, 1959, p. 27.
[21] Iron and Coal Trades Review (London), vol. 178, No. 4746, May 8, 1959, p. 1096.
[22] Iron and Coal Trades Review (London), vol. 178, Mar. 13, 1959, pp. 611–612.
Bureau of Mines, Mineral Trade Notice: Vol. 49, No. 5, November 1959, pp. 17–19.

expected to total 300,000 short tons of iron and steel sheets and some tinplate.[23]

U.S.S.R.—Pig-iron and steel production in the Soviet Union amounted to 47 million and 65 million tons, respectively, increases of 9 percent each over 1958. Steel pipe showed the greatest increase for steel products, output rising 13 percent. Steel-pipe production was given high priority because of the extensive oil- and gas-pipeline construction underway in the U.S.S.R. More than 1,200 miles of gas pipeline were placed in operation at Serpukhov-Leningrad. In addition, about 1,200 miles of crude-oil and refined-product lines were built.[24]

United Kingdom.—Except for the depression of the late twenties, steel output has climbed steadily in the United Kingdom. In 1959 the industry consisted of more than 300 companies, a labor force of 422,000 and a productive capacity of 27 million short tons. Of the 300 companies, 25 accounted for 95 percent of the steel and 35 percent of the pig iron produced. The greater part of the industry was nationalized by the Iron and Steel Act of 1949, but most of the companies were returned to private ownership and in 1959 only 12 companies were government-owned. Only 1 of the 12 belongs to the group of 25 major companies. The denationalizing of the remaining 12 companies will be in line with present government policy. Privately owned companies were under the jurisdiction of the Iron and Steel Board. This organization reviewed productive capacity, arranged for the procurement of raw materials, and set prices. The board established maximum domestic steel prices but did not control export prices. Among its other responsibilities were the importing of raw materials (mainly iron ore) and the promotion of research.

The United Kingdom has almost doubled steelmaking capacity since 1939, and the expected increase in demand will call for further expansion.

The industry has been increasing investments annually, as follows: £75 million in 1956, £95 million in 1957, and £105 million in 1958. Indications are that investments will total £400 million in the period 1959–61.

TABLE 23.—Steel production in the United Kingdom, 1955 and 1962 (planned), by type of plant

Production from—	1955		1962	
	Million tons	Percent	Million tons	Percent
First-class modern plant of economic size, installed or extensively reconstructed since World War II	4.75	22	11	35
Efficient, though older, plant useful for many years	12	54	14.75	48
Plant well below the average, but capable for some years of useful life in conditions of high demand	3	14	3.25	11
Obsolete plant	1.5	7	1.5	4
Unclassified (mainly small works making special-quality steels)	.75	3	.75	2
Total	22	100	31.25	100

---

[23] Blast Furnace and Steel Plant, vol. 48, No. 1, January 1960, p. 105.
Foreign Trade (Ottawa, Canada), vol. 113, No. 4, Feb. 13, 1960, p. 12.

[24] American Geographical Society, Soviet Geography: Review and Translations, January–February 1960, 80 pp.

Individual companies, as well as the entire industry, have a vigorous research program. New techniques are being applied to obtain greater output from existing equipment. One steel company announced that it would install a 22.5-ton electric furnace and two continuous-casting machines to provide 40,000 tons of billets a year. At United Steel's Appleby Frodingham works, one of the four new blast furnaces, operating on 100-percent sinter, achieved a record weekly output of 13,160 tons. Much progress also was made in improving the efficiency of steelmaking and the expansion of strip mills.[25]

ASIA

India.—India's second 5-year plan, which started in 1956, was more than half complete. In the private sector, Tata Iron & Steel Company finished its expansion programs, which boosted steelmaking capacity to 2 million tons per year, and Indian Iron & Steel Co. at Burnpur increased its capacity to 1 million tons. The main features of these two plants are as follows:

Plant	Tata Iron & Steel Co.	Indian Iron & Steel Co.
Blast furnaces	1 at 600 tons per day. 2 at 800 tons per day. 2 at 1,000 tons per day. 1 at 1,500 tons per day.[2]	2 at 600 tons per day. 2 at 1,200–1,300 tons per day.[1]
Coke rate, lb. per ton	Large furnaces, 1,900–1,950. Small furnaces, 1,950–2,050.	Large furnaces, 1,900–2,000. Small furnaces, 2,200.
Sinter plant capacity, tons per day.	5,000.	
Steelmaking	Duplex process-acid Bessemer and basic open hearth.	Duplex process-acid Bessemer and basic open hearth.
Mixers	No. 2 shop—1 1,300-ton. No. 3 shop—2 800-ton.	2 inactive, 1 600-ton and 1 800-ton
Converters	No. 2 shop—3 25-ton. No. 3 shop—3 32-ton.	3 22- to 25-ton.
Open-hearth furnaces	No. 2 shop—1 200-ton (tilter). 2 250-ton tilters. No. 3 shop—7 200-ton (fixed).	1 100-ton (fixed). 6 200- to 250-ton (tilters).

[1] The two larger furnaces are designed for high top-pressure operation and are provided with 25-feet-diameter hearths and a working volume of 37,000 cu. ft. or 30.9 cu. ft. per ton of daily output.

[2] The new 1,500-ton-per-day furnace has a 28-feet-diameter hearth and a useful volume of 53,170 cu. ft. or 35.4 cu. ft. per ton per day. This furnace is designed for high top-pressure operation.

In the Government sector, construction of blast furnaces, steelmaking equipment, and some rolling mills at the Bhilai, Rourkela, and Durgapur plants had not progressed on schedule. The general features of these plants were given in the 1957 Minerals Yearbook, volume I. India's main blast furnace problems resulted from the high-ash-content coke and, at several plants, from a high alumina-silica ratio of Indian iron ores and high-silica limestone. Because of the low quality of available coke, the use of sinter, particularly self-fluxing sinter, reportedly may be emphasized. Sintering plants were installed at the Tata Iron & Steel and Bhilai plants, and provisions were made for sintering plants at the Rourkela and Durgapur plants.[26]

---

[25] The Mining Journal (London), vol. 252, No. 6444, Feb. 20, 1959, pp. 192–193. Foreign Trade (Ottawa, Canada), vol. 112, No. 12, Dec. 5, 1959, pp. 22–24.

[26] Iron and Coal Trades Review (London), vol. 179, No. 4762, Oct. 23, 1959, pp. 639–645.

Japan.—Japan continued expanding its iron and steel industry in its second modernization program (1957–62), with outlays calling for $10 million (360 yen=US $1.). Investments were 124.3 billion yen, an increase of 16 percent over 1958.

Operations were begun at three large blast furnaces, each with a 1,650-ton daily capacity. These furnaces were at Kawasaki Steel Corporation, Chiba works; Fuji Iron & Steel Company, Hirohata works; and Yawata Steel, Tobata works.

Two 60-ton oxygen converters were brought into operation by Yawata Iron and Steel Company, and a third was scheduled to operate in 1960. Fuji planned to add two 60-ton converters at its Hirohata works, and Nippon Kokan planned to add two 60-ton converters at its Mizue works. Amagasaki Iron and Steel Company expected to add two 30-ton converters.

Japan was second to the United States in number of strip mills, some of which could roll steel in 6-foot-wide strips. New hot-strip mills, with an annual capacity of 5 million short tons, were to be installed. A list of rolling mills completed since December 1957 follows:

Hot-strip mills: Kawasaki Steel Corp., Chiba works; Nippon Kokan Kabushiki Kaisha, Mizue works.

Blooming mills: One by Nippon Kokan's Mizue works; two by Yawata Iron and Steel Co., Ltd., one for plate mill and one for strip mill.

Large-section mill: Yawata Steel's rail works.

Medium-section mills: Kobe Steel Works, Ltd., Wakinohama works; Otani Steel Works, Ltd., rolling mill.

Medium- and small-section mill: Kanto Steel Manufacturing Company, Ltd., Shibukawa works, for special steels.

Small-section mills: Nisshin Steel Works, Ltd., No. 3 mill; Otani Steel's rolling mill.

Hoop mills: Nisshin Steel Works' Amagasaki mills (hot-rolling strip mills).

Sheets mill: Nippon Kogyo Steel Works Co., Ltd.

Cold-rolling mills: Nippon Metallurgical Industry Co., Ltd., Kawasaki works for special steel; Yodogawa Seiko Steel Works, Ltd., Kure works.

Plate mills: Nisso Steel Manufacturing Co., Ltd., Oshima works; Fuji Iron and Steel Co., Ltd., Hirohata works.

Tire and wheel mills: Sumitomo Metal Industries, Ltd.

Cold-strip and reversing mills: Kawasaki Steel's Chiba works; Nippon Kokan's Mizue works; Yawata Steel's No. 3 strip mill; Osaka Shipbuilding Company, Ltd., Yokohama works, (two mills); Toyo Kohan Co., Ltd., Nisshin Steel Works' Nanyo works; and Fuji Steel's Hirohata works.

Mills under construction in September 1959 were:

Blooming mill: Kobe Steel, Wakinohama works, Sumitomo Metal's Wakayama works, and Fuji Steel's Muroran and Hirohata works.

Large-section mill: Yawata Steel, large-section mill.

Medium-section mills: Tokushu Seiko Co. Ltd., Kawasaki works (for special steel); Sumitomo Metal Industries.

Medium- and small-section mill: Amagasaki Iron and Steel Manufacturing Co., Ltd.

As a result of these additions and some not listed, the six major steel companies planned to produce 20 percent more iron and steel than in 1959. Japanese pig-iron production in 1959 was 10.4 million short tons, 28 percent over 1958, and crude steel was 18.3 million tons, a 37-percent increase. The program called for increasing pig-iron and steel capacities to 15.4 and 22 million tons, respectively.

The percentages of steel made by the various processes in 1959 were: Open hearth, 74; converter, 7; and electric, 19. Hot-rolled steel products totaled 14.2 million short tons, a 34-percent increase over 1958. Exports of steel declined slightly, but those to the United States increased sharply. Of the 2 million tons exported, 724,000 tons went to the United States, compared with 428,000 tons in 1958. Imports included 308,000 tons of pig iron and 353 tons of finished steel products.[27]

China.—China was rapidly expanding its iron and steel industry in an attempt to meet the needs of China's 600 million people. Eighteen key iron and steel centers were planned or under construction; these would increase capacity about 16 million tons. Large expansion plans were underway at Anshan, Wuhan, and Paotow, the largest steel centers, where modern iron- and steel-making facilities were being installed. Steel output at these three plants reportedly would reach 20 million tons within 3 years.

Anshan, whose estimated steel production exceeded 5 million tons in 1958, had over 40 major production units, some of which were completed during China's first 5-year plan (1952–57). Included in the expansion plans were 2 new iron-ore mines, 7 ore-dressing and sintering plants, 10 batteries of coke ovens, 2 steelmaking shops, 8 rolling mills, and 3 refractories. All were constructed with the aid of the Soviet Union. Anshan was one of 156 basic industrial projects covered by Sino-Soviet economic agreements.

The No. 10 blast furnace at Anshan, China's largest, tapped its first iron in November. A new 2,500-ton-per-day furnace began operating in September at Paotow. The first heat was tapped from the new 500-ton-heat-capacity open hearth at the Wuhan Iron and Steel Works on September 30. With the aid of East German experts, high-sulfur pig iron was desulfurized to 0.024 percent of this plant.

Medium-size integrated iron and steel works were located at Chungking, Hantan (Hopei Province), Tsinan (Shantung Province, and Maanshan (Anhwei Province). All of these plants were expanding steelmaking capacity, and each plant planned an annual steel output of 6.5 million tons. Among the smaller plants being built or enlarged (each over 100,000-ton capacity per year) were the Ocheng Iron and Steel plant, Hupeh Province; the Lienyuon Iron and Steel plant, Hunan Province; and the Chekiang Iron and Steel plant.

Chinese scientists admitted that the 30,000 small backyard furnaces and thousands of small side-blown converters (0.5–13 tons), built and operated at many locations by factory workers, schoolteachers, housewives, peasants, and students, were technically backward. However, these furnaces offered a quicker way of attaining high steelmaking capacity (10 million tons in 1959) than building larger units. The Communist Chinese Ministry of the Metallurgical Industry estimated that it would take three or four times as long to build a single blast furnace with an annual capacity of 300,000 tons of pig iron as it would to build 100 small blast furnaces with the same combined total

---

[27] Far East Iron and Steel Trade Reports, No. 62, Mar. 12, 1960, p. 7.
The Japan Iron and Steel Federation, Monthly Report of the Iron and Steel Statistics: Vol 3, No. 3, March 1960, 23 pp.

capacity. Small furnaces also required less investment per unit of capacity. These furnaces can be brought into production quickly and make use of small deposits of iron ore. Small furnaces also make better use of China's abundant manpower. Although the output of these furnaces could be used for many applications, the furnaces could not produce quality pig iron and steel. Perhaps less than half of them operated in 1959.

The types of steel made in China are not well known, although about 500 grades were made. Some new products reportedly made in 1959 were high-strength structural steels, clad stainless steel, beams 22 inches high, plates up to 91 inches wide, nickel-free austenitic strainless steel, and high-speed steel without chromium. Manganese, vanadium, silicon, and other metals, plentiful in China, were to be used to replace nickel and chromium.

At Anshan's pushbutton seamless tubing mill, production of 6.5-inch diameter tubes was begun. To overcome the shortage of cast and forged steel, the Chinese were making extensive use of nodular cast iron. The cost of crankshafts at the Shenyang tractor plant was reduced 70 percent by using nodular iron instead of forged steel. The East Chemical Engineering Institute made steel directly from iron ore with natural gas.[28]

AFRICA

Algeria.—The Algerian Government reportedly agreed to construct a 400,000- to 500,000-ton-capacity steel plant at Bone in eastern Algeria. The new plant, scheduled to begin operating in 1962, will use high-grade iron ore from the Quenza mines. Natural gas was to be piped to the Bone area from Hassi R'Mel by 1960, and coke (which is not produced in Algeria) was to be imported from the United States.[29]

Kenya.—The Steel Corp. of East Africa, Ltd., incorporated in July 1959, planned to spend $1.1 million on an east African steel plant. A site on the outskirts of Nairobi was being considered for the melting furnaces and rolling mill. Iron and steel scrap, the basic raw material, would be procured locally for manufacturing reinforcing bars, mild steel rounds, profiles, and sections made to British Standard Specifications.[30]

Morocco.—The Moroccan Government was considering the construction of a $60 million steel plant at Cap de l'Eau, a small fishing village 15 miles west of the Algerian border. High-grade iron ore is available from Nador, and Algerian natural gas or Moroccan anthracite coal could be used as reductants.[31] Morocco has ample hydroelectrical power.

ported; most of this pig iron went to Japan and the United States.

Union of South Africa.—An appreciable tonnage of pig iron was ex-

---

[28] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 6, December 1959, p. 18.
Metal Bulletin (London), Nov. 24, 1959, p. 21.
Steel, vol. 144, No. 24, June 15, 1959, pp. 99–103.
Steel Review, British Iron and Steel Federation: July 1959, pp. 8–19.
Iron and Steel, vol. 32, No. 11, October 1959, pp. 91–487.

[29] Bureau of Mines, Mineral Trade Notes: Vol. 48, No. 6, June 1959, p. 13.

[30] Iron and Coal Trades Review (London), vol. 179, No. 4770, Dec. 18, 1959, p. 1148.
Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 2, February 1960, p. 10.

[31] Engineering News Record, vol. 164, No. 3, Jan. 21, 1960, p. 53.

At yearend, a new 500-ton-per-day blast furnace was about to be blown in; in addition, two Graef rotor oxygen steelmaking furnaces, each designed to produce 300,000 tons of steel annually, were under construction. With these new installations, the approximate South African iron and steel capacity will be: Pig iron, 2.4 million short tons, ingot steel, 2.8 million tons, and rolled-steel products, 1.6 million tons.[32]

OCEANIA

Australia.—Broken Hill Pty. Co., Ltd., planned to build a £30 million ($67.5 million) steel plant at Whyalla, several hundred miles north of Adelaide. The new plant will use the oxygen method of producing steel, a new procedure for Australia. Construction of the plant was scheduled to begin late in 1960. The company also operated a blast furnace at Whyalla, which produced small quantities of pig iron, electric steel ingots, and steel castings.[33]

The largest blast furnace in the Southern Hemisphere was blown in May 28, 1959, by the Broken Hill Pty. Co., Ltd., at Port Kembla. The furnace with a hearth diameter of 29 feet, has a daily capacity of 1,900 short tons of pig iron or an annual capacity in excess of 655,000 tons. The new furnace, together with the seven already operating in Australia, brought the Commonwealth's ironmaking capacity to about 3.4 million tons annually.[34]

A third open-hearth furnace, commissioned at Port Kembla, raised ingot capacity by 335,000 tons per year, bringing the total steelmaking capacity of this plant to 2.3 million short tons.[35]

New Zealand.—New Zealand expected to be producing a substantial part of its steel needs in reinforcing rods, angles, and engineering rounds by the end of 1961. Iron and steel scrap will be processed into these products. Various sources indicated that an embargo would be placed on the export of ferrous scrap suitable for this mill.[36]

TECHNOLOGY

The steel industry continued studies on methods of increasing iron and steel output and improving efficiency. Jones and Laughlin Steel Corp. planned to build a 32-foot-hearth-diameter blast furnace with a daily capacity of 3,500 short tons—the world's largest. Some added features necessary for high capacity (4,000 tons per day) blast furnaces of sizes equal to those in use are: The furnace stove and other facilities must be constructed as pressure vessels and be provided with definite sealing against even minute leakage; blowing capacity must be expanded to 200,000-c.f.m. units at 40 p.s.i.g.; the charge system must be modified; high gas pressures must be used for gas cleaning, thus eliminating electrostatic precipitators; and auxiliary facilities such as casthouse size must be doubled to handle twice

---

[32] U.S. Consul, Amcongen, Johannesburg, State Department Dispatch 218, Mar. 3, 1960.
[33] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 6, June 1960, p. 13.
[34] Industrial and Mining Standard (Melbourne, Australia), vol. 114, No. 2882, June 18, 1959, p. 11.
[35] Iron and Coal Trades Review (London), vol. 179, No. 4766, Nov. 20, 1959, pp. 901–902.
[36] Iron and Coal Trades Review (London), vol. 180, No. 4775, Jan. 22, 1960, p. 206.

as much pig iron. There would be a 33-percent reduction in the labor force per ton of iron.[37]

Natural gas was used to replace 30 percent of the coke charge, and output was increased 25 percent in the Bureau of Mines experimental blast furnace. Pittsburgh Coke and Chemical Company used coke-oven gas to replace part of the coke charge. The use of coke-oven gas up to 4 percent of the blast volume resulted in a coke saving of 212 pounds per ton of iron and 9.5-percent increase in output. Further tests are planned.

In the United States there was no reported commercial use of direct iron as a source of metallics for steelmaking. However, the details of several processes were disclosed. The Strategic-Udy (HyL) and the H-Iron processes were in operation or under construction in North America. (See the Technology section, Iron and Steel chapter, Minerals Yearbook, vol. I, 1957 and 1958.) Plants employing the Strategic-Udy process were planned or under construction in the Montreal, Canada, area; at Clarksdale, Ariz.; and at Anaconda, Mont. Premium Iron Ores, Ltd., of Montreal was planning a 150,000-ton-per-year merchant iron plant using the HyL process in the Lake Superior region. Natural gas was to be piped from Alberta. The Hojalata y Lamina S. A. plant at Monterrey, N. Mex., with a daily output of 500 tons, was the largest in the World. The output of the Alan Wood H-Iron plant at Conshohocken was devoted to powdered metallurgical uses. Bethlehem was constructing a 110-ton-per-day H-Iron plant at Los Angeles.

In basic oxygen steelmaking, Algoma Steel substituted iron-ore agglomerates for half of the scrap normally used in its basic oxygen converter, with no apparent loss in metallic yield.

In the experimental oxygen converter at Donawitz, Austria, the scrap charge was increased from 30 to 50 percent by the addition of coke breeze. It was also found that water, either liquid or vapor, would eliminate sulfur in the converter. However, the water or steam additions were discontinued during the latter part of the refining period to eliminate occluded hydrogen from the melt. A vigorous carbon boil at the end of the heat releases any hydrogen contamination.

Wheeling Steel Corp. announced plans for adapting its Bessemer converter process at Mingo Junction, Ohio, to additions of steam and oxygen in place of air. The low-nitrogen content of steel from this process renders it comparable to open-hearth grades.

A new Belgium process, called OCP (oxygene-chaux-pulverisee), converts pig iron to low-nitrogen steel. In this operation, high-purity oxygen, carrying suspended powdered lime, is blown into the converters from the top. It is claimed that hot metal, at any phosphorus level, however high, can be dephosphorized and a considerable reduction in sulfur realized.

The OLP (oxygene-lime-poudre) process, developed by IRSID (French Steel Research Institute), has been used to refine high-phosphorus pig iron. The process is similar to the LD converter but blows lime and oxygen through a water-cooled lance directed against

---

[37] Rice, O. R., The Ultra-High-Pressure Blast Furnace (Koppers Co., Inc.): October 1959, 42 pp.

the surface of the bath. The vessel is tilted at the end of the first two stages to decant excessive slag. Prerefining iron in the blast-furnace runner was tried at several plants in the United States and Europe.

At the Bureau of Mines Pyrometallurgical Laboratory, oxygen was blown on the surface of molten pig iron in a covered runner. Most of the silicon and as much as 50 percent of the carbon were removed. In Europe, oxygen was blown through a porous slab of cement without too much turbulence, using an oxygen tuyère inlet at the bottom of the runner. Although this arrangement results in large quantities of slag and fume, considerable silicon and carbon are removed.[38]

At the Fairless works of U.S. Steel Corp., oxygen lances through a suspended basic roof were used in a campaign of 368 heats averaging 342 tons. The furnace averaged 43 tons per hour with a ratio of hot metal to ingot of 0.73, a fuel rate of 2,350,000 B.t.u. per ton, and an oxygen consumption of 439 cubic feet per ton. Seventy-three of U.S. Steel's open-hearth furnaces were equipped with roof lances. At Weirton, W. Va., 105 tons per hour of steel was made in its 600-ton open-hearth furnace. The oxygen requirement for this run was 898 cubic feet per net ton, with 693 cubic feet through roof lances and 205 cubic feet for combustion.[39]

Interest in high-strength steels was considerable. A Bureau of Mines survey of high-strength steel shipments for 1958 showed that steel producers shipped 10,113 tons for end uses that require an ultimate tensile strength greater than 200,000 p.s.i. Some typical applications were: Aircraft landing gear and airframe components, wing pylon parts and fasteners, wing attachment fittings and superstrength bolts, sheet or plate parts for supersonic speeds, pressure vessels for aircraft use, oil-well perforating guns, carbide-bit bodies, military-tank torsion bars, and missile motor cases and domes.

The Bureau of Mines produced an uranium-bearing steel analyzing C, 0.40 percent, Mn, 0.25, Si, 0.02, Ni, 2.00, and U, 1.40, and with an ultimate tensile strength approaching 300,000 p.s.i. Ford Motor Company made a low-alloy steel with an ultimate strength of 500,000 p.s.i. by heavy mechanical working of modified SAE 4340, with a 92-percent minimum reduction in cross-section area between 800° and 1,050° F. This procedure breaks up austenite and results in a fine-grained martensitic structure after quenching. Yield strength, which is sometimes identical with ultimate tensile strength, is achieved by subsequent tempering. The tempered martensitic structural steel is superior to bainite or pearlite microstructures for high-strength applications. Ford calls the process Ausform.[40]

Foreign steel mills were ordering large continuous-casting machines that would cast slabs up to 8 inches thick by 50 inches wide. Slabs as much as 36 inches wide were produced by this method in England. An interesting development in continuous casting was the use of an electromagnetic method for controlling the supply of liquid steel in

---

[38] Madsen, I. E., Developments in the Iron and Steel Industry During 1959: Iron and Steel Eng., vol. 37, No. 1, January 1960, pp. 93–145.

Steel, French Converter Process Produces Quality Steel: Vol. 146, No. 5, Feb. 1, 1960, pp. 92–94.

[39] Blast Furnace and Steel Plant, Use of Oxygen Lances and Basic Brick in Open-Hearth Furnace Roofs: Vol. 48, No. 1, January 1960, pp. 68–74, 78–80.

[40] Steel, vol. 145, No. 12, Sept. 21, 1959, pp. 84–86.

the casting tube. The field thus acts simultaneously as a pump and a heater.[41]

Practical experience with L.D. (basic oxygen converter) steel for constructing ships showed that it was equal and in various respects better than steel made by other processes. Testing was conducted by the Flensberg Shipbuilding Company in West Germany.[42]

A new system called Direct-On, developed by Ferro Corp., Cleveland, covers steel with a single porcelain enamel coating instead of the two or three needed by conventional methods. Nonpremium cold-rolled steel or premium enameling stock may be used. Coatings are more flexible and tougher.[43]

Linde Company, Division of Union Carbide, developed a practical process for using oxygen to assist scrap meltdown in electric-arc furnaces. The process utilized newly designed oxygen-fuel gas door or wall burners to speed the operation. Production tests gave the following results: Production increased from 15 to 20 percent; power consumption decreased 15 to 20 percent; use of oxygen resulted in uniform scrap melting rates; and electrode consumption remained normal.[44]

In recent years tests were run on the use of molten pig iron (high and low phosphorus) to replace up to 70 percent of the normal scrap charge. This research was undertaken at Gerlafingen (Switzerland) Steelworks of Ludw. von Roll'schen Eisenwerke A. G. Other furnace additives included lime and iron ore. An average of 173 heats, produced in the 12-ton furnace, with 50 percent of molten high-phosphorus pig iron, showed that meltdown time was decreased 32 percent and power consumption 23 percent, compared with results using a 100-percent cold-scrap charge. In the 40-ton furnace, with 50 percent of liquid pig iron, energy requirements were reduced 29 percent using low-phosphorus pig iron and 23 percent using high-phosphorus pig iron. The melting rates were correspondingly 37 and 32 percent higher.[45]

A new technique was developed by National Research Corporation, Cambridge, Mass., for vacuum deposition of pure aluminum on various base metals and steel. The coated material was tough and ductile and resisted corrosion. It may be anodized, colored, or buffed. Aluminum coating can be applied in thicknesses up to 0.004 inch. Coating costs were about 10 cents a square foot for large-volume parts such as automobile grilles. It also was reported that a large steel company signed a license agreement for the process to be used for vacuum coating aluminum sheets for cans and other products.[46]

Steel companies developed a thin tinplate which weighs only half as much as conventional tinplate. The weight saving will reduce shipping costs for foods and other products packaged in tin cans.

U.S. Steel started producing vinyl-coated steel sheets at its Irvin works. Almost any desired finish, from linen to leather, can be

---

[41] Revue Universelle des Mines, vol. 14, No. 12, December 1958, pp. 634–643.

[42] Acier Stahl Steel, vol. 24, No. 10, October 1959, pp. 407–412.

[43] Steel, vol. 145, No. 1, July 6, 1959, pp. 7–76.

[44] Hinds, G. W., A New Concept for Using Oxygen in Electric Furnaces: Iron and Steel Eng., vol. 6, No. 3, December 1959.

[45] Durrer, R., and Heintze, G., Hot Metal in the Electric Arc Furnace: Iron Age, vol. 184, No. 13, Sept. 24, 1959.

[46] Steel, Thicker Coatings Add New Dimension to Markets for Vacuum Metallizers: Vol. 144, No. 22, June 1, 1959, pp. 96–97.

obtained in cut sheets or coils. In the process, liquid plastisols are bonded and cured to steel in a continuous-mill coating process. Before cooling, the coating can be embossed with any texture that can be engraved on a printing roll. Coating thicknesses range from 0.008 to 0.020 inch. The coated steels are available in 18 to 32 gage coils up to 52 inches wide and in cut lengths and on either cold-rolled, nongalvanized or galvanized steels.

The Republic Steel Corp. Youngstown pipemill was producing plastic-coated steel pipe which was corrosion resistant and would withstand heavy handling and weather abuse. The product is more economical for many applications than conventional steel pipe wrapped with tape for use in the field.[47]

In England very low carbon steel, with over 3 percent boron, was produced and forged for use as control rods in atomic reactors. The Hadfield research team discovered that boron-bearing steel containing up to 4.75 percent boron could be forged if residual aluminum was maintained at a specified level. Boron-bearing steel, without aluminum, was not forgeable. At United Steel's Swinden, England, laboratories, a new high-strength, low-carbon boron-bearing steel, containing 0.5 percent molybdenum, was produced. It had an approximate tensile strength of 315,000 p.s.i.[48]

In the U.S.S.R. the use of self-fluxing sinter and/or briquetted limestone to replace charge ore and limestone in open-hearth steelmaking resulted in a much more rapid slag formation during melting, earlier (flush) slag removal, and a corresponding reduction in melting time. The use of agglomerate and flux materials (briquettes and sinter) with a basicity ratio (CaO/SiO_2) of 2.0 to 2.5, with only minimum additions of ore and limestone, reduced the melting time in the 370-ton furnace by 40 to 45 minutes and increased furnace output per hour 6 to 7 percent. Other benefits included improved dephosphorizing and desulfurizing capacity of the slag. These experiments were carried out at the Nizhnaya Salda, Chusovoi, and Kuznetsk works. Self-fluxing sinter was used at Magnitogorsk and ore-limestone briquettes at Azovstal.[49]

The High Authority of the European Coal and Steel Community authorized a 3-year extension of the 50-percent subsidy for research with the Liege low-shaft furnace, which was to have been terminated at the end of 1959. Research continued on the injection of fuel oil through the low-shaft furnace tuyères. This resulted in a 25-percent reduction in coke consumption, representing a 15-percent reduction in coke and fuel oil (carbon rate, 1 kg. of fuel oil equals 2.5 kg. of coke) and nearly a 15-percent increase in productivity. In the experiments, 100-percent Dwight-Lloyd 3- to 25-mm. sinter (corresponding to a coke size of 10 to 25 mm.) and a 900° C. hot-blast temperature were used. By raising the hot-blast temperature from 800° to 900° C., oxygen enrichment of the blast was unnecessary with this burden. Another series of tests on fuel-oil injection was conducted between April and September in a blast furnace of Acieries

---

[47] Madsen, I. E., Developments in the Iron and Steel Industry During 1959: Iron and Steel Eng., vol. 37, No. 1, January 1960, pp. 93–145.

[48] Steel Review, The British Iron and Steel Federation Quarterly, January 1959, pp. 10–12.

[49] Stal, No. 5, May 1959, p. 342.

de Pompey in Larraine, and the results of the tests were substantially the same as at Liege. Studies were carried out on the effect of blast temperature, high top pressure, faster driving rates, and oxygen enrichment of the blast. These investigations were performed in conjunction with research on fuel-oil injection. The results were promising.

Direct reduction of iron-ore processes included the use of a rotary furnace by the Freidrich Krupp machinery and steel construction firm at its experimental plant at Rheinhausen and the construction and operation of a shaft furnace by the Finsider Research Institute. At yearend a full-scale standard test was to be conducted in the rotary furnace on the reduction of Venezuelan hematite. The furnace was to be fired with coke-oven gas, and coke breeze or low-temperature hard coal and brown coal were to be used as reducing agents. Other projects supported by the Authority included studies on flame radiation for improving the calorific efficiency of fuels for industrial use; elimination of brown smoke from basic, Bessemer, and oxygen converters; preparation of a complete and up-to-date metallographical atlas; abstracting technical iron and steel literature from Russian and Eastern European languages; beneficiation of siliceous iron ores by flotation; basic research on the physical chemistry of metals and slag reactions for improving the quality of pig iron and steel; combustion of unscrubbed blast-furnace gas to eliminate the need of gas-cleaning equipment; and removal of zinc from flue dust before recycling the dust in the blast furnace.[50]

---

[50] European Coal and Steel Community [Eighth General Report on the Activities of the Community]: Feb. 1, 1959, 455 pp.

Iron and Steel Scrap

By James E. Larkin [1] and Selma D. Harris [2]

DOMESTIC use of ferrous scrap for all purposes in 1959 rose 17 percent over 1958 despite a 116-day strike in the steel industry. Greater demand for domestic scrap began in January and continued until the strike began in mid-July. This period was highlighted by the record use of 22 million short tons of scrap during the second quarter. After the strike, record steel production in December required 80 percent of the total scrap used during that month.

The metallic charge in steelmaking furnaces, excluding iron ore and agglomerates, consisted of 16 and 7 percent more scrap and pig iron,

TABLE 1.—Salient statistics of ferrous scrap and pig iron in the United States, in short tons

	1958	1959
Stocks, Dec. 31: Ferrous scrap and pig iron at consumers' plants:		
Total scrap	9,593,600	9,993,488
Pig iron	3,964,269	2,979,257
Total	13,557,869	12,972,745
Consumption: Ferrous scrap and pig iron charged to—		
Steel furnaces: [1]		
Total scrap	43,023,625	49,793,577
Pig iron	51,299,102	54,698,928
Total	94,322,727	104,492,505
Iron furnaces: [2]		
Total scrap	12,431,359	15,187,580
Pig iron	5,963,234	7,074,263
Total	18,394,593	22,261,843
Miscellaneous uses [3] and ferroalloy production:		
Total scrap	904,951	1,080,359
All uses:		
Total ferrous scrap	56,359,935	66,061,516
Pig iron	57,262,336	61,773,191
Grand total	113,622,271	127,834,707
Imports of scrap (including tinplate scrap)	332,622	309,448
Export of scrap: Iron and steel	[4] 2,927,860	4,849,076
Scrap:		
Average price, per long ton, No. 1 Heavy-Melting, Pittsburgh [5]	$39.42	$43.40
Average value, per long ton, for export [6]	[4] $36.50	$38.22

[1] Includes open-hearth, basic oxygen converter, Bessemer, electric, and crucible furnaces.
[2] Includes cupola, air, and blast furnaces; also direct castings.
[3] Includes rerolling, reforging, copper precipitation, nonferrous, and chemical uses.
[4] Revised figure.
[5] Iron Age.
[6] As computed from export data obtained from Bureau of the Census.

---

[1] Commodity specialist.
[2] Statistical clerk.

respectively, than in 1958. Ferrous scrap used in 1959 in these furnaces comprised 48 percent of the combined total of scrap and pig iron used, 2 percent higher than during the previous year; however, the daily consumption rate was greater by 15 percent. A contributing factor to the change in the scrap to pig iron ratio was the greater use of scrap by a small portion of the steel industry that operated during the strike.

LEGISLATION AND GOVERNMENT PROGRAMS

On December 30, 1958, the Bureau of Foreign Commerce, U.S. Department of Commerce, announced that, beginning January 1, 1959, license applications to export ferrous scrap would be issued for a maximum validity period of 6 months. Up to January 1, 1959, because of short-supply considerations, the validity period had been set at 3 months, except for scrap destined for Mexico and offshore scrap exported to any destination.

A hearing on various aspects of the scrap industry was held on June 24, 1959, by the Monopoly Subcommittee of the Senate Small Business Committee. The findings and recommendations of this hearing at which some representatives of the steel industry and scrap industry were present, are contained in Senate Report 1013, Monopoly and Technological Problems in the Scrap Steel Industry, Report of the Select Committee on Small Business, U.S. Senate.

The U.S. Department of Commerce announced on July 2, 1959, that relaying and other used rails could be exported without a license. However, rerolling rails and scrap rails would still require a license.

Effective October 29, 1959, the U.S. Department of Commerce announced some changes in the export-licensing requirements. The changes applicable to ferrous scrap are: (1) Exporters are no longer required to file an additional copy of their export declaration with the Bureau of Customs for transmittal to the Bureau of Foreign Commerce, and (2) applications for licenses are not required to specify the quantity of each grade of scrap.

AVAILABLE SUPPLY

Consumers of ferrous scrap had a net supply made available at their plants of 66 million short tons during 1959, a 17-percent increase over the supply made available during the previous year. Home scrap produced and scrap received from dealers and other sources increased 11 and 24 percent, respectively. These data exclude scrap on hand at dealers' yards.

TABLE 2.—Ferrous scrap supply [1] available for consumption in 1959, by districts and States, in short tons

District and State	Home production	Receipts from dealers and all others	Total new supply	Shipments[2]	New supply available for consumption
Connecticut	75, 264	80, 468	155, 732	7, 035	148, 697
Maine and New Hampshire	7, 257	10, 187	17, 444	514	16, 930
Massachusetts	124, 831	133, 214	258, 045	25, 207	232, 838
Rhode Island	40, 059	58, 979	99, 038	2, 262	96, 776
Vermont	9, 652	9, 863	19, 515	34	19, 481
Total, New England: 1959	257, 063	292, 711	549, 774	35, 052	514, 722
1958	248, 252	267, 765	516, 017	44, 940	471, 077
New Jersey	164, 016	450, 616	614, 632	19, 807	594, 825
New York	1, 553, 252	1, 453, 408	3, 006, 660	57, 663	2, 948, 997
Pennsylvania	8, 762, 704	5, 629, 245	14, 391, 949	609, 237	13, 782, 712
Total, Middle Atlantic: 1959	10, 479, 972	7, 533, 269	18, 013, 241	686, 707	17, 326, 534
1958	9, 626, 604	5, 757, 055	15, 383, 659	653, 699	14, 729, 960
Illinois	3, 438, 185	3, 366, 393	6, 804, 578	216, 646	6, 587, 932
Indiana	4, 326, 539	2, 639, 884	6, 966, 423	139, 619	6, 826, 804
Michigan	2, 904, 092	2, 705, 172	5, 609, 264	38, 698	5, 570, 566
Ohio	7, 224, 137	5, 048, 884	12, 273, 021	348, 898	11, 924, 123
Wisconsin	545, 819	517, 291	1, 063, 110	126, 549	936, 561
Total, East North Central: 1959	18, 438, 772	14, 277, 624	32, 716, 396	870, 410	31, 845, 986
1958	15, 637, 097	11, 507, 262	27, 144, 359	739, 145	26, 405, 214
Iowa	156, 462	284, 816	441, 278	2, 570	438, 708
Kansas and Nebraska	55, 692	113, 912	169, 604	2, 180	167, 424
Minnesota, North Dakota, and South Dakota	215, 169	237, 660	452, 829	2, 236	450, 593
Missouri	179, 309	712, 490	891, 799	[3] 3, 121	894, 920
Total, West North Central: 1959	606, 632	1, 348, 878	1, 955, 510	3, 865	1, 951, 645
1958	543, 620	1, 240, 614	1, 784, 234	8, 589	1, 775, 645
Delaware, District of Columbia, and Maryland	2, 047, 184	690, 145	2, 737, 329	60, 872	2, 676, 457
Florida and Georgia	68, 005	244, 279	312, 284	1, 364	310, 920
North Carolina	26, 504	52, 070	78, 574	7, 975	70, 599
South Carolina	16, 348	10, 140	26, 488	----------	26, 488
Virginia and West Virginia	844, 868	863, 174	1, 708, 042	25, 317	1, 682, 725
Total, South Atlantic: 1959	3, 002, 909	1, 859, 808	4, 862, 717	95, 528	4, 767, 189
1958	2, 954, 859	1, 325, 652	4, 280, 511	53, 174	4, 227, 337
Alabama	1, 287, 131	1, 246, 688	2, 533, 819	202, 979	2, 330, 840
Kentucky, Mississippi, and Tennessee	546, 317	922, 745	1, 469, 062	51, 636	1, 417, 426
Total, East South Central: 1959	1, 833, 448	2, 169, 433	4, 002, 881	254, 615	3, 748, 266
1958	1, 891, 835	1, 935, 311	3, 827, 146	211, 566	3, 615, 580
Arkansas, Louisiana, and Oklahoma	50, 439	145, 666	196, 105	1, 016	195, 089
Texas	685, 461	1, 027, 207	1, 712, 668	37, 639	1, 675, 029
Total, West South Central: 1959	735, 900	1, 172, 873	1, 908, 773	38, 655	1, 870, 118
1958	612, 671	901, 087	1, 513, 758	9, 236	1, 504, 522
Arizona, Nevada, and New Mexico	18, 185	65, 359	83, 544	2, 135	81, 409
Colorado and Utah	891, 300	634, 955	1, 526, 255	7, 610	1, 518, 645
Idaho and Montana	3, 399	11, 694	15, 093	1	15, 092
Total, Rocky Mountain: 1959	912, 884	712, 008	1, 624, 892	9, 746	1, 615, 146
1958	1, 046, 755	498, 288	1, 545, 043	18, 157	1, 526, 886
California	1, 035, 073	1, 359, 344	2, 394, 417	81, 262	2, 313, 155
Oregon	45, 921	173, 541	219, 462	5, 956	213, 506
Washington	69, 625	228, 763	298, 388	3, 251	295, 137
Total, Pacific Coast: 1959	1, 150, 619	1, 761, 648	2, 912, 267	90, 469	2, 821, 798
1958	1, 151, 842	1, 676, 479	2, 828, 321	80, 393	2, 747, 928
Total, United States: 1959	37, 418, 199	31, 128, 252	68, 546, 451	2, 085, 047	66, 461, 404
1958	33, 713, 535	25, 109, 513	58, 823, 048	1, 818, 899	57, 004, 149

[1] New supply available for consumption is a net figure computed by adding home production to receipts from dealers and all others and deducting consumers scrap shipped, transferred, or otherwise disposed of during the year. The plus or minus differences in stock levels at the beginning and end of the year are not taken into consideration.

[2] Includes scrap shipped, transferred, or otherwise disposed of during the year.

[3] Data shown in shipments column are plus figures owing to adjustments in accounting procedures.

TABLE 3.—Consumption of ferrous scrap and pig iron in the United States in 1959, by type of consumer and type of furnace, in short tons

Type of furnace or equipment	Type of consumer		
	Manufacturers of steel ingots and castings [1]		
	Total scrap	Pig iron	Total scrap and pig iron
Open-hearth	38,018,851	51,136,138	89,154,989
Basic oxygen converter	580,501	1,574,261	2,154,762
Bessemer	191,041	1,481,734	1,672,775
Electric [2]	8,507,137	336,588	8,843,725
Total steelmaking furnaces	47,297,530	54,528,721	101,826,251
Cupola	820,419	451,846	1,272,265
Air	29,666	10,402	40,068
Blast [3]	3,188,586	----------	3,188,586
Direct castings	----------	1,384,327	1,384,327
Miscellaneous	182,321	----------	182,321
Total: 1959	51,518,522	56,375,296	107,893,818
1958	44,834,040	52,914,977	97,749,017
	Manufacturers of steel castings [4]		
Open-hearth	638,415	114,334	752,749
Bessemer	9,698	675	10,373
Electric	1,638,607	31,667	1,670,274
Total steelmaking furnaces	2,286,720	146,676	2,433,396
Cupola	468,476	20,925	489,401
Air	299,392	49,306	348,698
Total: 1959	3,054,588	216,907	3,271,495
1958	2,242,439	147,114	2,389,553
	Iron foundries and miscellaneous users		
Bessemer	2,465	476	2,941
Electric [2]	206,862	23,055	229,917
Total steelmaking furnaces	209,327	23,531	232,858
Cupola	9,437,670	3,939,345	13,377,015
Air	943,371	191,024	1,134,395
Direct castings	----------	1,027,088	1,027,088
Ferroalloy	315,199	----------	315,199
Miscellaneous	582,839	----------	582,839
Total: 1959	11,488,406	5,180,988	16,669,394
1958	9,283,456	4,200,245	13,483,701
	Total		
Open-hearth	38,657,266	51,250,472	89,907,738
Basic oxygen converter	580,501	1,574,261	2,154,762
Bessemer	203,204	1,482,885	1,686,089
Electric [2]	10,352,606	391,310	10,743,916
Total steelmaking furnaces	49,793,577	54,698,928	104,492,505
Cupola	10,726,565	4,412,116	15,138,681
Air	1,272,429	250,732	1,523,161
Blast [3]	3,188,586	----------	3,188,586
Direct castings	----------	2,411,415	2,411,415
Ferroalloy	315,199	----------	315,199
Miscellaneous	765,160	----------	765,160
Total: 1959	66,061,516	61,773,191	127,834,707
1958	56,359,935	57,262,336	113.622,271

[1] Includes only those castings made by companies producing steel ingots.
[2] Includes small quantities of scrap and pig iron consumed in crucible furnaces.
[3] Includes consumption in all blast furnaces producing pig iron.
[4] Excludes companies that produce both steel ingots and steel castings.

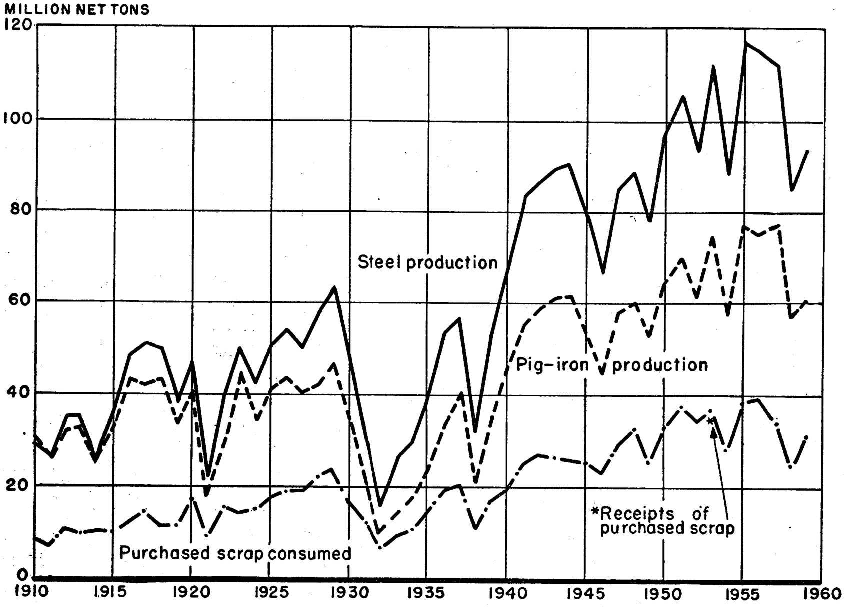

FIGURE 1.—Consumption of purchased scrap in the United States, 1910–52, and output of pig iron and steel, 1910–59. Figures on consumption of purchased scrap for 1910–32, are from *State of Minnesota* v. *Oliver Iron Mining Co., et al.*, Exhibits, vol. 5, 1935, p. 328; those for 1933–34 are estimated by authors; and those for 1935–52 are based on Bureau of Mines records. Data for 1953–59 represent receipts of purchased scrap by consumers, based on Bureau of Mines records. Data on steel output were supplied by the American Iron and Steel Institute.

TABLE 4.—Proportion of ferrous scrap and pig iron used in furnaces in the United States, in percent

Type of furnace	1958		1959	
	Scrap	Pig iron	Scrap	Pig iron
Open-hearth	41.5	58.5	43.0	57.0
Basic oxygen converter	----	----	26.9	73.1
Bessemer	[1] 19.3	[1] 80.7	12.1	87.9
Electric [2]	96.9	3.1	96.4	3.6
Cupola	70.0	30.0	70.9	29.1
Air	82.9	17.1	83.5	16.5

[1] Includes oxygen-steel process.
[2] Includes crucible furnaces.

CONSUMPTION BY DISTRICTS AND STATES

The use of domestic scrap for all purposes was greater in eight of the nine geographical areas. The greatest increase tonnagewise was in the East North Central district; whereas the greatest percentage increase occurred in the West South Central district. As in previous years, the largest consuming districts for scrap were East North Central, Middle Atlantic, and South Atlantic. The States consuming the largest quantities of scrap, and the percentages consumed, were Pennsylvania, 21 (20 in 1958); Ohio, 18 (16 in 1958); Indiana, 10 (12 in 1958); and Illinois, 10 (10 in 1958).

TABLE 5.—Consumption of ferrous scrap and pig iron in the United States in 1959, by districts and States, in short tons

District and State	Total scrap	Pig iron	Total scrap and pig iron
Connecticut	143, 617	34, 047	177, 664
Maine and New Hampshire	17, 012	4, 195	21, 207
Massachusetts	231, 871	77, 114	308, 985
Rhode Island	99, 682	45, 792	145, 474
Vermont	20, 802	8, 329	29, 131
Total New England: 1959	512, 984	169, 477	682, 461
1958	482, 974	158, 584	641, 558
New Jersey	579, 320	149, 673	728, 993
New York	2, 957, 426	2, 988, 093	5, 945, 519
Pennsylvania	13, 866, 340	15, 489, 188	29, 355, 528
Total Middle Atlantic: 1959	17, 403, 086	18, 626, 954	36, 030, 040
1958	14, 422, 484	17, 215, 667	31, 638, 151
Illinois	6, 590, 717	5, 141, 524	11, 732, 241
Indiana	6, 722, 993	7, 296, 402	14, 019, 395
Michigan	5, 444, 200	4, 138, 861	9, 583, 061
Ohio	11, 971, 285	11, 574, 983	23, 546, 268
Wisconsin	920, 983	255, 452	1, 176, 435
Total East North Central: 1959	31, 650, 178	28, 407, 222	60, 057, 400
1958	26, 245, 699	25, 110, 682	51, 356, 381
Iowa	440, 198	93, 718	533, 916
Kansas and Nebraska	164, 125	5, 251	169, 376
Minnesota, North Dakota, and South Dakota	453, 920	432, 814	886, 734
Missouri	843, 155	73, 518	916, 673
Total West North Central: 1959	1, 901, 398	605, 301	2, 506, 699
1958	1, 753, 594	517, 589	2, 271, 183
Delaware, District of Columbia, and Maryland	2, 746, 351	3, 554, 242	6, 300, 593
Florida and Georgia	316, 504	13, 850	330, 354
North Carolina	70, 382	24, 732	95, 114
South Carolina	32, 923	17, 846	50, 769
Virginia and West Virginia	1, 586, 706	2, 449, 489	4, 036, 195
Total South Atlantic: 1959	4, 752, 866	6, 060, 159	10, 813, 025
1958	4, 268, 434	6, 302, 868	10, 571, 302
Alabama	2, 262, 418	3, 125, 492	5, 387, 910
Kentucky, Mississippi, and Tennessee	1, 384, 621	771, 705	2, 156, 326
Total East South Central: 1959	3, 647, 039	3, 897, 197	7, 544, 236
1958	3, 626, 749	3, 847, 979	7, 474, 728
Arkansas, Louisiana, and Oklahoma	204, 756	7, 222	211, 978
Texas	1, 702, 897	768, 110	2, 471, 007
Total West South Central: 1959	1, 907, 653	775, 332	2, 682, 985
1958	1, 455, 215	779, 517	2, 234, 732
Arizona, Nevada, and New Mexico	84, 824	142	84, 966
Colorado and Utah	1, 399, 448	1, 846, 990	3, 246, 438
Idaho, Montana, and Wyoming	14, 443	309	14, 752
Total Rocky Mountain: 1959	1, 498, 715	1, 847, 441	3, 346, 156
1958	1, 528, 093	2, 044, 568	3, 572, 661
California	2, 279, 668	1, 379, 104	3, 658, 772
Oregon	214, 781	1, 904	216, 685
Washington	293, 148	3, 100	296, 248
Total Pacific Coast: 1959	2, 787, 597	1, 384, 108	4, 171, 705
1958	2, 576, 693	1, 284, 882	3, 861, 575
Total United States: 1959	66, 061, 516	61, 773, 191	127, 834, 707
1958	56, 359, 935	57, 262, 336	113, 622, 271

TABLE 6.—Consumption of ferrous scrap and pig iron by districts and States, by type of manufacturers, 1959, in short tons

District and State	Steel ingots and castings[1]		Steel castings[2]		Iron foundries and miscellaneous users	
	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron
Connecticut	45,278	------	4,297	271	94,042	33,776
Maine and New Hampshire	------	------	2,829	101	14,183	4,094
Massachusetts	105	------	17,454	2,609	214,312	74,505
Rhode Island	63,247	28,769	------	------	36,435	17,023
Vermont	------	------	------	------	20,802	8,329
Total New England: 1959	108,630	28,769	24,580	2,981	379,774	137,727
1958	124,847	45,438	33,718	4,517	324,409	108,629
New Jersey	147,988	32,295	49,931	1,645	381,401	115,733
New York	2,310,045	2,824,771	117,107	7,529	530,274	155,793
Pennsylvania	12,678,270	14,685,235	429,536	70,852	758,534	733,101
Total Middle Atlantic: 1959	15,136,303	17,542,301	596,574	80,026	1,670,209	1,004,627
1958	12,480,185	16,333,998	491,496	51,728	1,450,803	829,941
Illinois	5,035,148	4,630,165	360,693	25,979	1,194,876	485,380
Indiana	5,846,662	6,992,748	171,429	14,872	704,902	288,782
Michigan	3,208,077	3,468,452	185,137	3,170	2,050,986	667,239
Ohio	10,126,783	10,845,031	517,610	52,440	1,326,892	677,512
Wisconsin	------	------	258,581	5,657	662,402	249,795
Total East North Central: 1959	24,216,670	25,936,396	1,493,450	102,118	5,940,058	2,368,708
1958	20,738,696	23,135,317	1,018,187	70,480	4,488,816	1,904,885
Iowa	------	------	38,468	578	401,730	93,140
Kansas and Nebraska	------	------	114,392	516	49,733	4,735
Minnesota, North Dakota, and South Dakota	260,825	383,579	33,594	230	159,501	49,005
Missouri	564,806	25,441	119,522	14,587	158,827	33,490
Total West North Central: 1959	825,631	409,020	305,976	15,911	769,791	180,370
1958	984,937	370,989	168,691	6,047	599,966	140,553
Delaware, District of Columbia, and Maryland	2,639,871	3,506,068	28,419	172	78,061	48,002
Florida and Georgia	268,642	------	11,253	106	36,609	13,744
North Carolina	------	------	------	------	70,382	24,732
South Carolina	------	------	------	------	32,923	17,846
Virginia and West Virginia	1,213,185	2,339,336	65,671	7,495	307,850	102,658
Total South Atlantic: 1959	4,121,698	5,845,404	105,343	7,773	525,825	206,982
1958	3,749,194	6,121,600	91,934	7,526	427,306	173,742
Alabama	1,455,544	2,251,721	45,975	124	760,899	873,647
Kentucky, Mississippi, and Tennessee	912,272	553,811	39,198	1,277	433,151	216,617
Total East South Central: 1959	2,367,816	2,805,532	85,173	1,401	1,194,050	1,090,264
1958	2,427,765	2,950,946	83,131	1,539	1,115,853	895,494
Arkansas, Louisiana, and Oklahoma	106,610	1,034	52,341	1,231	45,805	4,957
Texas	1,252,666	742,267	103,403	646	346,828	25,197
Total West South Central: 1959	1,359,276	743,301	155,744	1,877	392,633	30,154
1958	1,012,622	747,215	120,357	1,310	322,236	30,992
Arizona, Nevada, and New Mexico	------	------	48,941	74	35,883	68
Colorado and Utah	1,215,618	1,794,838	27,155	581	156,675	51,571
Idaho, Montana, and Wyoming	------	------	------	------	14,443	309
Total Rocky Mountain: 1959	1,215,618	1,794,838	76,096	655	207,001	51,948
1958	1,302,619	1,998,298	50,259	891	175,215	45,379

See footnotes at end of table.

TABLE 6.—Consumption of ferrous scrap and pig iron by districts and States, by type of manufacturers, 1959, in short tons—Continued

District and State	Steel ingots and castings [1]		Steel castings [2]		Iron foundries and miscellaneous users	
	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron
California	1,787,463	1,269,735	135,104	2,408	357,101	106,961
Oregon	146,539		39,606	216	28,636	1,688
Washington	232,878		36,942	1,541	23,328	1,559
Total Pacific Coast: 1959	2,166,880	1,269,735	211,652	4,165	409,065	110,208
1958	2,013,175	1,211,176	184,666	3,076	378,852	70,630
Total United States: 1959	51,518,522	56,375,296	3,054,588	216,907	11,488,406	5‘180,988
1958	44,834,040	52,914,977	2,242,439	147,114	9,283,456	4,200,245

[1] Includes only those castings made by companies producing steel ingots.

[2] Excludes companies that produce both steel ingots and steel castings.

TABLE 7.—Consumption of ferrous scrap and pig iron in open-hearth furnaces in the United States in 1959, by districts and States, in short tons

District and State	Total scrap	Pig iron	Total scrap and pig iron
Massachusetts, New Jersey, and Rhode Island	211,039	61,676	272,715
New York	2,085,236	2,824,999	4,910,235
Pennsylvania	9,960,128	13,301,590	23,261,718
Total New England and Middle Atlantic: 1959	12,256,403	16,188,265	28,444,668
1958	10,000,747	14,974,310	24,975,057
Illinois	3,622,889	4,115,022	7,737,911
Indiana	5,772,583	6,998,399	12,770,982
Michigan and Wisconsin	1,835,928	2,637,914	4,473,842
Ohio	6,741,469	9,379,075	16,120,544
Total, East North Central: 1959	17,972,869	23,130,410	41,103,279
1958	16,095,971	20,555,435	36,651,406
Minnesota and Missouri	573,395	422,680	996,075
Total, West North Central: 1959	573,395	422,680	996,750
1958	619,705	375,339	995.044
Delaware, Maryland, and West Virginia	3,432,624	5,833,605	9,266,229
Total, South Atlantic: 1959	3,432,624	5,833,605	9,266,229
1958	3,214,114	6,102,484	9,316,598
Alabama, Kentucky, Tennessee, and Texas	2,120,279	3,231,750	5,352,029
Total, East and West South Central: 1959	2,120,279	3,231,750	5,352,029
1958	1,946,664	3,399,388	5,346,052
California, Colorado, Utah	2,301,696	2,443,762	4,745,458
Total, Rocky Mountain and Pacific Coast: 1959	2,301,696	2,443,762	4,745,458
1958	2,464,865	3,000,581	5,465,446
Total, United States: 1959	38,657,266	51,250,472	89,907,738
1958	34,342,066	48,407,537	82,749,603

TABLE 8.—Consumption of ferrous scrap and pig iron in Bessemer converters in the United States in 1959, by districts and States, in short tons

District and State	Total scrap	Pig iron	Total scrap and pig iron
Connecticut and New Jersey	936	132	1,068
Pennsylvania	86,051	312,095	398,146
Total, New England and Middle Atlantic: 1959	86,987	312,227	399,214
1958	249,766	792,301	1,042,067
Illinois, Michigan, and Ohio	110,638	1,170,528	1,281,166
Total, East North Central: 1959	110,638	1,170,528	1,281,166
1958	373,688	1,835,517	2,209,205
Delaware, Maryland, and Louisiana	5,242	117	5,359
Total, South Atlantic and West South Central: 1959	5,242	117	5,359
1958	5,266	78	5,344
California, Colorado, and Washington	337	13	350
Total, Rocky Mountain and Pacific Coast: 1959	337	13	350
1958	2,637	8,010	10,647
Total, United States: 1959	203,204	1,482,885	1,686,089
1958	631,357	2,635,906	3,267,263

TABLE 9.—Consumption of ferrous scrap and pig iron in electric[1] steel furnaces in the United States in 1959, by districts and States, in short tons

District and State	Total scrap	Pig iron	Total scrap and pig iron
Connecticut and New Hampshire	57,651	816	58,467
Massachusetts	19,305	1,134	20,439
Total, New England: 1959	76,956	1,950	78,906
1958	52,499	1,312	53,811
New Jersey	25,385	2,143	27,528
New York	166,180	3,639	169,819
Pennsylvania	1,774,097	27,047	1,801,144
Total, Middle Atlantic: 1959	1,965,662	32,829	1,998,491
1958	1,559,047	26,872	1,585,919
Illinois	1,312,658	201,559	1,514,217
Indiana	129,471	2,705	132,176
Michigan	874,396	21,697	896,093
Ohio	2,299,463	30,583	2,330,046
Wisconsin	172,866	4,143	177,009
Total, East North Central: 1959	4,788,854	260,687	5,049,541
1958	3,338,344	151,254	3,489,598
Iowa, Kansas, and Nebraska	153,669	1,135	154,804
Minnesota	22,697	230	22,927
Missouri	327,996	706	328,702
Total, West North Central: 1959	504,362	2,071	506,433
1958	494,833	1,552	496,385
Delaware, District of Columbia, and Maryland	110,372	1,318	111,690
Florida and Georgia	279,896	105	280,001
Virginia and West Virginia	141,003	204	141,207
Total, South Atlantic: 1959	531,271	1,627	532,898
1958	375,942	1,431	377,373
Alabama	449,244	80,061	529,305
Kentucky, Mississippi, and Tennessee	386,555	2,801	389,356
Total, East South Central: 1959	835,799	82,862	918,661
1958	782,298	66,560	848,858
Arkansas, Louisiana, and Oklahoma	150,768	1,231	151,999
Texas	409,214	3,649	412,863
Total, West South Central: 1959	559,982	4,880	564,862
1958	477,415	3,188	480,603
Arizona, Colorado, Nevada, and Utah	69,036	403	69,439
Total, Rocky Mountain: 1959	69,036	403	69,439
1958	46,196	936	47,132
California	570,063	3,115	573,178
Oregon	186,145	216	186,361
Washington	264,476	670	265,146
Total, Pacific Coast: 1959	1,020,684	4,001	1,024,685
1958	923,628	2,554	926,182
Total, United States: 1959	10,352,606	391,310	10,743,916
1958	8,050,202	255,659	8,305,861

---

[1] Includes small quantities of scrap and pig iron consumed in crucible furnaces.

TABLE 10.—Consumption of ferrous scrap and pig iron in cupola furnaces in the United States in 1959, by districts and States, in short tons

District and State	Total scrap	Pig iron	Total scrap and pig iron
Connecticut	51,916	27,428	79,344
Maine and New Hampshire	11,961	2,783	14,744
Massachusetts	188,201	71,513	259,714
Rhode Island	36,436	17,023	53,459
Vermont	20,802	8,328	29,130
Total, New England: 1959	309,316	127,075	436,391
1958	255,143	100,567	355,710
New Jersey	292,244	114,602	406,846
New York	394,362	148,157	542,519
Pennsylvania	593,742	244,320	838,062
Total, Middle Atlantic: 1959	1,280,348	507,079	1,787,427
1958	1,157,883	479,809	1,637,692
Illinois	930,927	239,335	1,170,262
Indiana	616,849	274,418	891,267
Michigan	2,323,726	775,851	3,099,577
Ohio	1,411,078	506,679	1,917,757
Wisconsin	584,296	223,489	807,785
Total, East North Central: 1959	5,866,876	2,019,772	7,886,648
1958	4,354,971	1,593,150	5,948,121
Iowa	261,808	89,547	351,355
Kansas and Nebraska	49,733	4,734	54,467
Minnesota, North Dakota, and South Dakota	164,812	46,040	210,852
Missouri	148,062	31,033	179,095
Total, West North Central: 1959	624,415	171,354	795,769
1958	513,750	133,918	647,668
Delaware and Maryland	82,731	56,916	139,647
Florida	8,241	2,828	11,069
Georgia	26,840	10,916	37,756
North Carolina	70,328	24,732	95,060
South Carolina	31,690	17,847	49,537
Virginia	295,061	35,528	330,589
West Virginia	22,782	65,036	87,818
Total, South Atlantic: 1959	537,673	213,803	751,476
1958	438,738	190,964	629,702
Alabama	686,266	876,945	1,563,211
Kentucky and Mississippi	128,987	66,667	195,654
Tennessee	300,378	150,581	450,959
Total, East South Central: 1959	1,115,631	1,094,193	2,209,824
1958	1,075,424	978,261	2,053,685
Arkansas, Louisiana, and Oklahoma	50,129	5,991	56,120
Texas	363,149	87,138	450,287
Total, West South Central: 1959	413,278	93,129	506,407
1958	350,255	91,946	442,201
Colorado	85,973	28,996	114,969
Utah	82,503	46,662	129,165
Idaho and Montana	9,335	310	9,645
Total, Rocky Mountain: 1959	177,811	75,968	253,779
1958	143,013	70,738	213,751
California	350,133	105,638	455,771
Oregon	27,799	1,688	29,487
Washington	23,285	2,417	25,702
Total, Pacific Coast: 1959	401,217	109,743	510,960
1958	364,651	70,062	434,713
Total, United States: 1959	10,726,565	4,412,116	15,138,681
1958	8,653,828	3,709,415	12,363,243

TABLE 11.—Consumption of ferrous scrap and pig iron in air furnaces in the United States in 1959, by districts and States, in short tons

District and State	Total scrap	Pig iron	Total scrap and pig iron
Connecticut	35, 942	5, 771	41, 713
Massachusetts and New Hampshire	12, 838	5, 157	17, 995
Total, New England: 1959	48, 780	10, 928	59, 708
1958	44, 659	9, 106	53, 765
New Jersey and New York	27, 303	11, 038	38, 341
Pennsylvania	148, 385	47, 064	195, 449
Total, Middle Atlantic: 1959	175, 688	58, 102	233, 790
1958	132, 642	44, 626	177, 268
Illinois	199, 001	29, 973	228, 974
Indiana	93, 541	20, 381	113, 922
Michigan	160, 206	10, 586	170, 792
Ohio	399, 060	73, 050	472, 110
Wisconsin	109, 333	24, 825	134, 158
Total, East North Central: 1959	961, 141	158, 815	1, 119, 956
1958	673, 614	118, 415	792, 029
Iowa, Minnesota, and Missouri	13, 331	9, 013	22, 344
Total, West North Central: 1959	13, 331	9, 013	22, 344
1958	10, 203	6, 646	16, 849
Delaware, North Carolina, and West Virginia	20, 253	11, 005	31, 258
Total, South Atlantic: 1959	20, 253	11, 005	31, 258
1958	14, 426	7, 911	22, 337
Alabama and Texas	44, 961	2, 226	47, 187
Total, East and West South Central: 1959	44, 961	2, 226	47, 187
1958	33, 603	1, 865	35, 468
California	8, 275	643	8, 918
Total, Pacific Coast: 1959	8, 275	643	8, 918
1958	11, 085	1, 103	12, 188
Total, United States: 1959	1, 272, 429	250, 732	1, 523, 161
1958	920, 232	189, 672	1, 109, 904

TABLE 12.—Consumption of ferrous scrap in blast furnaces in the United States in 1959, by districts and States, in short tons

District and State	Total scrap
Massachusetts and New York	154, 294
Pennsylvania	1, 027, 609
Total, New England and Middle Atlantic:	
1959	1, 181, 903
1958	1, 173, 309
Illinois	363, 890
Indiana	108, 944
Michigan and Minnesota	51, 328
Ohio	876, 152
Total, East and West North Central:	
1959	1, 400, 314
1958	1, 118, 973
Alabama	197, 264
Kentucky, Maryland, Tennessee, Texas, and West Virginia	333, 062
Total, South Atlantic, East and West South Central:	
1959	530, 326
1958	506, 147
California, Colorado, and Utah	76, 043
Total, Rocky Mountain and Pacific Coast:	
1959	76, 043
1958	58, 870
Total, United States:	
1959	3, 188, 586
1958	2, 857, 299

TABLE 13.—Consumption of ferrous scrap by feroalloy producers in the United States in 1959, by districts, in short tons

District	Total scrap
Middle Atlantic: 1959	47,691
1958	19,840
East North Central: 1959	53,782
1958	32,652
West North Central: 1959	135,374
1958	72,818
South Atlantic: 1959	13,671
1958	5,765
East South Central: 1959	59,148
1958	53,417
Pacific Coast: 1959	5,533
1958	8,034
United States: 1959	315,199
1958	192,526

TABLE 14.—Consumption of ferrous scrap in miscellaneous uses in the United States in 1959, by districts and States, in short tons

District and State	Total scrap
Connecticut and Massachuetts	11,677
Total, New England: 1959	11,677
1958	15,527
New Jersey	114,818
New York	83,974
Pennsylvania	86,187
Total, Middle Atlantic: 1959	284,979
1958	244,400
Illinois	144,953
Indiana	1,605
Michigan and Wisconsin	14,835
Ohio	80,388
Total, East North Central: 1959	241,781
1958	263,726
Minnesota	489
Missouri	43,312
Total, West North Central: 1959	43,801
1958	36,044
Georgia, Virginia, and West Virginia	20,746
Total, South Atlantic: 1959	20,746
1958	12,398
Alabama and Texas	66,674
Total East South Central and West South Central: 1959	66,674
1958	58,523
Arizona, Idaho, and Montana	37,778
Colorado and Utah	3,766
Total, Rocky Mountain: 1959	41,544
1958	40,729
California and Washington	53,958
Total, Pacific Coast: 1959	53,958
1958	41,078
Total, United States: 1959	765,160
1958	712,425

TABLE 15.—Consumption of ferrous scrap by grades, by districts and States, in 1959, in short tons

District and State	No. 1 Heavy-Melting steel	No. 2 Heavy-Melting steel	No. 1 and electric-furnace bundles	No. 2 and all other bundles	Low-phosphorus scrap	Cast-iron scrap, other than borings	All others
Connecticut	4,275	--------	1,591	451	36,623	35,650	65,027
Maine and New Hampshire	2,746	--------	--------	--------	317	11,671	2,278
Massachusetts	10,100	1,062	--------	--------	14,365	166,130	40,214
Rhode Island	756	33,471	3,650	--------	14,658	21,349	25,798
Vermont	3,376	486	--------	--------	--------	16,940	--------
Total, New England	21,253	35,019	5,241	451	65,963	251,740	133,317
New Jersey	8,711	19,460	40,345	29,985	46,744	264,771	169,304
New York	1,222,870	63,336	160,894	254,914	104,122	376,515	774,775
Pennsylvania	5,283,076	653,599	1,256,266	577,564	821,293	1,468,423	3,806,119
Total, Middle Atlantic	6,514,657	736,395	1,457,505	862,463	972,159	2,109,709	4,750,198
Illinois	1,918,600	828,916	411,193	626,366	360,314	858,008	1,587,320
Indiana	3,202,005	162,168	904,404	271,963	230,200	680,865	1,271,388
Michigan	713,693	3,438	740,470	349,659	532,627	1,357,461	1,746,852
Ohio	3,421,151	516,359	998,197	522,742	1,117,186	1,433,307	3,962,343
Wisconsin	74,774	17,582	1,186	38,861	237,572	319,692	231,316
Total, East North Central	9,330,223	1,528,463	3,055,450	1,809,591	2,477,899	4,649,333	8,799,219
Iowa	29,901	13,134	--------	3,234	38,910	190,492	164,527
Kansas and Nebraska	3,513	--------	--------	--------	65,884	45,136	49,592
Minnesota, North Dakota, and South Dakota	105,493	50,531	752	31,403	15,027	151,404	99,310
Missouri	46,259	512,866	--------	12,167	22,617	174,907	74,339
Total, West North Central	185,166	576,531	752	46,804	142,438	561,939	387,768
Delaware, District of Columbia, and Maryland	1,308,608	93,019	206,713	126,898	32,964	246,628	731,521
Florida and Georgia	90,578	128,792	81	3,400	2,856	29,636	61,161
North Carolina	--------	--------	--------	--------	1,358	65,680	3,344
South Carolina	54	--------	--------	--------	--------	25,533	7,336
Virginia and West Virginia	93,697	119,991	69,169	222,536	69,930	273,343	738,040
Total, South Atlantic	1,492,937	341,802	275,963	352,834	107,108	640,820	1,541,402
Alabama	617,284	139,871	108,700	243,681	53,909	691,275	407,698
Kentucky, Mississippi, and Tennessee	507,531	110,036	80,772	118,169	50,367	326,885	190,861
Total, East South Central	1,124,815	249,907	189,472	361,850	104,276	1,018,160	598,559
Arkansas, Louisiana, and Oklahoma	--------	84,883	--------	17,093	47,030	42,591	13,159
Texas	76,022	813,883	5,929	136,325	85,262	403,138	182,338
Total, West South Central	76,022	898,766	5,929	153,418	132,292	445,729	195,497
Arizona, Nevada, and New Mexico	5,582	--------	--------	--------	--------	1,034	78,208
Colorado and Utah	764,401	39,861	5,417	35,059	3,031	268,285	283,394
Idaho, Montana, and Wyoming	--------	--------	--------	--------	--------	8,508	5,935
Total, Rocky Mountain	769,983	39,861	5,417	35,059	3,031	277,827	367,537
California	966,168	201,292	154,647	177,445	60,842	406,128	313,146
Oregon	71,657	52,691	22,990	--------	2,754	23,353	41,336
Washington	121,896	55,853	3,451	39,771	16,889	25,576	29,712
Total, Pacific Coast	1,159,721	309,836	181,088	217,216	80,485	455,057	384,194
Total, United States	20,674,777	4,716,580	5,176,817	3,839,686	4,085,651	10,410,314	17,157,691

STOCKS

Consumers' Stocks.—Total ferrous-scrap stocks held by consumers fluctuated during the first 5 months of the year, but by June 30 they had begun to rise and reached a record level of 9,993,000 short tons on December 31, 1959. These stocks were 4 percent greater than at the beginning of the year and were equivalent to a 55-day supply at an average daily scrap-consumption rate of 181,000 short tons. Increases occurred in seven of the nine districts; the largest increase—

TABLE 16.—Consumers' stocks of ferrous scrap and pig iron on hand in the United States by districts and States, in short tons

District and State	Dec. 31, 1958		Dec. 31, 1959	
	Total scrap	Pig iron	Total scrap	Pig iron
Connecticut	16, 897	5, 011	21, 448	8, 508
Maine and New Hampshire	1, 578	165	1, 443	358
Massachusetts	32, 827	68, 279	32, 769	52, 634
Rhode Island	10, 014	4, 873	9, 192	3, 172
Vermont	2, 023	556	1, 697	826
Total, New England	63, 339	78, 884	66, 549	65, 498
New Jersey	82, 338	33, 820	96, 861	31, 337
New York	727, 497	408, 042	725, 741	314, 495
Pennsylvania	2, 148, 016	1, 001, 960	2, 000, 858	478, 193
Total, Middle Atlantic	2, 957, 851	1, 443, 822	2, 823, 460	824, 025
Illinois	989, 465	250, 594	1, 035, 819	253, 120
Indiana	1, 009, 923	165, 723	1, 125, 334	165, 515
Michigan	410, 010	283, 014	521, 064	244, 716
Ohio	1, 464, 214	676, 217	1, 409, 411	405, 694
Wisconsin	64, 039	21, 578	78, 308	32, 689
Total, East North Central	3, 937, 651	1, 397, 126	4, 169, 936	1, 101, 734
Iowa	38, 568	21, 297	36, 866	28, 037
Kansas and Nebraska	14, 565	555	17, 417	582
Minnesota, North Dakota, and South Dakota	131, 861	85, 784	132, 457	82, 466
Missouri	202, 057	29, 023	251, 476	21, 332
Total, West North Central	387, 051	136, 659	438, 216	132, 417
Delaware, District of Columbia, and Maryland	329, 380	193, 296	258, 138	147, 827
Florida and Georgia	16, 156	1, 481	24, 643	2, 061
North Carolina	5, 398	1, 631	4, 935	2, 217
South Carolina	2, 349	2, 464	2, 366	2, 924
Virginia and West Virginia	169, 624	23, 905	260, 929	65, 867
Total, South Atlantic	522, 907	222, 777	551, 011	220, 896
Alabama	242, 424	325, 999	319, 050	343, 260
Kentucky, Mississippi, and Tennessee	192, 335	90, 774	225, 344	82, 752
Total, East South Central	434, 759	416, 773	544, 394	426, 012
Arkansas, Louisiana, and Oklahoma	37, 801	1, 515	23, 112	1, 986
Texas	356, 454	29, 331	332, 987	28, 225
Total, West South Central	394, 255	30, 846	356, 099	30, 211
Arizona, Nevada, and New Mexico	21, 098	63	17, 385	157
Colorado and Utah	183, 273	167, 334	302, 479	115, 437
Idaho, Montana, and Wyoming	5, 396	218	6, 045	475
Total, Rocky Mountain	209, 767	167, 615	325, 909	116, 069
California	518, 231	68, 737	539, 577	60, 576
Oregon	47, 257	114	51, 020	253
Washington	120, 532	916	127, 317	1, 566
Total, Pacific Coast	686, 020	69, 767	717, 914	62, 395
Total, United States	9, 593, 600	3, 964, 269	9, 993, 488	2, 979, 257

232,000 tons—was in the East North Central district. Stocks of pig iron held by consumers and suppliers on December 31, 1959, were 25 percent less than those on hand December 31, 1958.

Suppliers' Stocks.—A combined total of 864 dealers, brokers, and

TABLE 17.—Consumers' stocks of ferrous scrap, by grades, by districts and States, Dec. 31, 1959, in short tons

District and State	No. 1 Heavy-Melting steel	No. 2 Heavy-Melting steel	No. 1 and electric-furnace bundles	No. 2 and all other bundles	Low-phosphorus scrap	Cast-iron scrap, other than borings	All others
Connecticut	702	---	85	22	8,662	3,160	8,817
Maine and New Hampshire	260	---	---	---	12	913	258
Massachusetts	2,477	248	44	---	3,590	14,170	12,240
Rhode Island	300	3,157	24	---	382	1,989	3,340
Vermont	212	21	---	---	---	1,464	---
Total, New England	3,951	3,426	153	22	12,646	21,696	24,655
New Jersey	4,421	3,086	11,438	4,137	15,369	38,540	19,870
New York	298,603	4,622	67,208	137,763	16,194	55,671	145,680
Pennsylvania	566,811	130,192	185,403	152,018	187,077	147,171	632,186
Total, Middle Atlantic	869,835	137,900	264,049	293,918	218,640	241,382	797,736
Illinois	235,544	84,619	83,184	220,075	70,343	87,204	254,850
Indiana	564,686	37,765	187,427	78,298	42,041	133,514	81,603
Michigan	71,505	89	135,538	67,476	88,031	59,923	98,502
Ohio	312,954	38,821	258,753	80,672	165,000	122,683	430,528
Wisconsin	9,211	526	58	375	28,011	19,562	20,565
Total, East North Central	1,193,900	161,820	664,960	446,896	393,426	422,886	886,048
Iowa	1,555	1,558	---	129	3,597	14,204	15,823
Kansas and Nebraska	33	---	---	---	5,732	7,396	4,256
Minnesota, North Dakota, and South Dakota	30,427	23,866	141	25,170	1,829	12,612	38,412
Missouri	6,037	109,414	---	2,313	2,946	79,298	51,468
Total, West North Central	38,052	134,838	141	27,612	14,104	113,510	109,959
Delaware, District of Columbia, and Maryland	111,394	2,527	284	10,160	3,624	102,904	27,245
Florida and Georgia	14,437	5,205	745	753	72	1,493	1,938
North Carolina	90	---	---	---	208	4,436	201
South Carolina	46	---	---	---	---	851	1,469
Virginia and West Virginia	3,808	20,509	89	124,849	11,508	35,563	64,603
Total, South Atlantic	129,775	28,241	1,118	135,762	15,412	145,247	95,456
Alabama	106,709	24,790	21,634	31,640	15,094	57,863	61,320
Kentucky, Mississippi, and Tennessee	95,742	41,635	11,452	27,648	1,721	13,526	33,620
Total, East South Central	202,451	66,425	33,086	59,288	16,815	71,389	94,940
Arkansas, Louisiana, and Oklahoma	---	14,741	---	---	3,608	2,626	2,137
Texas	3,943	215,159	346	37,434	7,989	37,290	30,826
Total, West South Central	3,943	229,900	346	37,434	11,597	39,916	32,963
Arizona, Nevada, and New Mexico	5,233	---	---	---	---	270	11,882
Colorado and Utah	92,200	61,457	18,509	97,558	704	18,430	13,621
Idaho, Montana, and Wyoming	---	---	---	---	---	1,596	4,449
Total, Rocky Mountain	97,433	61,457	18,509	97,558	704	20,296	29,952
California	169,065	95,036	59,393	61,538	11,906	64,858	77,781
Oregon	31,065	8,326	6,505	---	346	695	4,083
Washington	51,833	33,820	818	6,843	1,743	5,699	26,561
Total, Pacific Coast	251,963	137,182	66,716	68,381	13,995	71,252	108,425
Total, United States	2,791,303	961,189	1,049,078	1,166,871	697,339	1,147,574	2,180,134

automobile wreckers, which is only a small segment of this industry, reported to the Bureau of Mines that they had 1,555,000 short tons of ferrous scrap in their yards on December 31, 1959.

TABLE 18.—Consumers' stocks, production, receipts, consumption, and shipments of ferrous scrap, by grades, in 1959, in short tons

Grades of scrap	Total stocks on hand Jan. 1, 1959	Scrap produced	Receipts from dealers and all others	Total consumption	Shipments	Total stocks on hand Dec. 31, 1959
No. 1 Heavy-Melting steel	3,071,854	14,929,716	5,209,728	20,674,777	68,266	2,791,303
No. 2 Heavy-Melting steel	804,638	1,768,191	3,163,460	4,716,580		961,189
No. 1 and electric furnace bundles	916,146	833,612	4,545,618	5,176,817		1,049,078
No. 2 and all other bundles	793,179	307,399	3,980,334	3,839,686		1,166,871
Low-phosphorus scrap	621,859	1,175,234	3,106,589	4,085,651		697,339
Cast-iron scrap, other than borings	1,262,037	6,140,183	4,491,142	10,410,314	335,474	1,147,574
All others	2,123,887	12,263,864	6,631,381	17,157,691	1,681,307	2,180,134
Total, all grades	9,593,600	37,418,199	31,128,252	66,061,516	2,085,047	9,993,488

TABLE 19.—Stocks of ferrous scrap and pig iron on hand at plants of major consuming industries, in short tons

	Manufacturers of steel ingots and castings	Manufacturers of steel castings	Iron foundries and miscellaneous users	Total
	SCRAP STOCKS			
Dec. 31, 1959	8,482,711	486,182	1,024,595	9,993,488
Dec. 31, 1958	8,240,853	459,409	893,338	9,593,600
	PIG-IRON STOCKS			
Dec. 31, 1959	2,279,815	44,997	654,445	2,979,257
Dec. 31, 1958	3,414,782	40,870	508,617	3,964,269

TABLE 20.—Dealers, brokers, and automobile wreckers'[1] shipments of ferrous scrap in 1959, by grades, by districts and States, in short tons

District and State	Shipments[2]							
	No. 1 Heavy-Melting steel	No. 2 Heavy-Melting steel	No. 1 and electric-furnace bundles	No. 2 and all other bundles	Low-phosphorus scrap	Cast-iron scrap, other than borings	All others	Total all grades
Connecticut	9,223	14,493	2,012	10,883	7,660	7,086	43,817	95,174
Maine	1,815	1,832	38	1,421	397	2,683	1,241	9,427
Massachusetts	14,161	23,812	2,297	31,579	4,221	26,676	35,293	138,039
New Hampshire	1,228	3,692	44	426	145	4,121	2,416	12,072
Rhode Island	8,193	11,220	4,140	24,594	8,720	22,782	8,316	87,965
Vermont	1,009	1,879	171	1,027	18	2,382	222	6,708
Total, New England	35,629	56,928	8,702	69,930	21,161	65,730	91,305	349,385
New Jersey	170,432	78,052	17,939	70,226	23,812	37,096	51,163	448,720
New York	217,088	110,986	12,945	180,637	8,471	90,293	102,332	722,752
Pennsylvania	249,452	93,727	63,709	157,194	54,215	71,002	227,480	916,779
Total, Middle Atlantic	636,972	282,765	94,593	408,057	86,498	198,391	380,975	2,088,251

See footnotes at end of table.

TABLE 20.—Dealers, brokers, and automobile wreckers'[1] shipments of ferrous scrap in 1959, by grades, by districts and States, in short tons—Continued

District and State	Shipments[2]							
	No. 1 Heavy-Melting steel	No. 2 Heavy-Melting steel	No. 1 and electric-furnace bundles	No. 2 and all other bundles	Low-phosphorus scrap	Cast-iron scrap, other than borings	All others	Total all grades
Illinois	85,690	51,908	123,325	55,151	41,416	55,611	540,971	954,072
Indiana	15,462	8,879	15,228	25,020	4,489	17,927	76,709	163,714
Michigan	27,041	23,071	30,444	21,559	62,421	39,233	122,830	326,599
Ohio	46,731	59,377	21,197	44,201	47,857	62,082	556,614	838,059
Wisconsin	13,307	18,642	20,202	43,338	51,495	59,842	116,360	323,186
Total, East North Central	188,231	161,877	210,396	189,269	207,678	234,695	1,413,484	2,605,630
Iowa	2,162	14,095	5,576	8,242	6,763	14,550	37,542	88,930
Kansas	6,351	21,451	571	12,089	3,842	10,568	14,765	69,637
Minnesota	46,608	40,196	7,314	29,003	7,190	25,720	52,076	208,107
Missouri	37,038	196,828	6,080	20,081	19,795	48,051	45,893	373,766
Nebraska	2,703	12,800	703	7,936	3,018	9,256	5,763	42,179
North Dakota	1,249	5,377	--------	2,093	--------	5,263	8,064	22,046
South Dakota	374	3,806	--------	3,670	588	2,924	12,376	23,738
Total, West North Central	96,485	294,553	20,244	83,114	41,196	116,332	176,479	828,403
Delaware	628	1,689	480	--------	--------	2,063	429	5,289
District of Columbia	318	6,315	651	7,710	--------	3,498	452	18,944
Florida	14,475	16,619	223	21,880	--------	6,373	4,307	63,877
Georgia	10,110	30,957	2,949	30,426	2,433	16,491	8,025	101,391
Maryland	304,911	49,336	93,325	44,134	7,079	16,526	55,360	570,671
North Carolina	21,972	20,682	2,989	33,331	8,503	26,981	12,429	126,887
South Carolina	4,664	10,391	538	6,596	--------	7,349	11,439	40,977
Virginia	21,537	26,085	249	29,995	3,929	23,568	25,533	130,896
West Virginia	13,716	19,131	2,959	15,122	9,387	10,626	12,254	83,195
Total, South Atlantic	392,331	181,205	104,363	189,194	31,331	113,475	130,228	1,142,127
Alabama	8,615	18,049	12,445	45,353	31,303	81,290	34,989	232,044
Kentucky	8,025	10,638	2,854	13,446	302	17,472	10,778	63,515
Mississippi	1,568	5,243	--------	2,043	--------	2,353	1,633	12,840
Tennessee	24,130	23,811	26,888	38,998	15,765	29,056	77,859	236,507
Total, East South Central	42,338	57,741	42,187	99,840	47,370	130,171	125,259	544,906
Arkansas	2,166	14,438	--------	5,878	3,337	6,485	2,055	34,359
Louisiana	101,660	76,237	3,413	58,299	2,065	17,806	9,802	269,282
Oklahoma	9,115	16,675	741	13,222	5,868	10,122	7,472	63,215
Texas	137,944	188,844	12,515	89,703	25,212	61,431	525,849	1,041,498
Total, West South Central	250,885	296,194	16,669	167,102	36,482	95,844	545,178	1,408,354
Arizona, Nevada, and New Mexico	4,108	6,752	68	2,354	360	3,181	2,052	18,875
Colorado and Utah	9,452	21,447	--------	77,040	222	8,732	12,342	129,235
Idaho, Montana, and Wyoming	5,503	7,007	--------	1,954	389	7,965	12,582	35,400
Total, Rocky Mountain	19,063	35,206	68	81,348	971	19,878	26,976	183,510
California	60,381	71,821	4,424	89,668	2,070	23,368	33,327	285,059
Oregon and Washington	47,490	37,001	522	30,236	1,596	13,479	33,209	163,533
Total, Pacific Coast	107,871	108,822	4,946	119,904	3,666	36,847	66,536	448,592
Total, United States	1,769,805	1,475,291	502,168	1,407,758	476,353	1,011,363	2,956,420	9,599,158

---

[1] Reported by a monthly average of 887 companies shipping approximately 47 percent of purchased scrap received by domestic consumers, exported, and adjusted for imports.

[2] Includes shipments from yards and direct shipments by dealers and brokers from other than yard operations to domestic consumers and for export.

TABLE 21.—Stocks of ferrous scrap held by dealers, brokers, and automobile wreckers,[1] on Dec. 31, 1959, by grades, by districts and States, in short tons

District and State	No. 1 Heavy-Melting steel	No. 2 Heavy-Melting steel	No. 1 and electric-furnace bundles	No. 2 and all other bundles	Low-phosphorus scrap	Cast-iron scrap, other than borings	All others	Total, all grades
Connecticut	401	663	137	1,091	918	1,397	10,741	15,348
Maine	635	1,052	--------	967	18	668	1,272	4,612
Massachusetts	1,635	2,387	212	9,379	410	1,273	14,731	30,027
New Hampshire	410	602	--------	146	--------	384	724	2,266
Rhode Island	51	263	79	2,216	62	280	11,300	14,251
Vermont	292	888	67	1,083	--------	930	653	3,913
Total, New England	3,424	5,855	495	14,882	1,408	4,932	39,421	70,417
New Jersey	11,056	26,568	921	19,764	8,064	2,478	24,238	93,089
New York	21,764	13,563	146	13,575	2,482	12,609	16,370	80,509
Pennsylvania	16,169	15,011	4,862	14,539	3,251	4,453	110,582	168,867
Total, Middle Atlantic	48,989	55,142	5,929	47,878	13,797	19,540	151,190	342,465
Illinois	3,659	3,345	336	3,447	1,011	3,289	131,104	146,191
Indiana	1,448	3,130	159	8,727	605	1,246	19,342	34,657
Michigan	3,527	2,717	1,411	12,459	5,806	2,406	29,053	57,379
Ohio	13,569	22,230	1,688	4,303	2,459	2,307	102,049	148,605
Wisconsin	1,043	2,839	1,043	4,115	1,293	3,848	47,537	61,718
Total, East North Central	23,246	34,261	4,637	33,051	11,174	13,096	329,085	448,550
Iowa	1,467	3,205	--------	998	74	1,341	9,395	16,480
Kansas	1,807	1,379	--------	597	1,134	698	3,072	8,687
Minnesota	10,941	8,147	4,317	3,537	170	19,528	54,107	100,747
Missouri	1,204	3,268	50	1,796	996	1,627	9,877	18,818
Nebraska	151	678	--------	634	134	576	3,431	5,604
North Dakota	--------	68	--------	--------	--------	504	1,674	2,246
South Dakota	213	137	--------	606	112	65	6,918	8,051
Total, West North Central	15,783	16,882	4,367	8,168	2,620	24,339	88,474	160,633
Delaware	44	434	--------	--------	--------	139	193	810
District of Columbia	--------	--------	--------	1	--------	9	112	122
Florida	850	2,693	--------	2,601	--------	1,547	8,635	16,326
Georgia	1,869	2,264	65	3,094	--------	365	8,932	16,589
Maryland	6,031	4,543	1,890	24,339	47	8,556	38,014	83,420
North Carolina	3,502	3,300	321	1,603	--------	485	7,150	16,361
South Carolina	652	207	--------	596	--------	107	16,553	18,115
Virginia	6,156	2,491	--------	22,293	493	1,102	10,763	43,298
West Virginia	2,177	1,104	--------	101	1,120	231	15,464	20,197
Total, South Atlantic	21,281	17,036	2,276	54,628	1,660	12,541	105,816	215,238
Alabama	22	84	504	--------	405	123	18,045	19,183
Kentucky	1,471	1,890	426	1,839	--------	490	1,198	7,314
Mississippi	159	996	--------	1,104	--------	240	2,394	4,893
Tennessee	3,496	1,893	2,285	1,110	1,530	866	22,183	33,363
Total, East South Central	5,148	4,863	3,215	4,053	1,935	1,719	43,820	64,753
Arkansas	777	1,308	--------	2,157	56	978	3,771	9,047
Louisiana	2,398	5,119	713	2,350	28	836	15,096	26,540
Oklahoma	746	623	--------	318	349	855	12,905	15,796
Texas	3,316	5,670	1,670	17,064	655	2,980	56,818	88,173
Total, West South Central	7,237	12,720	2,383	21,889	1,088	5,649	88,590	139,556
Arizona, Nevada, and New Mexico	113	93	--------	--------	11	64	93	374
Colorado and Utah	2,072	5,811	--------	308	--------	419	5,836	14,446
Idaho, Montana, and Wyoming	874	900	--------	45	--------	380	643	2,842
Total, Rocky Mountain	3,059	6,804	--------	353	11	863	6,572	17,662
California	7,324	5,536	28	12,336	477	1,303	8,246	35,250
Oregon and Washington	10,466	13,090	56	15,336	716	2,252	18,202	60,118
Total, Pacific Coast	17,790	18,626	84	27,672	1,193	3,555	26,448	95,368
Total, United States	145,957	172,189	23,386	212,574	34,886	86,234	879,416	1,554,642

---

[1] Reported by 864 companies representing approximately 23 percent of the scrap collection industry with or without processing equipment, as shown in the 1954 Census of Business, Wholesale Trade.

PRICES[3]

The price of No. 1 Heavy-Melting scrap at Pittsburgh was at a yearly high of $47.25 per long ton in February—$10.75 higher than in February 1958. The price for this grade of scrap dropped to $37.25 per ton in May but increased to $47.00 per ton in November, after which it declined to $42.70 in December—4 percent lower than at the beginning of the year.

No. 1 Heavy-Melting scrap at Chicago averaged $38.90 per long ton for the year. The highest price—$44.25 per ton—for this grade of scrap was in February, and the lowest price of the year—$32.00—was in May.

The average composite price of No. 1 Heavy-Melting iron and steel scrap was $40.49 for the year—$2.40 higher than the 1958 average. The composite price for this grade of scrap fluctuated between a low of $34.41 per long ton in May and a high of $45.67 in November, after which it dropped to $41.90 in December and the averaged remained a little higher than in January.

The average composite price for No. 2 Bundles, was quoted at $23.33 in April and May—the lowest both for 1959 and since September 1954. An upward trend followed this low and reached a high for the year of $31.33 in November, but in December the price had dropped to $28.23 per ton—3 percent lower than at the beginning of the year.

The average value of exports (see table 1), including all grades of scrap, from the United States during 1959 was $38.22 per long ton—$1.72 higher than the 1958 average.

TABLE 22.—Average monthly price and composite price per long ton for No. 1 Heavy-Melting scrap in 1959

	Chicago	Pittsburgh	Philadelphia	Composite price [1]
January	$43.00	$44.50	$35.75	$41.08
February	44.25	47.25	39.50	43.66
March	40.10	43.90	37.30	40.43
April	33.50	38.00	33.75	35.08
May	32.00	37.25	34.00	34.41
June	34.50	42.50	36.70	37.90
July	35.50	43.50	39.00	39.33
August	36.75	43.50	39.50	39.91
September	39.70	44.30	41.10	41.70
October	43.25	46.50	44.75	44.83
November	44.00	47.00	46.00	45.67
December [2]	40.30	42.70	42.70	41.90
Average: [2] 1959	38.90	43.40	39.17	40.49
1958	[3] 37.22	39.42	[3] 37.60	[3] 38.09

[1] Composite price, Chicago, Pittsburgh, and Philadelphia.
[2] Estimate.
[3] Revised figure.

---

[3] Iron Age, vol. 185, No. 1, Jan. 7, 1960, p. 286.

FOREIGN TRADE [4]

The export-licensing regulations governing the exportation of ferrous scrap remained in effect through 1959.

The Bureau of Foreign Commerce changed the validity period for export license applications effective January 1, 1959, from 3 months to 6 months.

On July 28, 1959, Public Law 86–115 was approved; it continued through June 30, 1960, the suspension of duties on certain metal scrap, including ferrous scrap. The approval was retroactive to June 30, 1959, the expiration date of the previous law.

Imports.—Ferrous-scrap imports, including tinplate, decreased 7 percent in quantity but rose 5 percent in value when compared with the preceding year. The largest quantity imported was from Canada (84 percent of the total imports) followed by Belgium-Luxembourg (7 percent); and the United Kingdom (4 percent); 5 percent was from other countries. Of the total imports, 13 percent was tinplate scrap, mostly from Canada, compared with 11 percent during the preceding year.

Exports.—Total exports increased 66 percent over 1958 and were 47 percent higher than the 5-year pre-World War II annual average (1935–39) of 3,298,000 short tons. Total ferrous scrap, excluding rerolling materials, exported during 1959 increased 67 percent in quantity and 76 percent in value over 1958. Scrap exported to Japan was nearly five times greater than during the previous year.

TABLE 23.—Ferrous scrap imported for consumption in the United States, by countries, in short tons

[Bureau of the Census]

Country	1958	1959
North America:		
Bahamas	951	372
Barbados	710	
Canada	315,955	258,712
Costa Rica		467
Cuba	2,552	3,576
Dominican Republic	557	3
French West Indies	428	
Leeward and Windward Islands	390	
Mexico		107
Panama	1,062	7
Trinidad and Tobago	376	
Other	195	159
Total	323,176	263,403
South America:		
British Guiana	838	
Other	220	
Total	1,058	
Europe:		
Austria		17
Belgium-Luxembourg		21,103
Czechoslovakia		218
Denmark		71
Europe—Continued		
Finland		154
France	218	5,273
Germany, West	139	4,187
Netherlands	13	383
Norway	45	
Sweden	32	1,112
United Kingdom	7,532	13,219
Total	7,979	45,737
Asia:		
India	22	22
Japan	276	118
Lebanon		3
Total	298	143
Africa:		
Madagascar	89	
Morocco		78
Mozambique		29
Total	89	107
Oceania	22	58
Grand total:		
Short tons	332,622	309,448
Value	$11,069,149	$11,590,695

---

[4] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson. Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 24.—Ferrous scrap exported from the United States, by countries of destination, in short tons

[Bureau of the Census]

Destination	Iron and steel scrap including tinplate and terneplate scrap [1]		Rerolling material	
	1958	1959	1958	1959
North America:				
Canada	264,550	601,429	312	818
Mexico	288,525	419,027	[2] 32,974	6,817
Nicaragua	----------	5,451	----------	----------
Other North America	22	53	----------	----------
Total	553,097	1,025,960	[2] 33,286	7,635
South America:				
Argentina	----------	1,086	----------	----------
Brazil	----------	26	----------	----------
Colombia	44	788	----------	----------
Other South America	131	----------	----------	----------
Total	175	1,900	----------	----------
Europe:				
Belgium-Luxembourg	23,894	----------	----------	----------
Finland	----------	23,481	----------	----------
France	142,889	10,159	----------	----------
Germany, West	138,035	95,037	----------	----------
Italy	1,246,783	370,794	----------	----------
Netherlands	628	445	----------	----------
Spain	104,037	77,579	----------	----------
Sweden	3,930	83,084	----------	----------
Switzerland	----------	3,360	----------	----------
Other Europe	19,753	98	----------	----------
Total	1,679,949	664,037	----------	----------
Asia:				
Japan	617,695	3,039,122	10,691	29,058
Nansei and Nanpo Islands	----------	----------	1,132	6,208
Taiwan	31,127	74,188	----------	----------
Other Asia	673	122	----------	846
Total	649,495	3,113,432	11,823	36,112
Africa	35	----------	----------	----------
Grand total: Short tons	2,882,751	4,805,329	[2] 45,109	43,747
Value	$92,710,992	$162,751,898	[2] $2,700,794	$2,712,536

[1] Excludes circles, cobbles, strip and scroll shear butts from tinplated scrap. Owing to this exclusion, plus revisions, the 1958 data will differ from that shown in 1958 Minerals Yearbook, table 23, p. 615.

[2] Revised figure.

TABLE 25.—Ferrous scrap imported into and exported from the United States, by classes

[Bureau of the Census]

Classes	1958		1959	
	Short tons	Value	Short tons	Value
Imports:				
Iron and steel scrap	295,859	$10,068,777	267,839	$10,492,866
Tinplate scrap	36,763	1,000,372	41,609	1,097,829
Total	332,622	11,069,149	309,448	11,590,695
Exports:				
Nos. 1 and 2 Heavy-Melting steel scrap	[1] 1,916,097	[1] 64,161,974	3,126,453	111,601,017
Nos. 1 and 2 baled steel scrap	[1] 613,210	[1] 17,360,964	1,013,616	27,790,398
Borings, shovelings, and turnings	[1] 54,500	[1] 1,050,899	86,082	2,083,217
Iron scrap	[1] 223,828	[1] 7,330,700	414,745	14,582,133
Rerolling material	[1] 45,109	[1] 2,700,794	43,747	2,712,536
Other scrap (terneplated and tinplated) [2]	75,116	2,806,455	164,433	6,695,133
Total	[1] 2,927,860	[1] 95,411,786	4,849,076	165,464,434

[1] Revised figure.

[2] Excludes circles, cobbles, strip and scroll shear butts from tinplated scrap. Owing to this exclusion, plus revisions, the 1958 data will differ from that shown in 1958 Minerals Yearbook, table 24, p. 616.

WORLD REVIEW

EUROPE

United Kingdom.—The Government, with consent of the British Iron and Steel Federation, permitted scrap exports during the last 4 months of 1958 and until March 7, 1959.[5]

The supply and quality of scrap have been a recurring problem in the steel industry in the United Kingdom. Interest in research into various aspects of the ferrous scrap industry contributed to the forming of a Research Panel by the National Federation of Scrap Iron, Steel, and Metal Merchants.[6]

ASIA

Japan.—Import contracts for 283 shiploads of ferrous scrap were placed with U.S. suppliers. This was a sharp rise over the contracts placed for 65 shiploads during 1958.[7]

Japanese scrap buyers took advantage of reduced prices in early 1959 and bought many old ships that were available for demolition. Between April and June they bought 33 out of 130 overage ships offered on world markets.[8]

OCEANIA

Australia.—The Acting Minister for Trade in Australia announced on October 3, 1958, that on January 1, 1959, the export quota on iron and steel scrap would be reduced to insure adequate supplies for the Australian mills and foundries.[9]

TECHNOLOGY

A new operating technique involving the use of coke breeze in oxygen steelmaking furnaces was reported. The new practice is said to increase the use of scrap in these furnaces up to 50 percent.[10] This work reportedly was done in a 2-ton converter in Austria.

An afterburner-type incinerator, especially engineered to help small and medium-size scrap processors solve their air pollution problems, was developed at a plant in Cordele, Ga.[11] In the operation of the incinerator four automobiles can be processed per hour.

A furnace for melting unprepared scrap at a rate to meet the charge requirements of several open-hearth or electric steel-producing furnaces is described in U.S. Patent 2,886,304, issued May 12, 1959, to James M. Guthrie.[12]

---

[5] Iron and Coal Trades Review, vol. 178, No. 4738, Mar. 13, 1959, pp. 538–584.

[6] Metal Bulletin, No. 4414, July 24, 1959, p. 26.

[7] U.S. Embassy, Tokyo, Japan, State Department Dispatch 761: Dec. 29, 1959.

[8] Waste Trade Journal, vol. 107, No. 21, Aug. 8, 1959, p. 13.

[9] Bureau of Mines, Mineral Trade Notes: Vol. 46, No. 6, February 1959, p. 18.

[10] Madsen, I. E., Developments in the Iron and Steel Industry During 1959: Iron and Steel Engineer, vol. 37, No. 1, January 1960, p. 119.

[11] Steel, vol. 145, No. 6, Aug. 10, 1959, p. 132.

[12] Guthrie, J. M., Steel Production: U.S. Patent 2,886,304, May 12, 1959.

Iron Oxide Pigments

By John W. Hartwell[1] and Betty Ann Brett[2]

◆

DOMESTIC sales of crude iron oxide pigment in 1959 declined slightly, but those of finished pigments increased to the highest quantity and value since 1951.

DOMESTIC PRODUCTION

The demand for crude iron oxide pigments continued strong. Nevertheless, a drop of nearly one-third in crude sienna sales led to an overall decline in pigment sales, despite increased sales of all other iron oxides.

Combined sales of nearly 118,000 tons of finished natural and manufactured iron oxide pigments were the highest since 1951. A 19-percent increase in sales over 1958 halted the gradual decline which had started in 1956.

TABLE 1.—Salient statistics of iron oxide pigment materials in the United States

	1950–54 (average)	1955	1956	1957	1958	1959
Mine production:						
Iron oxide pigment mines:						
Short tons	[1] 23, 100	23, 600	21, 400	20, 300	30, 100	29, 000
Iron-ore mines:						
Short tons	[1] 22, 600	32, 600	32, 500	29, 000	24, 600	24, 900
Crude pigments sold or used:						
Iron oxide pigment mines:						
Short tons	[1] 18, 300	20, 300	17, 300	18, 400	30, 700	29, 100
Value	[1] $160, 500	$175, 800	$168, 000	$193, 400	$234, 300	$250, 900
Iron-ore mines:						
Short tons	[1] 22, 600	32, 600	32, 500	29, 000	24, 600	24, 900
Value	[1] $211, 000	$243, 600	$300, 300	$268, 900	$210, 500	$219, 000
Finished pigments sold or used:						
Short tons	[2] 113, 400	115, 300	113, 900	104, 900	98, 400	117, 600
Value	[2] $14, 248, 400	$17, 471, 700	$17, 103, 500	$16, 405, 300	$15, 822, 000	$19, 037, 400
Imports:						
Short tons	10, 700	14, 000	13, 100	13, 100	11, 700	14, 800
Value	$788, 200	$1, 195, 600	$1, 201, 700	$1, 314, 400	$1, 159, 700	$1, 495, 100
Exports:						
Short tons	4, 400	4, 700	5, 100	3, 700	3, 900	4, 300
Value	$690, 900	$893, 900	$909, 200	$1, 038, 200	$1, 064, 600	$1, 039, 600

[1] 1954 only.
[2] Includes mineral blacks, 1950–51.

---

[1] Commodity specialist.
[2] Statistical clerk.

TABLE 2.—Crude iron oxide pigment materials mined and sold or used in the United States, 1959, by States

State	Number of producers	Quantity mined (short tons)	Quantity sold or used (short tons)	Value
Pennsylvania	2	1,083	1,083	$7,400
Colorado	5	35,699	35,841	282,200
Michigan				
Minnesota				
Oregon				
Georgia	3	17,136	17,123	180,300
New York				
Virginia				
Total	10	53,918	54,047	469,900

TABLE 3.—Crude iron oxide pigment materials produced and sold or used by processors in the United States, by kinds

Pigments	1958			1959		
	Quantity mined (short tons)	Quantity sold or used		Quantity mined (short tons)	Quantity sold or used	
		Short tons	Value		Short tons	Value
Brown iron oxide:						
Sienna	16,167	16,417	$112,800	11,259	11,186	$100,700
Umber	263	278	3,700	468	600	5,800
Red iron oxide	28,239	28,239	265,800	31,203	31,203	307,700
Yellow iron oxide:						
Ocher	7,006	7,006	38,300	7,135	7,135	32,400
Natural yellow iron oxide, sulfur mud, and miscellaneous pigments	3,080	3,370	24,200	3,853	3,923	23,300
Total	54,755	55,310	444,800	53,918	54,047	469,900

TABLE 4.—Sales of finished iron oxide pigments in the United States, 1959, by States

State	Number of producers	Quantity sold (short tons)	Value
Missouri	1	1,800	$56,000
Georgia	4	12,934	1,249,500
Maryland			
Virginia			
Illinois	8	76,481	11,677,500
Pennsylvania			
New Jersey			
Other States [1]	4	26,389	6,054,400
Total	17	117,604	19,037,400

[1] Includes California, New York, Ohio, and a quantity unspecified by State.

TABLE 5.—Finished iron oxide pigments sold by processors in the United States, by kinds

Pigment	1958		1959	
	Short tons	Value	Short tons	Value
Natural:				
Black: Magnetite	384	$31,100	321	$26,700
Brown:				
Iron oxide (metallic)	5,997	601,900	6,618	636,100
Umbers: Burnt	2,452	376,100	2,950	453,100
Raw	559	78,300	637	91,100
Vandyke brown	168	37,600	192	45,300
Red:				
Iron oxide	14,063	764,900	19,398	994,900
Sienna, burnt	1,032	219,400	1,157	242,400
Pyrite cinder	801	44,200	1,097	58,700
Yellow:				
Iron oxide	131	6,100	46	4,600
Ocher	4,278	163,900	4,844	209,100
Sienna, raw	688	139,800	789	166,100
Total natural	30,553	2,463,300	38,049	2,928,100
Manufactured:				
Black: Magnetic	1,801	534,300	2,043	606,100
Brown: Iron oxide	1,436	417,400	2,024	533,900
Red:				
Pure red iron oxides:				
Calcined copperas	12,062	3,452,400	16,694	4,789,800
Other chemical processes	4,866	1,419,500	6,395	1,900,000
Other manufactured red iron oxides	23,126	2,629,000	25,202	2,611,800
Venitian red	4,696	642,400	3,098	364,400
Yellow: Iron oxide	11,994	2,921,600	14,533	3,502,000
Total manufactured	59,981	12,016,600	69,989	14,308,000
Mixtures of natural and manufactured red iron oxides	5,176	861,000	6,635	1,139,900
Other and unspecified	2,712	481,100	2,931	661,400
Grand total	98,422	15,822,000	117,604	19,037,400

PRICES

Prices quoted for iron oxide pigments were virtually unchanged from 1958.

TABLE 6.—Prices quoted on finished iron oxide pigments, per pound, in bags, unless otherwise specified

[Oil, Paint and Drug Reporter]

Iron oxide pigments	1959	Iron oxide pigments	1959
Black:		Red:	
Pure	$0.1475	Domestic (pure)	$0.1425
Synthetic	.1275	Natural (75-85 percent ferric oxide)	.0675
Brown:		Persian Gulf	.0875
Pure	.1425	Spanish (barrels)	.0575
Metallic	.0525	Sienna, burnt	.0650
Umber, American, burnt	.0750	Venetian, 40 percent	.0675
Umber, Turkey, burnt	.0825	Yellow:	
Umber, American, raw	.0775	Ocher, natural, French	.0625
Umber, Turkey, raw	.0850	Ocher, natural, Peruvian	.0230
Vandyke (barrels)	.0950	Ocher, hydrated, pure	.1225
		Sienna, raw	.0675

FOREIGN TRADE [3]

Imports of refined ocher in 1959 came principally from the Union of South Africa. Less than 0.5 percent originated in Canada. About 83 percent of the crude ocher came from the Union of South Africa and the balance from France.

TABLE 7.—Selected iron oxide pigments imported for consumption in the United States

[Bureau of the Census]

Pigments	1958		1959	
	Short tons	Value	Short tons	Value
Natural:				
Ocher, crude and refined	217	$10,312	213	$13,427
Siennas, crude and refined	555	48,867	1,399	95,143
Umber, crude and refined	2,278	73,256	2,078	68,195
Vandyke brown	204	14,649	202	13,875
Other [1]	2,485	123,360	3,161	160,250
Total natural	5,739	270,444	7,053	350,890
Manufactured (synthetic)	5,933	889,255	7,776	1,144,198
Grand total	11,672	1,159,699	14,829	1,495,088

[1] Classified by the Bureau of the Census as "Natural iron oxide and iron hydroxide pigments, n.s.p.f."

TABLE 8.—Iron oxide and hydroxide pigments (n.s.p.f.) imported for consumption in the United States, by country of origin

[Bureau of the Census]

Country	Synthetic				Natural			
	1958		1959		1958		1959	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Canada	1,170	$248,900	1,480	$302,300	5	$800	----------	----------
Sweden	----------	----------	28	4,600	----------	----------	----------	----------
United Kingdom	828	125,400	859	127,300	368	38,600	171	$15,800
Netherlands	67	7,000	101	12,200	----------	----------	----------	----------
Germany, West	3,848	506,900	5,255	694,600	----------	----------	19	2,500
Spain	20	800	79	3,200	2,112	83,900	2,640	117,300
France	(1)	300	----------	----------	(1)	100	331	24,600
Total	5,933	889,300	7,802	1,144,200	2,485	123,400	3,161	160,200

[1] Less than 1 ton.

Malta and Italy supplied all the crude and refined siennas imported in 1959. Malta shipped 64 percent of the crude sienna (36 percent of the total value) and 14 percent of the refined (8 percent of the value).

All of the crude umber and over 81 percent of the refined came from Malta. The United Kingdom shipped almost 17 percent of the total refined umber, and the balance (about 2 percent) came from Italy.

---

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

Vandyke-brown imports from West Germany were 86 percent in 1959 compared with 75 percent in 1958. The balance came from the Netherlands.

TABLE 9.—Iron oxide pigments exported from the United States, by countries of destination

[Bureau of the Census]

Country	1958		1959	
	Short tons	Value	Short tons	Value
North America:				
Canada	2,389	$419,470	3,093	$507,205
Cuba	184	59,810	184	58,812
Dominican Republic	9	2,297	30	9,158
Guatemala	45	10,815	25	5,887
Haiti	10	7,587	1	117
Mexico	93	33,296	56	35,056
Netherlands Antilles	4	1,520	22	5,090
Other North America	70	6,671	27	9,236
Total	2,804	541,466	3,438	630,561
South America:				
Chile	18	13,025	70	31,487
Colombia	79	28,695	86	28,996
Ecuador	8	1,000	5	1,491
Peru	14	4,404	12	4,010
Venezuela	146	25,895	46	17,334
Other South America	2	4,747	5	2,591
Total	267	77,766	224	85,909
Europe:				
Belgium-Luxembourg	9	4,732	16	6,451
France	40	16,603	28	15,949
Iceland	6	1,683	2	735
Netherlands	178	33,802	34	1,395
Portugal	14	4,265	10	3,195
Sweden	9	5,915	2	560
Switzerland	17	5,841	25	5,237
United Kingdom	12	5,934	21	9,740
Other Europe	5	4,612	10	8,965
Total	290	83,387	148	52,227
Asia:				
Indonesia	6	3,397		
Japan	18	9,464	33	15,747
Korea, Republic of	130	95,865		
Philippines	149	73,550	182	82,762
Other Asia	52	9,277	9	5,821
Total	355	191,553	224	104,330
Africa:				
Union of South Africa	94	31,365	98	33,122
Other Africa			6	2,794
Total	94	31,365	104	35,916
Oceania	104	139,047	199	130,621
Grand total	3,914	1,064,584	4,337	1,039,564

WORLD REVIEW

Argentina.—The quantity and value of ocher produced in 1958 are unknown, but 2.2 short tons valued at $187 was exported.[4] Production in 1957 had been 230 tons.

---

[4] U.S. Embassy, Buenos Aires, Argentina, State Department Dispatch 312: Aug. 21, 1959, p. 14.

Australia.—Iron oxide production in 1958 was about 17,000 short tons, compared with 7,361 tons in 1957.[5]

Brazil.—In 1958 production of iron oxide pigments by seven manufacturers was about 2,915 short tons valued at nearly $800,000.[6]

Canada.—Production of ocher in 1958 declined to 2,060 short tons valued at $162,000, compared with 7,520 tons valued at $187,000 in 1957. This decline was attributed to the growing use of natural gas as a domestic fuel in eastern Canada, replacing manufactured gas for which large quantities of iron oxide were used as a cleansing agent.

The known Canadian deposits of pigment-grade iron oxide are bog ores. Two of these deposits, now being worked, are in Champlain County, Quebec. A processing plant is at Red Mill, 7 miles east of Three Rivers, Quebec.

The Northern Pigment Co., Ltd., New Toronto, Ontario, produced synthetic iron-oxide pigments.

TABLE 10.—Production, trade, and consumption of Canadian iron oxide, in short tons

Year	Production (natural)	Imports		Exports	Consumption		
		Ocher, sienna, umber	Oxides, fillers, colors	Natural and synthetic	Coke and gas industries	Paint industry	
						Natural and synthetic	Ocher, sienna, umber
1948	13,180	1,460	3,890	5,250	9,160	2,220	300
1949	13,620	1,580	3,410	3,390	8,190	2,050	260
1950	13,700	1,540	4,100	3,930	11,620	2,450	270
1951	13,340	1,470	4,550	3,650	10,310	2,950	250
1952	11,490	1,000	4,220	3,060	8,300	2,440	230
1953	10,310	1,170	5,260	3,050	7,990	2,460	240
1954	5,800	1,050	4,440	3,110	9,170	2,190	210
1955	7,700	990	5,700	3,620	6,840	2,300	220
1956	8,800	1,160	6,240	3,200	8,750	2,170	220
1957	7,520	950	4,830	3,440	6,000	1,900	260
1958	2,060	680	(1)	2,400	(1)	(1)	(1)

[1] Data not available.

Source: Woodrooffe, H. M., Mineral Pigments and Fillers, 1958 (Preliminary): Dept. Mines and Tech. Surveys, Ottawa, Canada, Review 43, July 1959, p. 2.

Cyprus.—The quantity of umber exported in 1959 was 4,434 short tons valued at over $137,000.[7]

Germany, West.—Natural iron oxide pigments produced in 1958 totaled 64,800 short tons compared with 62,836 tons in 1957.[8]

India.—Ocher production in 1958 was about 20,000 short tons valued at more than $74,000, compared with over 17,000 tons valued at nearly $71,000 in 1957. Exports were 95 tons in 1958 and 68 tons in 1957.[9]

---

[5] Chemical Engineering and Mining Review (Melbourne), vol. 51, No. 10, July 15, 1959, p. 40.

[6] U.S. Consulate, São Paulo, Brazil, State Department Dispatch 219: Dec. 18, 1959, p. 2.

[7] U.S. Consulate, Nicosia, Cyprus, State Department Dispatch 141: Feb. 12, 1960, p. 2.

[8] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 2, August 1959, p. 48.

[9] U.S. Embassy, New Delhi, India, State Department Dispatch 1431: June 4, 1959, pp. 36, 41.

Iran.—Persian Gulf iron oxide production in 1958 was reported to be 3,307 short tons; output of other iron oxide pigments totaled about 220 tons.[10]

Morocco.—Total production of natural red and yellow pigments in 1958 was 2,124 short tons. Exports, local consumption, and yearend stocks were 2,283, 228, and 407 tons, respectively.[11]

Pakistan.—Production of ocher in 1959 was about 313 tons valued at nearly $1,200. Free iron content of the pigment ranged from 26 to 48 percent.[12]

Paraguay.—The only source of iron oxide pigments known to have been worked in recent years was near Tobatí. The deposit was finely divided clay containing 2 to 7 percent ocher. Production figures were unknown.[13]

Peru.—Ocher production exceeded 25 short tons valued at $13,018 in 1959.[14]

Arabia Peninsula States.—Ocher from the Island of Abu Musa was the only mineral produced in this area. Production has decreased from 20,000 to 5,000 tons a year in recent years. The entire output was used by Golden Valley Colours, Ltd., England.[15]

TECHNOLOGY

An outline was given of the properties of inorganic and organic red pigments.[16]

Studies showed that the formation of Fe_3O_4 from aqueous solutions of ferrous and ferric salts was favored by precipitation with aqueous ammonia but inhibited with ammonia in methyl alcohol.[17]

The dehydration of ferric hydroxide was studied under various conditions.[18]

The performance standards of pigments are becoming more exacting. The resistance to heat, light, and attack by chemicals and the ease of dispersion of various pigments were listed.[19]

Synthetic iron oxides were classified into seven types, according to their method of manufacture. The range of physical and chemical properties permitted a choice of raw materials for manufacturing magnetic ferrites.[20]

---

[10] U.S. Embassy, Tehran, Iran, State Department Dispatch 835: May 14, 1959, p. 1.

[11] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 6, December 1959, p. 42.

[12] U.S. Embassy, Karachi, Pakistan, State Department Dispatch 974: Apr. 25, 1960, encl. 1, p. 1.

[13] Eckel, E. B., Geology and Mineral Resources of Paraguay, A Reconnaissance: Geol. Survey Prof. Paper 327, 1959, pp. 89–90.

[14] U.S. Embassy, Lima, Peru, State Department Dispatch 615: Apr. 20, 1960, encl. 1, p. 2.

[15] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 1, January 1960, p. 26.

[16] Bonnie, Sevier, Jr., Red Pigments for Coatings: Official Digest, Federation Paint & Varnish Production Clubs, vol. 30, 1958, pp. 1113–1121; Chem. Abs., vol. 53, No. 22, Nov. 25, 1959, col. 22987e.

[17] Yamaguchi, S., [Conditions for the Formation of Different Iron Oxides]: Ztschr. anorg. allgem. Chem. (Leipzig, Germany), vol. 285, No. 1–2, 1956, pp. 100–102; Ceram. Abs., February 1959, p. 64.

[18] Kuwabara, Toshihide, Yamaoka, Meiiti, and Kanehiro, Tadao, [Inorganic Pigments: VI, Production of Yellow Iron Oxide]: Osaka Kogyo Gijutsu Shikenjo Kiho, vol. 5, 1954, pp. 181–189; Ceram. Abs., February 1959, p. 51.

Minami, Soichiro, and Ando, Tokuo, [VII, Hydrothermal Conversion of Ferric Hydroxide], pp. 190–196; Ceram. Abs., February 1959, p. 51.

[19] Varley, D. M., Properties Required of Pigments: Paint Manufacturing, vol. 28, 1958, pp. 344–347, 379–382; Chem. Abs., vol. 53, No. 6, Mar. 25, 1959, col. 5701a.

[20] Stephens, R. A., Iron Oxides as Raw Materials for the Manufacture of Magnetic Ferrites: Bull. Am. Ceram. Soc., vol. 38, No. 3, March 1959, pp. 106–109.

A method of manufacturing yellow iron oxide was described. The iron contained in the solution of ferric sulfate and iron shavings was precipitated as a hydroxide by oxidation with air, hydrogen hydroxide, and trace amounts of heavy metals.[21]

The method of manufacture, chemical composition, physical properties, and application of yellow iron oxide and other yellow pigments were described.[22]

Federal, military, and contractor specifications for numerous protective coatings, including paints, were published, and new specification numbers were listed with superseded or comparable specifications.[23]

A process of recovering iron oxide for use as a pigment from a manganese ore containing 33.5 percent Mn and 22.3 percent Fe was described.[24]

Synthetic iron oxides were prepared under various conditions and examined by X-ray diffraction and differential thermal analysis.[25]

Eleven red iron oxide pigments were used to prepare solid-color enamels, and the enamels were tested for color stability by outdoor exposure in Florida and Delaware.[26]

The color of iron oxide powders prepared by calcining iron salts was studied with a spectrophotometer. The color of iron oxide pigment powders ranged from light to dark as the particle size increased.[27]

The use of iron oxide in making antirust paint primers was described.[28]

A patent was issued for a method of manufacturing iron oxide for pigments and other uses. The product of this process would be a uniform, uncontaminated iron oxide.[29]

A method of manufacturing black iron oxide pigment was patented in Austria.[30]

A method of preparing a hydrophobic, colloidal, hydrous iron oxide pigment and a coating containing the pigment was patented.[31]

---

[21] Krause, Alfons; Kranz, Maksymilian; and Witkowska, Anna. [The Influence of Trace Elements on the Color and Structure of Yellow Ferric Hydroxides]: Przemysl Chem. (Warsaw, Poland), vol. 37, 1958, pp. 580–582; Chem. Abs., vol. 53, No. 14, July 25, 1959, col. 12909a.

[22] Herrmann, Erwin, [Yellow Pigments]: Farbe u. Lack (Hannover, Germany), vol. 65, 1959, pp. 636–646; Chem. Abs., vol. 54, No. 4, Feb. 25, 1960, col. 3989d.

[23] Ordnance Tank-Automotive Command, Detroit Arsenal, Research and Development Division, Materials Branch, Reference Index of the Current Protective Coatings Specifications: U.S. Dept. of Commerce, PB151166, 1959, 159 pp.

[24] Venkatasubramanian, T. R., and Aravamuthan, V., [Manganese Sulfate and Iron Oxide]: Indian, vol. 59, No. 713, Feb. 4, 1959; Chem. Abs., vol. 53, No. 18, Sept. 25, 1959, col. 17451a.

[25] Schwertman, U., [Synthesis of Definite Iron Oxides Under Various Conditions]: Ztschr. anorg. allgem. Chem. (Leipzig, Germany), vol. 298, 1959, pp. 337–348; Chem. Abs., vol. 53, No. 17, Sept. 10, 1959, col. 15843i.

[26] McConaghie, H. A., Color Stability of Red Iron Oxide Pigments: Official Dig., Federation Paint & Varnish Production Clubs, vol. 29, 1957, pp. 1144–1152; Chem. Abs., vol. 53, No. 5, Mar. 10, 1959, col. 4767g.

[27] Takada, Toshio, [Effect of Particle Size and Shape on the Color of Ferric Oxide Powders]: Funtai oyobi Funmatsuyakin, vol. 4, 1958, pp. 160–168, 187–191; Chem. Abs., vol. 53, No. 4, Feb. 25, 1959, col. 2725b and 3638f.

[28] Estrada, Neil, Anti-Rust Additives in Primer Paints: Offic. Dig., Federation Paint & Varnish Production Clubs, vol. 29, 1957, pp. 1077–1085; Chem. Abs., vol. 53, No. 3, Feb. 10, 1959, col. 2641d.

[29] Cauterman, P. A. F. (assigned to Northern Pigment Co., Ltd., Toronto, Canada), Method of Forming Uniform Uncontaminated Iron Oxide for Pigment and Other Uses: U.S. Patent 2,904,402, Sept. 15, 1959.

[30] Maruschek, H. K., [Black Iron Oxide Pigment]: Austrian Patent 199,285, Aug. 25, 1958; Chem. Abs., vol. 53, No. 6, Mar. 25, 1959, col. 5703c.

[31] Edwards, W. H. (assigned to E. I. du Pont de Nemours & Co.), Beneficiated Iron Oxide Pigment and Coating Compositions Containing Same: U.S. Patent 2,917,400, Dec. 15, 1959.

Kyanite and Related Minerals

By James D. Cooper [1] and Gertrude E. Tucker [2]

⁂

DURING 1959 imports of kyanite and related minerals nearly equalled the 1957 volume, after a year in which they had dropped to the lowest level since data first became available in 1937. United States production of kyanite and of synthetic mullite was about the same as in 1957 and substantially higher than in 1958.

Kyanite, sillimanite, andalusite, dumortierite, topaz, and synthetic mullite are discussed in this chapter because their properties and end use are similar. All are aluminum silicates that can be used to produce mullite-containing refractories.

DOMESTIC PRODUCTION

Kyanite, the only natural mullite-forming mineral produced in the United States, was recovered as minus-35-mesh flotation concentrate. Production increased about 25 percent over 1958 owing to increased demand. The two companies producing kyanite were Commercialores, Inc., from deposits near Clover, S.C., and Kyanite Mining Corp., from deposits near Farmville, Prince Edward County, Va., and Willis Mountain, near Dillwyn, Buckingham County, Va. Commercialores also developed a kyanite deposit on the southern edge of Crowder Mountain near Gastonia, N.C.

Synthetic mullite output was about 17,000 short tons, compared with revised figures for 1957 and 1958 of 19,000 and 13,500 tons, respectively. The 1959 production was valued at about $2 million.

CONSUMPTION AND USES

Mullite, produced from natural ores or by synthesis from bauxite and clay, was used almost entirely in manufacturing superduty refractory brick and shapes and in mortars, cements, plastics, and ramming mixtures.

About 90 percent of all mullite refractories was used in the metallurgical and glass industries, and most of the remaining 10 percent was used to make kiln furniture for the ceramic industry.

The initial cost of mullite refractories is considerably higher than that of fire-clay refractories; however, in furnace areas where temperatures are unusually high or where slagging is severe the lower maintenance cost of mullite refractories more than offsets their higher initial cost.

---

[1] Commodity specialist.

[2] Statistical assistant.

PRICES

Prices reported by industry for domestic kyanite were as follows: Per short ton, f.o.b. point of shipment, 35-mesh, carlots, in bulk, $42 to $44, in bags $45 to $47; 200-mesh, in bags, carlots, $53 to $55. Prices reported in E&MJ Metal and Mineral Markets for imported kyanite (60-percent grade) in bags were $76 to $81 per ton, c.i.f. Atlantic ports.

FOREIGN TRADE [3]

Imports of kyanite and related minerals increased sharply over 1958 but were still 6 percent below 1957, indicating that the gradual decline in imports begun in 1952 was continuing. The gradual decline is attributed partly to availability of domestically produced synthetic mullite. Exports of kyanite and related minerals in 1959 were the highest on record.

TABLE 1.—Kyanite and allied minerals imported for consumption into and exported from the United States

[Bureau of the Census]

Imports			Exports		
Year and origin	Short tons	Value	Year and destination	Short tons	Value
1950-54 (average)	11,498	[1] $455,022	1950-54 (average)	1,048	$44,672
1955	7,581	338,993	1955	1,716	87,315
1956	6,951	306,181	1956	1,331	63,193
1957	5,999	263,375	1957	2,588	129,963
1958			1958		
Europe: United Kingdom	7	502	North America:		
Asia: India	1,289	74,093	Canada	1,161	58,700
Africa: Union of South Africa	669	20,894	Dominican Republic	12	661
			Mexico	736	33,169
Total	1,965	95,489	Europe:		
			France	30	1,634
1959			Germany, West	265	14,313
Europe: Netherlands	41	3,663	Italy	121	7,360
Asia: India	3,452	172,044	Netherlands	73	3,983
Africa: Union of South Africa	2,140	75,931	United Kingdom	35	2,752
			Asia: Japan	60	4,290
Total	5,633	251,638	Total	2,493	126,862
			1959		
			North America:		
			Canada	1,829	108,535
			Mexico	562	28,082
			South America: Argentina	30	1,980
			Europe:		
			France	14	2,782
			Germany, West	105	5,992
			Italy	11	949
			Netherlands	12	811
			United Kingdom	15	4,023
			Asia: Japan	156	14,278
			Total	2,734	167,432

[1] 1954 data known to be not comparable with other years.

---

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

WORLD REVIEW

Australia.—Sillimanite production of 2,173 short tons in the first half of 1959 was greater than the total 1958 output.[4]

India.—In 1959 exports were 25,446 short tons of kyanite and 11,575 tons of sillimanite. Almost one-third of the kyanite went to the United Kingdom. West Germany received about half of the sillimanite.[5]

Assam Sillimanite, Ltd., obtained a license to build a plant with an annual capacity of approximately 50,000 tons of refractories. The plant was to be in the Ranchi district of Bihar. Technical assistance was to be furnished by the West German firm, Vereinigte Grossalmeroder Thonwerke, A. G. International Finance Corp., Washington, D.C., was to provide financial aid.[6]

Kenya.—Production of kyanite in 1959 was 793 short tons valued at US$43,593.[7]

South-West Africa.—Production of kyanite for January–September 1959 was 1,455 short tons, compared with 2,145 tons for the corresponding period in 1958.[8]

Union of South Africa.—Production of sillimanite and andalusite in 1959 totaled 49,591 short tons valued atUS$1,756,000. Exports were 42,223 tons valued at US$1,693,000.[9]

TECHNOLOGY

A bibliography of kyanite and related minerals was published, with references on geology, geographic occurrence, technology, and uses.[10] References through December 31, 1958, were cited.

Kyanite deposits of economic value in northern Karelia, Finland, were described.[11]

Two rare occurrences were described—kyanite-garnet gedritite in Clearwater County, Idaho,[12] and manganian andalusite in Rio Arriba County, N. Mex.[13]

Evidence was presented indicating that the mullite-corundum primary crystallization boundary in the systems $HgO-Al_2O_3-SiO_2$ and $CaO-Al_2O_3-SiO_2$ differs from the generally accepted boundary for

---

[4] Australia Bureau of Mineral Resources, Geology, and Geophysics, The Australian Mineral Industry: Vol. 12, No. 2, pt. 2, November 1959, p. 9; The Australian Mineral Industry, 1958 Review: 1959, p. 174.

[5] U.S. Embassy, New Delhi, India, State Department Dispatch 727: Feb. 19, 1960, enclosure 1, pp. 2–3.

[6] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 3, March 1960, pp. 24–25.

[7] U.S. Consulate, Nairobi, British East Africa, State Department Dispatch 435: Mar. 23, 1960, p. 1.

[8] Union of South Africa Department of Mines (Minerals), Quarterly Inf. Circ.: July–September 1959, p. 69.

[9] U.S. Consulate, Johannesburg, Union of South Africa, State Department Dispatch 233: Mar. 14, 1960, p. 1.

[10] Grametbaur, A. B., Selected Bibliography of Andalusite, Kyanite, Sillimanite, Dumortierite, Topaz, and Pyrophyllite in the United States: Geol. Survey Bull. 1019–N. 1959, pp. 973–1046.

[11] Aurola, Erkki [The Kyanite and Pyrophyllite Deposits in Northern Karelia (Finland)] : Geol. Tutkimuslaitos Geotek. Julkaisuja, No. 63, 1959, 36 pp.; Chem. Abs., vol. 53, No. 22, Nov. 25, 1959, col. 21478e.

[12] Hietanen, Anna, Kyanite-Garnet Gedritite Near Orofino, Idaho: Am. Mineral., vol. 44, No. 5–6, May–June 1959, pp. 539–564.

[13] Heinrich, E. W., and Corey, A. F., Manganian Andalusite From Kiawa Mountain, Rio Arriba County, New Mexico: Am. Mineral., vol. 44, No. 11–12, November–December 1959, pp. 1261–1271.

each system.[14] It also differs from the boundary proposed in 1951 by N. A. Toropov and F. Ya. Galakhov.[15] Revised ternary diagrams were constructed.

The stability and reactions of synthetic mullite in the presence of foreign oxide additives at temperatures of 1,200° to 1,700° C. were determined.[16] Ions of oxides that can be absorbed either contract, have no effect on, or expand the mullite lattice dimensions, depending on the radius of the absorbed ions. Certain ions, such as $Na+$, $K+$, Ca^{2+}, and Mg^{2+}, which are too large to be absorbed into the lattice, destroy mullite.

A process was developed to make improved mullite refractories from Canadian kyanite concentrate. Different quantities of calcined alumina and phosphoric acid were added, depending on economic factors and the type of refractory products required.[17]

The National Metallurgical Laboratory, Jamshedpur, India, developed a process for making high-temperature hot-face insulation and high-temperature dense refractories from coarse-bladed Indian kyanite. The process differed from conventional methods in preparation and blending of the raw materials and in temperature schedules for firing. It may result in a market for previously unusable material.[18]

The first iron blast furnace to be built with an all-sillimanite stack lining was completed at Scunthorpe, England. Operation of this furnace was of interest to iron makers and refractories manufacturers throughout the world.[19]

---

[14] Aramaki, Shigeo, and Roy, Rustrum, The Mullite-Corundum Boundary in the Systems $MgO\text{-}Al_2O_3\text{-}SiO_2$ and $CaO\text{-}Al_2O_3\text{-}SiO_2$: Jour. Am. Ceram. Soc., vol. 42, No. 12, Dec. 1, 1959, pp. 644–645.

[15] Toropov, N. A., and Galakhov, F. Ya. [The System $Al_2O_3\text{-}SiO_2$]: Doklady Akad. Nauk. S.S.S.R., vol. 78, No. 2, 1951, pp. 299–302.

[16] Gelsdorf, Günter, Müller-Hesse, Hermann, and Schwiete, H. E. [Additive Experiments on Synthetic Mullite and Substitution Experiments With Gallium Oxide and Germanium Dioxide: II]: Arch. Eisenhüttenw., vol. 29, No. 8, 1958, pp. 513–519; Ceram. Abs., vol. 42, No. 9, September 1959, p. 236.

[17] Svikis, V. D., Properties of Improved Phosphate-Stabilized Refractory Materials Made From Canadian Kyanite Concentrate: Bull. Am. Ceram. Soc., vol. 38, No. 5, May 1959, pp. 264–268.

[18] Iron and Coal Trades Review (London), Mullite Refractories From Kyanite: Vol. 179, No. 4757, Sept. 18, 1959, p. 348.

[19] Metallurgia (Manchester, England), First Sillimanite-Lined Blast Furnace: Vol. 60, No. 362, December 1959, p. 278.

Lead

By G. Richards Gwinn [1] and Edith E. den Hartog [2] [3]

⁂

Contents

THE DOMESTIC lead industry in 1959 was characterized by a considerably lower supply of metal than in preceding years, an increase in consumption, and a resulting reduction in refinery stocks. Recovery of secondary lead was greater, but mine and refinery production and imports decreased markedly from 1958. Import quotas remained in effect throughout the year. Common-grade lead (New York market) fluctuated from 11 to 13 cents a pound.

TABLE 1.—Salient statistics of the lead industry, in short tons

	1950-54 (average)	1955	1956	1957	1958	1959
United States:						
Production:						
Mine production of recoverable lead	375, 443	338, 025	352, 826	338, 216	267, 377	255, 586
Value (thousands)	$111, 040	$100, 731	$110, 787	$96, 730	$62, 566	$58, 785
Primary lead (refined):						
From domestic ores and base bullion	359, 019	321, 132	349, 188	347, 675	269, 082	225, 270
From foreign ores and base bullion	111, 673	158, 025	193, 120	185, 858	201, 074	115, 661
Antimonial lead (primary lead content)	18, 842	14, 586	13, 657	19, 870	16, 446	12, 402
Secondary lead (lead content)	487, 868	502, 051	506, 755	489, 229	401, 787	451, 387
Imports:						
Lead in ores and matte	114, 165	177, 479	196, 452	198, 479	201, 599	139, 178
Lead in base bullion	1, 414	----------	31	84	460	80
Lead in pigs, bars, and old	369, 102	284, 729	283, 392	333, 492	375, 022	271, 695
Exports of refined pig lead	1, 435	403	4, 628	4, 339	1, 359	2, 756
Stocks (lead content):						
At primary smelters and refineries	106, 931	89, 443	97, 043	143, 916	234, 290	171, 079
At consumer plants	120, 716	117, 458	123, 995	129, 310	122, 900	126, 496
Consumption of metal, primary and secondary	1, 170, 009	1, 212, 644	1, 209, 717	1, 138, 115	986, 387	1, 091, 149
Price, common lead, New York, average, cents per pound	14. 96	15. 14	16. 01	14. 66	12. 11	12. 21
World:						
Mine production	2, 060, 000	2, 430, 000	2, 490, 000	2, 620, 000	2, 560, 000	2, 530, 000
Smelter production	1, 995, 000	2, 250, 000	2, 410, 000	2, 525, 000	2, 500, 000	2, 420, 000
Price, common lead, London, average, cents per pound	14. 78	12. 19	14. 52	12. 05	9. 13	8. 88

---

[1] Commodity specialist.

[2] Statistical assistant.

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

LEGISLATION AND GOVERNMENT PROGRAMS

The third session of the United Nations Lead and Zinc Committee, April 28 to May 6, 1959, and the inaugural meeting of the Lead and Zinc Study Group, May 4 to 6, 1959, were held at United Nations Headquarters, New York, N.Y. No concrete intergovernmental agreements were made on the curtailment of metal production. The Lead and Zinc Study Group, an autonomous intergovernmental body, replaced the Lead and Zinc Committee. Membership was opened to governments of any countries that were members of the United Nations or appropriate specialized agencies, also to contracting parties to the General Agreements on Tariffs and Trade interested in the production or consumption of, or trade in, lead and zinc. The committee was charged with providing continuous, accurate information on the supply and demand position of lead and zinc and its probable development. For this purpose the group was asked to arrange for the collection of internationally comparable statistical data on lead and zinc.

The import quotas established in October 1958 by Presidential proclamation continued without revision throughout 1959. The value of the quota system was questioned. Some opinions were that (1) quotas should be expanded and extended; (2) quotas should be removed immediately with no increase in duties; and (3) quotas should be removed immediately with an increase in tariff rates.

In addition to maintaining import quotas, the Federal Government took additional measures to assist the domestic lead industry. A number of bills were introduced (and still pending) in Congress; an investigation was initiated by the Tariff Commission to study import trends of manufactured lead products not covered by quotas; and a Senate Resolution (S. Res. 162), adopted August 21, 1959, directed the U.S. Tariff Commission to investigate the domestic lead industry. This investigation would include specific findings of the Commission on the condition of the lead mining industry and would indicate what additional import restrictions, if any, were needed so that domestic lead mining might be conducted on a sound and stable basis. The report was to be submitted to Congress on or before March 31, 1960.

Under the Office of Minerals Exploration, which limited Government participation to one-half the cost and a maximum of $250,000 for any one contract, six new contracts were certified in 1959. Total expenditure authorized under the contracts was $221,796, of which the Government paid one-half or $110,898. Five of the contracts were for exploration of lead-zinc deposits and one for lead alone.

No surplus-agricultural-product barter contracts for lead were negotiated by the Commodity Credit Corporation (CCC), as lead had been removed from the list of materials eligible for barter late in December 1958. The addition of 45,000 short tons of lead to the CCC stockpile between February and October 1959 represented deliveries on contracts negotiated in earlier years. The last contract was completed on August 12, 1959.

No Government purchases of lead were made for the strategic stockpile as the Government procurement program had terminated at the end of 1958.

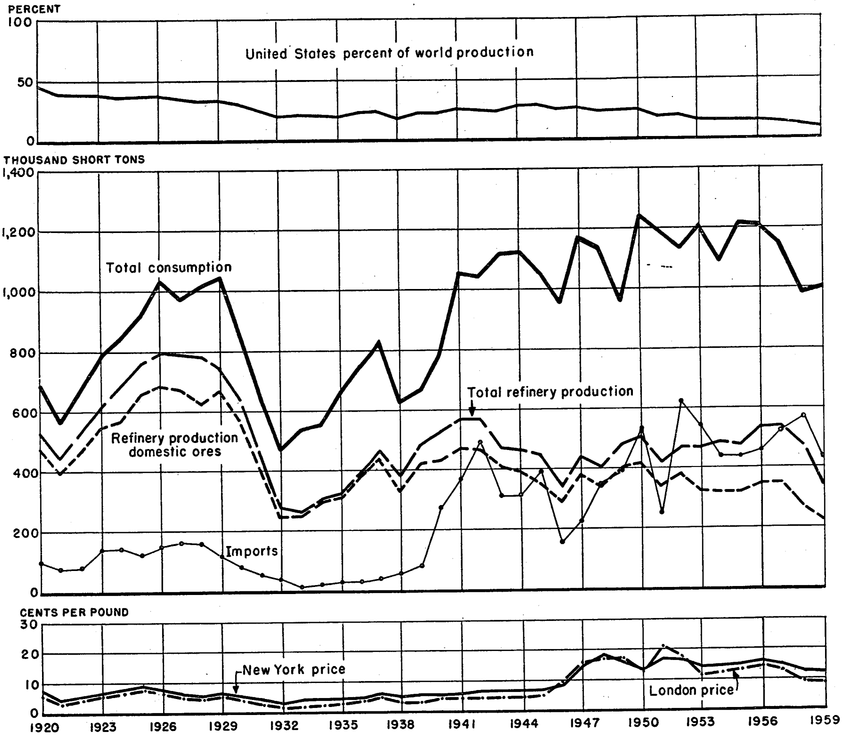

FIGURE 1.—Trends in the lead industry in the United States, 1920–59. Consumption includes primary refined, antimonial, and secondary lead and lead in pigments made directly from ore. Imports are factored to include 95 percent of the lead content of ores, mattes, and concentrates and 100 percent of pigs, bars, base bullion, and scrap.

DOMESTIC PRODUCTION

MINE PRODUCTION

The domestic output of 255,600 short tons of recoverable lead was the lowest in 60 years. It was 4 percent below the 1958 output and only 37 percent of the record production of 1925. The continuing decline was attributed to large lead-industry stock surpluses. The accumulation of stocks was due largely to the closing of many smelters from August 26 to almost the end of the year because of labor disputes. Monthly production declined from 23,600 tons in January to 19,700 in July. An upturn began in August, and output reached 22,000 tons in December.

The production of lead in the Western States was essentially the same as in 1958 but accounted for 56 percent of the total U.S. output compared with 53 percent in 1958.

Idaho produced 62,400 tons, an increase of 16 percent over 1958, and again ranked first among the lead-producing Western States and second in the United States. The Bunker Hill mine of the Coeur d'Alene district continued to be the State's largest producer. The increase in the Idaho output resulted chiefly from an increased extraction rate at the principal mines in Shoshone County. In the development of deeper ore in the Coeur d'Alene district depths in excess of 4,000 feet were reached. Mining at a depth of 4,420 feet, or 1,720 feet below sea level, was planned for the Sunshine mine. The Hercules mine of Day Mines, Inc., was closed in the latter part of the year.

Utah continued to hold second place among the producers of lead in the Western States. The United States and Lark mine maintained its position as the largest producer in the State; other important producers were the United Park City and Mayflower-Park Galena mines. A merger agreement was reached by Chief Consolidated Mining Co. and Shattuck-Denn Mining Corp. The Bear Creek Mining Co., domestic exploration affiliate of Kennecott Copper Corp., discovered and commenced development of a major silver-lead-zinc ore body in the Tintic district.

Colorado was the third largest lead producer in the Western States. The Eagle mine of New Jersey Zinc Co. at Gilman and the San Miguel property of Idarado Mining Co. were the two major lead producers in Colorado. The newly reopened Rico mine in Dolores County and the Emperius mine at Creede also made significant contributions to the State's lead production.

TABLE 2.—Mine production of recoverable lead in the United States, by States, in short tons

	1950–54 (average)	1955	1956	1957	1958	1959
Western States:						
Alaska	36	1	1	9	2	----------
Arizona	15,622	9,817	11,999	12,441	11,890	9,999
California	10,466	8,265	9,296	3,458	140	227
Colorado	25,397	15,805	19,856	21,003	14,112	12,907
Idaho	78,874	64,163	64,321	71,637	53,603	62,395
Montana	19,393	17,028	18,642	13,300	8,434	7,672
Nevada	6,152	3,291	6,384	5,979	4,150	1,357
New Mexico	4,169	3,296	6,042	5,294	1,117	829
Oregon	6	3	5	5	1	----------
South Dakota	3	----------	----------	----------	----------	----------
Texas	46	----------	----------	----------	----------	----------
Utah	46,382	50,452	49,555	44,471	40,355	36,630
Washington	10,216	10,340	11,657	12,734	9,020	10,310
Total	216,762	182,461	197,758	190,331	142,824	142,326
West Central States:						
Arkansas	9	----------	----------	----------	----------	38
Kansas	6,346	5,498	7,635	4,257	1,299	481
Missouri	127,744	125,412	123,783	126,345	113,123	105,165
Oklahoma	15,189	14,126	12,350	7,183	3,692	601
Total	149,288	145,036	143,768	137,785	118,114	106,285
States East of the Mississippi River:						
Illinois	3,355	4,544	3,832	2,970	1,610	2,570
Kentucky	73	----------	228	411	516	409
New York	1,345	1,037	1,608	1,667	579	481
Tennessee	31	----------	5	----------	----------	----------
Virginia [1]	3,133	2,999	3,045	3,152	2,934	2,770
Wisconsin	1,456	1,948	2,582	1,900	800	745
Total	9,393	10,528	11,300	10,100	6,439	6,975
Grand total	375,443	338,025	352,826	338,216	267,377	255,586

---

[1] Includes 4 tons from North Carolina in 1954, 2 tons in 1955, 10 tons in 1956, and 9 tons in 1957.

TABLE 3.—Principal ores yielding lead and zinc in the United States in 1959, in short tons[1]

States	Lead ore			Zinc ore			Lead-zinc ores			Copper-lead, copper-zinc and copper-lead-zinc ores			Total		
	Gross weight	Lead	Zinc	Gross weight	Lead	Zinc	Gross weight	Lead	Zinc	Gross weight	Lead	Zinc	Ore, gross weight	Lead	Zinc
Alaska	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
Arizona	4,087	239	18	16,139	------	3,264	346,147	9,720	23,617	96,299	26	10,309	462,672	9,985	37,208
Arkansas	------	------	------	------	------	------	1,600	38	49	------	------	------	1,600	38	49
California	485	62	1	------	------	------	1,555	160	74	------	------	------	2,040	222	75
Colorado	10,457	701	4	67	2	24	291,792	4,853	24,936	369,064	7,171	10,423	671,380	12,727	35,387
Idaho	84,917	7,670	835	(2)	(2)	(2)	848,960	50,377	46,231	------	------	------	933,877	58,047	47,066
Illinois	688	510	------	6,499	------	275	625,826	860	19,340	------	------	------	633,013	1,370	19,615
Kansas	500	31	------	700	13	51	15,185	437	966	------	------	------	16,385	481	1,017
Missouri	5,290,638	101,140	92	------	------	------	------	------	------	[3] 282,879	4,025	------	5,573,517	105,165	92
Montana	17,557	2,390	192	596,080	4,522	22,809	1,272	41	25	------	------	------	614,909	6,953	23,026
Nevada	4,701	613	64	------	------	------	1,034	138	45	------	------	------	5,735	751	109
New Mexico	------	------	------	------	------	------	[4] 74,552	757	4,606	------	------	------	74,552	757	4,606
Oklahoma	700	48	------	350	1	14	14,315	552	1,035	------	------	------	15,365	601	1,049
Tennessee	------	------	------	2,409,225	------	83,176	------	------	------	1,482,810	------	6,756	3,892,035	------	89,932
Utah	2,042	212	29	------	------	------	467,998	35,713	33,087	993	18	34	471,033	35,943	33,150
Washington	114	20	2	400	------	21	856,071	10,290	17,085	------	------	------	856,585	10,310	17,108
Wisconsin	------	------	------	452,806	700	11,316	11,584	45	319	------	------	------	464,390	745	11,635
New York						7,865		481	35,599					481	43,464
New Jersey															
	------	------	------	571,206	------	------	860,985	------	------	------	------	------	1,432,191	------	------
Pennsylvania						16,718									16,718
Virginia[5]						5,884		2,770	14,450					2,770	20,334
Total	5,416,886	113,636	1,237	4,053,472	5,238	151,417	4,418,876	117,232	221,464	2,232,045	11,240	27,522	16,121,279	247,346	401,640

[1] Does not include lead or zinc recovered from other ores, tailings, slags, dumps, etc., except where exclusion was impossible.

[2] Zinc and lead-zinc ores combined to avoid disclosing confidential data.

[3] Includes some copper concentrates yielding 146 tons of lead.

[4] All ores combined to avoid disclosing confidential data.

[5] Data partly combined to avoid disclosing confidential data.

Washington was one of the few States showing an increase in lead output. The Pend Oreille mine of Pend Oreille Mines and Metal Co. and the Grandview mine of American Zinc Lead and Smelting Co. were again the major producers. Mining companies opposed the planned construction of two large power dams in the Metaline district, Pend Oreille County, on the grounds that large resources of lead and zinc would be irrevocably lost by flooding.

The decline in lead output in Arizona, which began in 1958, continued through 1959. The Iron King mine operated by the Shattuck-Denn Mining Corp. was the State's leading producer. McFarland & Hullinger closed the San Xavier mine late in the year. The Ari-Vada Corp. began operating the McCracken lead-silver mine near Signal in Mohave County and constructed a new 150-ton mill to process the ore.

Lead production from Montana was the lowest since the economic depression of the early 1930's. The reduced output was attributed chiefly to a prolonged labor strike at the mines in Butte. A sizable block of lead-zinc-silver-gold ore was opened by leasers in a supposedly mined-out area of the Snowshoe mine. A new 100-ton selective flotation concentrator, utilizing jig tailings and ore from the mine, was placed in operation near Libby Mountain by St. Paul Lead Co., of Kellogg, Idaho, and Merger Mines Corp. of Coeur d'Alene, Idaho, joint owners

TABLE 4.—Leading lead-producing mines in the United States in 1959, in order of output

Rank	Mine	District or region	State	Operator	Type of ore
1	Federal	Southeastern Missouri.	Missouri	St. Joseph Lead Co	Lead.
2	Bunker Hill	Coeur d'Alene	Idaho	The Bunker Hill Co	Lead-zinc.
3	United States & Lark.	West Mountain (Bingham).	Utah	U.S. Smelting, Refining & Mining Co.	Gold-silver, lead-zinc.
4	Leadwood	Southeastern Missouri.	Missouri	St. Joseph Lead Co	Lead.
5	Indian Creek	do	do	do	Do.
6	Star	Coeur d'Alene	Idaho	The Bunker Hill Co	Lead-zinc.
7	Bonne Terre	Southeastern Missouri.	Missouri	St. Joseph Lead Co	Lead.
8	Pend Oreille	Metaline	Washington	Pend Oreille Mines & Metals Co.	Lead-zinc.
9	Iron King	Big Bug	Arizona	Shattuck-Denn Mining Corp.	Do.
10	Treasury Tunnel-Black Bear-Smuggler Union.	Upper San Miguel	Colorado	Idarado Mining Co	Copper-lead-zinc.
11	Page	Coeur d'Alene	Idaho	American Smelting & Refining Co.	Lead-zinc.
12	Lucky Friday	do	do	Lucky Friday Silver-Lead Mines Co.	Lead.
13	United Park City	Uintah	Utah	United Park City Mines Co.	Lead-zinc.
14	Butte Mines	Summit Valley	Montana	The Anaconda Co	Do.
15	Madison	Southeastern Missouri.	Missouri	National Lead Co	Lead-copper.
16	Mayflower-Galena	Blue Ledge	Utah	New Park Mining Co	Lead-zinc.
17	Eagle	Red Cliff (Battle Mountain).	Colorado	The New Jersey Zinc Co.	Copper, lead-zinc.
18	Austinville	Austinville	Virginia	do	Zinc-lead.
19	Grandview	Metaline	Washington	American Zinc, Lead & Smelting Co.	Lead-zinc.
20	Jack Waite	Eagle	Montana	American Smelting & Refining Co.	Lead.
21	Emperius	Creede	Colorado	Emperius Mining Co	Lead-zinc.
22	Sunshine	Coeur d'Alene	Idaho	Sunshine Mining Co	Silver.
23	Hercules	do	do	Day Mines, Inc	Lead-zinc.
24	Flux	Harshaw	Arizona	Nash & McFarland	Do.
25	Dayrock	Coeur d'Alene	Idaho	Day Mines, Inc	Lead.

of the Snowshoe mine. The mill also was to handle ore from other area operators on a custom basis.

Most of the Nevada lead production was recovered as a byproduct of processing manganese and gold-silver ores. The reopening of The New Jersey Zinc Co.'s Hanover mine-mill unit in New Mexico in late summer and the lease of the Linchburg mine by the same company increased the monthly production level in New Mexico by the end of the year.

Missouri continued in first place among the lead-mining States of the Nation. Mines in Oklahoma and Kansas remained closed throughout most of 1959 because of continued low metal prices and the lower grade of the ore.

The output of lead from the mines of the Southeast Missouri Lead Belt, although 7 percent below 1958, represented about 41 percent of the U.S. total. St. Joseph Lead Co. reduced lead mining operations from a 5-day to a 4-day workweek in February because of the declining metal market. The 5-day week was resumed, however, in August and maintained throughout the rest of the year. Development of the company's new Viburnum ore bodies in Crawford, Washington, and Iron Counties, continued. One of the three newly planned shafts was bottomed at approximately 800 feet, and a second shaft was collared and sunk to a considerable depth. Lateral cutting was begun on the bottomed shaft. Ore reserves were large, and the average grade of ore was considerably higher than that of parts of the district previously mined.

A small quantity of lead was recovered by reprocessing tailing dumps; however, no mine production was reported from the once richly productive Tri-State mines in northeast Oklahoma, southeast Kansas, and southwest Missouri.

Lead production from mines east of the Mississippi was derived almost exclusively from processing zinc ores in which lead occurred in small quantities. Improved zinc metal prices at the end of the year foreshadowed a possible improvement in the lead industry in the Eastern States.

SMELTER AND REFINERY PRODUCTION

Refined lead produced in the United States was derived from three sources—domestic mine production, imports of foreign ore and base bullion, and scrap material (treated largely at secondary smelters). The lead was recovered at primary refineries that treated ore, base bullion, and small quantities of scrap and at secondary plants that processed scrap exclusively. Refined lead and antimonial (hard)

TABLE 5.—Mine production of recoverable lead in the United States, by months, in short tons

Month	1958	1959	Month	1859	1959
January	26,123	23,626	August	19,592	21,922
February	23,827	21,449	September	19,570	20,719
March	18,440	21,156	October	21,200	21,208
April	25,896	21,432	November	21,382	20,279
May	24,528	20,375	December	22,716	22,129
June	22,961	21,634			
July	21,142	19,657	Total	267,377	255,586

lead were produced by both primary and secondary plants. Because of the large quantity of hard lead (such as battery scrap) melted at secondary smelters, the output from this type of operation was principally antimonial lead.

A list of primary smelters and refiners was presented in the Lead chapter of the 1957 Minerals Yearbook. The only changes are the deletion of the United States Smelting, Refining & Mining Co.'s smelter at Midvale, Utah, which shut down late in 1958, and a correction in the location of the Bunker Hill smelter and refinery, which is at Kellogg, Idaho. A list of the major secondary smelting firms and their plant locations follows:

American Smelting & Refining Co. (including Federated Metals Division) plants: Los Angeles, San Francisco, and Selby, Calif.; Whiting, Ind.; Omaha, Nebr.; Newark and Perth Amboy, N.J.; Houston, Tex.
Bers & Co., Inc., Philadelphia, Pa.
The Bunker Hill Co., Seattle, Wash.
Caswell, Strauss & Co., Inc., Sewaren, N.J.
Continental Smelting & Refining Co., McCook, Ill.
Detroit Lead Corp., Detroit, Mich.
Eastern Smelting & Refining Co., Los Angeles, Calif.
Electric Storage Battery Co., Philadelphia, Pa.
Goldsmith Bros., Div. of National Lead Co., Chicago, Ill.
Gopher Smelting & Refining Co., St. Paul, Minn.
Imperial Type Metals Co. plants: Chicago, Ill., and Philadelphia, Pa.
Industrial Metal Melting Co., Inc., Baltimore, Md.
Inland Metals Refining Co., Chicago, Ill.
Nassau Smelting & Refining Co., Inc., Tottenville, N.Y.
National Lead Co. (including Magnus Metal Division, Morris P. Kirk & Son, Inc., and Master Metals, Inc.) plants: Los Angeles, Calif.; Denver, Colo.; Atlanta, Ga.; Chicago and Granite City, Ill.; Indianapolis, Ind.; Topeka, Kans.; Baltimore, Md.; Boston and Fitchburg, Mass.; St. Louis Park, Minn.; St. Louis, Mo.; Omaha, Nebr.; Perth Amboy, N.J.; Albany and Depew, N.Y.; Cincinnati and Cleveland, Ohio; Portland, Oreg.; Pittsburgh, Pa.; Dallas and Houston, Tex.
National Metal & Smelting Co., Fort Worth, Tex.
North American Smelting Co., Wilmington, Del.
Price Battery Corp., Hamburg, Pa.
Revere Smelting & Refining Co., Newark, N.J.
Schuylkill Products Co., Baton Rouge, La.
Seitzinger's Inc., Atlanta, Ga.
Southeastern Lead Co., Tampa, Fla.
Southern Lead Co., Dallas, Tex.
U.S.S. Lead Refinery, Inc., East Chicago, Ind.
Hyman Viener & Sons, Richmond, Va.
Western Lead Products Co., Los Angeles, Calif.
Willard Smelting Co., Inc., Charlotte, N.C.
Winston Lead Smelting Co., Winston-Salem, N.C.

Refined Lead—Primary and Secondary.—The 12 active domestic primary lead smelters and refineries produced 342,100 tons of refined lead and 35,600 tons of lead in antimonial lead. A total of 379,900 tons of lead in primary raw materials and 27,700 tons in scrap was consumed. Smelter output, however, was interrupted during the year because of labor disputes which closed a large proportion of the smelters from August 20 until almost the end of the year.

Domestic ores were the source of 66 percent of the 340,900 tons of refined lead produced from primary sources, and foreign ores and bullion supplied 34 percent (57 and 43 percent, respectively, in 1958).

TABLE 6.—Refined lead produced at primary refineries in the United States, by source material, in short tons

Source	1950–54 (average)	1955	1956	1957	1958	1959
Refined lead:						
From domestic ores and base bullion	359,019	321,132	349,188	347,675	269,082	225,270
From foreign ores	110,276	157,863	193,084	185,798	200,299	115,616
From foreign base bullion	1,397	162	36	60	775	45
Total from primary sources	470,692	479,157	542,308	533,533	470,156	340,931
From scrap	4.339	4,079	4,069	3,263	2,338	1,194
Total refined lead	475,031	483,236	546,377	536,796	472.494	342,125
Average sales price per pound	$0.147	$0.149	$0.157	$0.143	$0.117	$0.115
Total calculated value of primary refined lead (thousands) [1]	$138,383	$142,789	$170,285	$152,590	$110,017	$78,414

[1] Excludes value of refined lead produced from scrap at primary refineries.

Primary lead smelters also produced 1,200 tons of refined lead from scrap and secondary lead smelters, 124,200 tons from scrap. Refined and remelt lead from all sources totaled 466,300 tons.

Antimonial Lead—Primary and Secondary.—Primary and secondary smelters produced 230,800 tons of antimonial lead (216,700 tons lead content)—about 9 percent above the 1958 total. Of the primary smelter output of 35,600 tons (lead content), 65 percent came from scrap, most of which was battery-lead plates, 18 percent from primary domestic sources, and 17 percent from foreign sources. Secondary smelters produced 181,200 tons (lead content) of antimonial lead.

Battery-lead plates accounted for 62 percent of the total lead- and tin-base scrap melted. Antimonial lead was the major product recovered.

Other Secondary Lead.—Secondary lead recovered by all plants consuming scrap totaled 451,400 tons—an increase of 12 percent over 1958. Secondary lead and copper smelters recovered 90 percent of the total, primary lead smelters 5 percent, and manufacturers and foundries 5 percent. Soft lead accounted for 125,400 tons; reclaimed lead in antimonial lead, 204,350 tons; lead-base alloys (solder, type metal, babbitts, and cable lead), 96,300 tons; and copper-base alloys, 25,300 tons. A small quantity was recovered from tin-base alloys.

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
1950–54 (average)	60,743	4,274	7.0	11,319	7,523	37,627	56,469
1955	64,044	3,555	5.6	5,259	9,327	45,903	60,489
1956	66,826	3,348	5.0	6,739	6,918	49,821	63,478
1957	67,786	3,064	4.5	10,271	9,599	44,852	64,722
1958	50,246	2,803	5.6	8,256	8,190	30,997	47,443
1959	37,487	1,924	5.1	6,447	5,955	23,161	35,563

TABLE 8.—Stocks and consumption of new and old lead scrap in the United States in 1959, gross weight, in short tons

Class of consumers and type of scrap	Stocks beginning of year[1]	Receipts	Consumption			Stocks end of year
			New scrap	Old scrap	Total	
Smelters and refiners:						
Soft lead	2,945	46,231	----------	46,251	46,251	2,925
Hard lead	938	16,491	----------	16,497	16,497	932
Cable lead	2,223	27,366	----------	27,695	27,695	1,894
Battery-lead plates	32,674	357,917	----------	361,976	361,976	28,615
Mixed common babbitt	1,159	5,416	----------	5,567	5,567	1,008
Solder and tinny lead	397	11,105	----------	10,911	10,911	591
Type metals	1,505	24,662	----------	25,087	25,087	1,080
Drosses and residues	15,228	77,482	76,089	----------	76,089	16,621
Total	57,069	566,670	76,089	493,984	570,073	53,666
Foundries and other manufacturers:						
Soft lead	92	99	9	160	169	22
Hard lead	165	461	1	473	474	152
Cable lead	34	316	----------	310	310	40
Battery-lead plates	90	----------	----------	57	57	33
Mixed common babbitt	295	9,748	----------	9,809	9,809	234
Solder and tinny lead	60	178	88	141	229	9
Type metals	----------	----------	----------	----------	----------	----------
Drosses and residues	282	----------	30	----------	30	252
Total	1,018	10,802	128	10,950	11,078	742
Grand total:						
Soft lead	3,037	46,330	9	46,411	46,420	2,947
Hard lead	1,103	16,952	1	16,970	16,971	1,084
Cable lead	2,257	27,682	----------	28,005	28,005	1,934
Battery-lead plates	32,764	357,917	----------	362,033	362,033	28,648
Mixed common babbitt	1,454	15,164	----------	15,376	15,376	1,242
Solder and tinny lead	457	11,283	88	11,052	11,140	600
Type metals	1,505	24,662	----------	25,087	25,087	1,080
Drosses and residues	15,510	77,482	76,119	----------	76,119	16,873
Total	58,087	577,472	76,217	504,934	581,151	54,408

[1] Revised figures.

TABLE 9.—Secondary metal recovered[1] from lead and tin scrap in the United States in 1959, by type of products, gross weight in short tons

	Lead	Tin	Antimony	Other	Total
Refined pig lead	103,474	----------	----------	----------	103,474
Remelt lead	21,905	----------	----------	----------	21,905
Total	125,379	----------	----------	----------	125,379
Refined pig tin	----------	3,268	----------	----------	3,268
Remelt tin	----------	336	----------	----------	336
Total	----------	3,604	----------	----------	3,604
Lead and tin alloys:					
Antimonial lead	204,346	394	12,343	186	217,269
Common babbitt	16,958	1,192	1,994	139	20,283
Genuine babbitt	38	204	41	6	289
Solder	21,587	4,772	332	77	26,768
Type metals	30,329	1,827	4,929	138	37,223
Cable lead	25,655	4	267	----------	25,926
Miscellaneous alloys	1,716	650	136	28	2,530
Total	300,629	9,043	20,042	574	330,288
Composition foil	37	2	1	----------	40
Tin content of chemical products	----------	955	----------	----------	955
Grand total	426,045	13,604	20,043	574	460,266

[1] Most of the figures herein represent actual reported recovery of metal from scrap rather than secondary metal content of shipments as in years before 1956.

TABLE 10.—**Secondary lead recovered in the United States, in short tons**

	1950–54 (average)	1955	1956	1957	1958	1959
As refined metal:						
At primary plants	4,339	4,079	4,069	3,263	2,338	1,194
At other plants	132,643	124,241	129,323	123,308	113,719	124,185
Total	136,982	128,320	133,392	126,571	116,057	125,379
In antimonial lead:						
At primary plants	37,627	45,903	49,821	44,852	30,997	23,161
At other plants	193,163	201,800	202,761	195,299	151,956	181,185
Total	230,790	247,703	252,582	240,151	182,953	204,346
In other alloys	120,096	126,028	120,781	122,507	102,777	121,662
Grand total:						
Short tons	487,868	502,051	506,755	489,229	401,787	451,387
Value (thousands)	$144,107	$149,611	$159,121	$139,919	$94,018	$103,819

TABLE 11.—**Lead recovered from scrap processed in the United States, by kind of scrap and form of recovery, in short tons**

Kind of scrap	1958	1959	Form of recovery	1958	1959
New scrap:			As soft lead:		
Lead-base	53,456	52,101	At primary plants	2,338	1,194
Copper-base	4,779	6,098	At other plants	113,719	124,185
Tin-base	283	426			
			Total	116,057	125,379
Total	58,518	58,625			
			In antimonial lead [1]	182,953	204,346
Old scrap:			In other lead alloys	90,059	96,282
Battery-lead plates	202,007	241,639	In copper-base alloys	12,673	25,342
All other lead-base	123,461	129,848	In tin-base alloys	45	38
Copper-base	17,795	21,272			
Tin-base	6	3	Total	285,730	326,008
Total	343,269	392,762	Grand total	401,787	451,387
Grand total	401,787	451,387			

[1] Includes 30,997 tons of lead recovered in antimonial lead from secondary sources at primary plants in 1958 and 23,161 tons in 1959.

CONSUMPTION AND USES

Domestic consumption of lead was 11 percent above 1958 but about 12 percent below the peak year 1950. Of the total consumed, 66 percent was soft lead, primary and secondary; 24 percent was lead content of antimonial lead; 4 percent was lead in alloys; 2 percent was lead in copper-base scrap; 3.6 percent was lead content of scrap which went directly to an end product; and 0.4 percent was lead recovered from ore in the production of leaded zinc oxide and other pigments.

Monthly consumption varied throughout the year. The high of 97,700 tons and the low of 84,900 tons were reached in October and November, respectively.

Approximately 72 percent of all lead used went into the manufacture of metal products, the largest quantity being for storage batteries (35 percent of all lead consumed), which used antimonial lead for grids and posts and soft lead for oxides. The second largest quantity (15 percent) was used for chemicals, 97 percent of which was for tetraethyl lead. Lead pigments used 10 percent; approximately 71 percent of the lead used in pigments was for manufacturing red lead and litharge.

Shipments of 27 million units of replacement batteries were reported by the Association of Battery Manufacturers, Inc., or about 7 percent above the 25.2 million units shipped in 1958.

TABLE 12.—Consumption of lead in the United States, by products, in short tons

	1958	1959
Metal products:		
Ammunition	40,215	45,328
Bearing metals	18,980	23,298
Brass and bronze	20,379	24,264
Cable covering	74,981	61,626
Calking lead	70,807	80,091
Casting metals	8,674	8,395
Collapsible tubes	8,432	9,442
Foil	4,586	3,745
Pipes, traps, and bends	23,044	24,825
Sheet lead	25,104	28,158
Solder	59,653	68,871
Terne metal	1,227	1,511
Type metal	26,740	27,966
Total	382,822	407,520
Storage batteries:		
Antimonial lead	159,795	187,284
Lead oxides	[1] 152,930	193,448
Total	312,725	380,732
Pigments:		
White lead	13,589	10,955
Red lead and litharge	64,892	74,116
Pigment colors	11,853	13,827
Other [2]	5,567	4,773
Total	95,901	103,671
Chemicals:		
Tetraethyl lead	159,412	160,020
Miscellaneous chemicals	3,233	4,485
Total	162,645	164,505
Miscellaneous uses:		
Annealing	5,114	5,129
Galvanizing	1,226	1,184
Lead plating	438	302
Weights and ballast	7,577	8,748
Total	14,355	15,363
Other, unclassified uses	17,939	19,358
Grand total [3]	986,387	1,091,149

[1] Corrected figure.
[2] Includes lead content of leaded zinc oxide and other pigments.
[3] Includes lead which went directly from scrap to fabricated products.

TABLE 13.—Consumption of lead in the United States, by months, in short tons

Month	1958	1959
January	82,385	89,122
February	72,096	85,124
March	77,723	85,431
April	79,969	91,564
May	76,214	96,443
June	81,131	96,285
July	80,635	90,648
August	84,456	92,601
September	90,222	95,162
October	92,611	97,698
November	84,367	84,903
December	84,578	86,168
Total [1]	986,387	1,091,149

[1] Includes lead content of leaded zinc oxide and other pigments and lead which went directly from scrap to fabricated products.

TABLE 14.—Consumption of lead in the United States in 1959, by class of product and types of material, in short tons

	Soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
Metal products	235,992	69,353	45,054	18,511	368,910
Storage batteries	197,733	182,959	40		380,732
Pigments	99,108	192			99,300
Chemicals	164,497	8			164,505
Miscellaneous	8,819	6,544			15,363
Unclassified	16,531	1,766	358		18,655
Total	722,680	260,822	45,452	18,511	[1] 1,047,465

[1] Excludes 39,313 tons of lead that went directly from scrap to fabricated products and 4,371 tons of lead contained in leaded zinc oxide and other pigments.

TABLE 15.—Lead consumption, by States, in 1959, in short tons[1]

State	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
California	74,113	25,068	1,657	664	101,502
Colorado	1,599	1,679	220	326	3,824
Connecticut	15,707	9,796	18	1,073	26,594
District of Columbia	106	52	---	---	158
Florida	1,935	4,172	---	---	6,107
Illinois	71,594	27,107	7,284	2,695	108,680
Indiana	48,456	31,486	2,380	836	83,158
Kansas	6,597	9,297	71	422	16,387
Kentucky	5	2,379	1	---	2,385
Maryland	7,777	7,876	781	---	16,434
Massachusetts	6,034	3,988	728	464	11,214
Michigan	11,766	11,641	1,210	748	25,365
Missouri	48,825	2,595	442	1,560	53,422
Nebraska	10,671	3,286	---	47	14,004
New Jersey	112,229	25,935	9,355	662	148,181
New York	47,615	5,690	10,729	1,296	65,330
Ohio	22,472	14,820	3,664	1,324	42,280
Pennsylvania	36,962	20,242	828	2,865	60,897
Rhode Island	3,015	267	63	---	3,345
Tennessee	381	5,929	256	336	6,902
Virginia	1,735	1,287	715	1,127	4,864
Washington	9,063	4,125	---	---	13,188
West Virginia	14,929	1,567	2	---	16,498
Wisconsin	913	3,309	86	161	4,469
Alabama and Georgia[2]	28,599	9,423	1,386	700	40,108
Iowa and Minnesota	1,132	5,888	829	359	8,208
Montana and Idaho	15,535	---	---	---	15,535
New Hampshire, Maine, and Delaware	3,572	838	960	221	5,591
Arkansas and Oklahoma	2,619	1,938	---	---	4,557
Hawaii and Oregon	778	2,181	13	271	3,243
North and South Carolina	36	3,054	---	---	3,090
Louisiana and Texas	114,851	12,882	1,682	353	129,768
Utah, Nevada, and Arizona	98	692	---	---	790
Undistributed	961	333	92	1	1,387
Total	722,680	260,822	45,452	18,511	1,047,465

[1] Excludes 39,313 tons of lead which went directly from scrap to fabricated products and 4,371 tons of lead contained in leaded zinc oxide and other nonspecified pigments.

[2] The following States are grouped to avoid disclosing individual company confidential data.

Nine States accounted for 71 percent of the total lead consumed (excluding scrap). New Jersey used 14 percent; Illinois and California, 10 percent each; Indiana, 8 percent; New York and Pennsylvania, 6 percent each; Missouri, 5 percent; and Louisiana and Texas combined, 12 percent.

LEAD PIGMENTS[4]

Activity increased in all of the major lead-pigment-consuming industries compared with 1958. The production of automobiles and trucks rose 31 percent; the value of public and private construction increased 6 and 13 percent, respectively; the value of paint sales increased 9 percent; and the combined consumption of natural and synthetic rubber rose 20 percent.

Production and Shipments.—Lead consumed in manufacturing lead pigments totaled about 280,000 tons compared with 236,000 tons in 1958, an increase of 19 percent.

White lead, red lead, litharge, and black oxide were made from refined lead and constituted 99 percent of all lead used in pigments. The lead content of leaded zinc oxide made up the remaining 1 per-

---

[4] Prepared by Arnold M. Lansche, commodity specialist, and Esther B. Miller, statistical assistant.

TABLE 16.—Salient statistics of the lead pigments[1] industry of the United States

	1950-54 (average)	1955	1956	1957	1958	1959
Shipments:						
White lead (dry and in oil) short tons	31,808	25,575	25,698	23,574	18,360	19,224
Red lead do	31,969	29,272	27,975	26,998	21,992	21,905
Litharge do	153,521	148,511	131,525	106,788	92,165	106,013
Black oxide[2] do	78,741	113,874	106,956	127,583	120,609	152,341
Value of pigments	$73,484,000	$69,133,000	$67,106,000	$54,148,000	$39,442,000	$43,835,000
Value per ton received by producers:						
White lead (dry)	382	392	413	416	388	382
Red lead	345	342	364	354	289	310
Litharge	321	326	346	321	277	275
Foreign trade:						
Value of exports	907,000	976,000	1,106,000	1,404,000	1,094,000	1,054,000
Value of imports	551,000	195,000	1,465,000	1,896,000	1,759,000	2,640,000
Export balance	356,000	781,000	−359,000	−492,000	−665,000	−586,000

[1] Excludes basic lead sulfate; figure withheld to avoid disclosing individual company confidential data.
[2] Production.

TABLE 17.—Production and shipments of lead pigments[1] in the United States

Pigment	1958				1959			
	Production (short tons)	Shipments			Production (short tons)	Shipments		
		Short tons	Value[2]			Short tons	Value[2]	
			Total	Average			Total	Average
White lead:								
Dry	12,760	12,589	$4,883,065	$388	12,352	12,436	$4,751,792	$382
In oil[3]	5,548	5,771	2,692,295	467	6,540	6,788	3,174,138	468
Red lead	21,934	21,992	6,363,384	289	21,949	21,905	6,789,381	310
Litharge	92,070	92,165	25,503,104	277	105,686	106,013	29,119,870	275
Black oxide	[4] 120,609	---	---	---	152,341	---	---	---

[1] Except for basic lead sulfate and orange mineral; 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.
[4] Revised figure.

TABLE 18.—Lead pigments[1] shipped by manufacturers in the United States, in short tons

Year	White lead			Red lead	Litharge	Black oxide[2]
	Dry	In oil	Total			
1950-54 (average)	20,332	11,476	31,808	31,969	153,521	78,741
1955	17,858	7,717	25,575	29,272	148,511	113,874
1956	17,448	8,250	25,698	27,975	131,525	106,956
1957	14,898	8,676	23,574	26,998	106,788	127,583
1958	12,589	5,771	18,360	21,992	92,165	[3] 120,609
1959	12,436	6,788	19,224	21,905	106,013	152,341

[1] Excludes basic lead sulfate and orange mineral; figures withheld to avoid disclosing individual company confidential data.
[2] Production by battery manufacturers.
[3] Revised figure.

TABLE 19.—Lead content of lead and zinc pigments[1] produced by domestic manufacturers, by sources, in short tons

Pigment	1958				1959			
	Lead in pigments produced from—			Total lead in pigments	Lead in pigments produced from—			Total lead in pigments
	Ore		Pig lead		Ore		Pig lead	
	Domestic	Foreign			Domestic	Foreign		
White lead			14,646	14,646			15,114	15,114
Red lead			19,883	19,883			19,974	19,974
Litharge			85,625	85,625			98,288	98,288
Black oxide			[2] 115,499	[2] 115,499			147,066	147,066
Leaded zinc oxide	2,675	727		3,402	2,500	1,405		3,905
Total	2,675	727	[2] 235,653	[2] 239,055	2,500	1,405	280,442	284,347

[1] Excludes lead in basic lead sulfate and orange mineral; figures withheld to avoid disclosing individual company confidential data.

[2] Revised figure.

TABLE 20.—Distribution of white lead (dry and in oil) shipments,[1] by industries, in short tons

Industry	1950–54 (average)	1955	1956	1957	1958	1959
Paints	26,164	19,825	20,288	19,253	15,288	15,148
Ceramics	1,143	484	633	667	268	243
Other	4,501	[2] 5,266	[3] 4,777	[3] 3,654	[3] 2,804	[3] 3,833
Total	31,808	25,575	25,698	23,574	18,360	19,224

[1] Excludes basic lead sulfate; figures withheld to avoid disclosing individual company confidential data.

[2] Includes 1,355 tons for plasticizers and stabilizers.

[3] Figures for plasticizers and stabilizers withheld to avoid disclosing individual company confidential data.

cent. Basic lead sulfate is not reported herein, except as it enters leaded zinc oxide; lead silicate, as it is derived from litharge, is included with litharge.

Consumption and Uses.—*White Lead.*—Paintmaking required 79 percent of the white lead shipments compared with 83 percent in 1958. Shipments to the ceramic industry furnished 1 percent of total distribution in 1959. Other uses for the pigments were in chemicals, greases, and plasticizers and stabilizers for plastics. A substantial part of the unspecified category belongs properly under paint.

Basic Lead Sulfate.—Substantial quantities of lead sulfate were used as an intermediate product in making leaded zinc oxide.

Red Lead.—The paint industry received 55 percent of the red lead compared with 62 percent in 1958. "Other" uses were in colors, lubricants, petroleum, rubber, and unspecified miscellaneous products.

Orange Mineral.—No production of this pigment was reported.

Litharge.—Battery makers continued to claim most of the litharge shipped to industry. Ceramics received about 15 percent, chrome pigments 4 percent, oil refining 3 percent, rubber 2 percent, varnish 4 percent, and the remaining 72 percent was classified as "Other," which consisted of chemicals, driers, floor covering, friction material, ink, insecticides, storage batteries, and unspecified uses.

Battery makers produced 152,000 tons of leaded litharge, commonly called black or gray suboxide, for making the paste used in filling the interstices of battery plates.

Prices.—The quoted price of white lead ranged from 17 to 18 cents a pound or $340 to $360 a ton in carlots in 1959. The average value of shipments of dry white lead was $382 a ton, down $6 from 1958; the in-oil variety was up $1 to $468. The quoted price of red lead ranged from 14.25 to 17.75 cents a pound or $285 to $355 a ton in less than carlots; average value of shipments rose $21 to $310 a ton. The quoted price of litharge ranged from 13.75 to 15.75 cents a pound or $275 to $315 a ton in less than carlots; average value of shipments decreased $2 a ton to $275.

Foreign Trade.—Imports of lead pigments and salts increased 52 percent in value and 55 percent in quantity compared with 1958. Imports of white lead, red lead, litharge, and other lead compounds rose 48, 631, 48, and 409 percent, respectively, over 1958; other lead pigments increased 28 tons.

TABLE 21.—Distribution of red-lead shipments, by industries, in short tons

Industry	1950–54 (average)	1955	1956	1957	1958	1959
Paints	13,826	14,308	14,331	15,993	13,726	12,098
Storage batteries	14,806	11,998	9,953	(1)	(1)	(1)
Ceramics	920	667	1,483	(1)	(1)	(1)
Other	2,417	2,299	2,208	11,005	8,266	9,807
Total	31,969	29,272	27,975	26,998	21,992	21,905

(1) Included with "Other."

TABLE 22.—Distribution of litharge shipments, by industries, in short tons

Industry	1950–54 (average)	1955	1956	1957	1958	1959
Storage batteries	99,157	90,200	82,041	(1)	(1)	(1)
Ceramics	20,907	24,173	19,802	18,071	(1)	15,340
Chrome pigments	8,533	6,025	3,558	3,955	3,731	4,682
Varnish	4,716	5,206	3,571	3,227	3,223	4,725
Insecticides	4,774	3,521	(1)	(1)	(1)	(1)
Oil refining	4,951	3,853	3,523	[2] 3,359	2,598	3,096
Rubber	2,359	1,947	2,266	[2] 1,298	1,247	1,808
Floor coverings	796	803	(1)	(1)	(1)	(1)
Other	7,328	12,783	16,764	76,878	81,366	76,362
Total	153,521	148,511	131,525	[2] 106,788	92,165	106,013

(1) Included with "Other."

[2] Revised figure.

TABLE 23.—Value of lead pigments and salts imported into and exported from the United States

[Bureau of the Census]

	Imports for consumption			Exports		
	1957	1958	1959	1957	1958	1959
Lead pigments:						
White lead	$25,508	$235,725	$322,712	$273,363	[1]$1,094,569	[1] $1,054,041
Red lead	60,040	13,243	94,861	242,166		
Litharge	1,794,078	1,509,165	2,218,008	888,586		
Other lead pigments	16,961	694	4,820	(2)	(2)	(2)
Total	1,896,587	1,758,827	2,640,401	(2)	(2)	(2)
Lead salts:						
Lead arsenate	-----------	-----------	-----------	231,495	412,411	276,420
Other lead compounds	15,003	10,770	53,533	18,332	(2)	(2)
Total	15,003	10,770	53,533	249,827	412,411	276,420
Grand total	1,911,590	1,769,597	2,693,934	(2)	(2)	(2)

[1] Beginning Jan. 1, 1958, exports not separately classified.
[2] Data not available.

TABLE 24.—Lead pigments and salts imported for consumption in the United States

[Bureau of the Census]

Year	Short tons							Total value
	White lead (basic carbonate)	Red lead	Litharge	Lead suboxide	Lead pigments n.s.p.f.	Lead arsenate	Other lead compounds	
1950–54 (average)	782	58	629	38	6	18	64	[1] $580,912
1955	----------	3	751	34	6	----------	352	266,615
1956	20	113	5,371	78	----------	----------	269	[1] 1,530,270
1957	92	258	8,118	33	1	----------	63	1,911,590
1958	724	64	7,712	----------	2	----------	55	1,769,597
1959	1,073	468	11,382	----------	30	----------	280	2,693,934

[1] Data known to be not comparable with other years.

TABLE 25.—Lead pigments and salts exported from the United States

[Bureau of the Census]

Year	Short tons					Total value
	White lead	Red lead	Litharge	Lead arsenate	Other lead compounds	
1950–54 (average)	805	464	1,281	294	36	$1,087,665
1955	957	325	1,459	540	33	1,212,731
1956	654	352	2,000	1,282	28	1,704,742
1957	812	622	2,502	608	17	1,653,942
1958	[1] 3,446			1,050	(2)	1,506,980
1959	[1] 3,178			699	(2)	1,330,461

[1] Beginning Jan. 1, 1958, white lead, red lead, and lithrage not separately classified.
[2] Data not available.

Exports of lead pigments and salts declined 12 percent in value and 14 percent in quantity, compared with 1958. Exports of lead arsenate decreased 33 percent.

STOCKS

Stocks of lead at primary producing plants, which had increased each month in 1958, continued upward through February of 1959. By December 31, however, inventories had declined to 171,100 tons—27 percent below 1958. These data represent physical inventories at the plants, irrespective of ownership, and do not include material in process or in transit. The American Bureau of Metal Statistics data show an additional 20,000 tons of bullion in process at and in transit to refineries and about 34,200 tons of ore in process at smelters—a total of nearly 225,300 tons of primary raw materials in stocks at these plants.

Consumers' and secondary smelters' stocks of lead in 1958 continued to decline through February 1959 to 114,600 tons, reached a peak of 156,000 tons in August, then droped to 126,500 tons by the end of December. The yearend total, however, was 3 percent above 1958.

TABLE 26.—Stocks of lead at primary smelters and refineries in the United States at end of year, in short tons

	1950-54 (average)	1955	1956	1957	1958	1959
Refined pig lead	44,556	21,871	30,237	74,194	176,098	107,683
Lead in antimonial lead	10,234	9,084	10,740	11,079	11,811	11,361
Lead in base bullion	13,266	15,585	11,141	8,855	9,485	12,840
Lead in ore and matte	38,875	42,903	44,925	49,788	36,896	39,195
Total	106,931	89,443	97,043	143,916	234,290	171,079

TABLE 27.—Consumer stocks of lead in the United States at end of year, by type of material, in short tons, lead content

Year	Refined soft lead	Antimonial lead	Unmelted white scrap	Lead in alloys	Lead in copper-base scrap	Drosses, residues, etc.	Total
1955	73,480	23,081	2,914	8,146	1,618	8,219	117,458
1956 [1]	73,673	40,226		8,007	2,089		123,995
1957	80,708	39,375		7,651	1,576		129,310
1958	76,924	37,511		7,056	1,409		122,900
1959	80,277	38,688		6,435	1,096		126,496

[1] Beginning 1956, consumer stocks of scrap were added to secondary smelter stocks of scrap, and secondary smelter metal stocks were included with consumer metal stocks.

PRICES

The quoted New York price for common lead was 13 cents a pound on January 1 and 12 cents a pound on December 31. There were 10 changes, however, during the year. From 13 cents a pound in early

TABLE 28.—Average monthly and yearly quoted prices of lead at St. Louis, New York, and London, in cents per pound[1]

Month	1958			1959		
	St. Louis	New York	London [2]	St. Louis	New York	London [2]
January	12.80	13.00	9.06	12.42	12.62	9.00
February	12.80	13.00	9.32	11.38	11.58	8.77
March	12.80	13.00	9.40	11.21	11.43	8.73
April	11.80	12.00	9.16	11.00	11.20	8.68
May	11.51	11.71	9.07	11.70	11.90	8.90
June	11.04	11.24	9.20	11.80	12.00	8.75
July	10.80	11.00	8.95	11.80	12.00	8.82
August	10.65	10.85	8.81	12.07	12.27	9.05
September	10.69	10.89	8.83	12.80	13.00	8.85
October	12.47	12.67	9.28	12.80	13.00	8.85
November	12.80	13.00	9.47	12.80	13.00	9.03
December	12.80	13.00	9.04	12.32	12.52	9.08
Average	11.91	12.11	9.13	12.01	12.21	8.88

[1] St. Louis: Metal Statistics, 1960, p. 495. New York: Metal Statistics, 1960, p. 489. London: E&MJ Metal and Mineral Markets.

[2] Conversion of English quotations into American money based on average rates of exchange recorded by Federal Reserve Board.

January, the price dropped to 11 cents by February 24, gained half a cent in March, and slumped again to 11 cents on April 1. By August 24 the price had again reached 13 cents. Greater consumer demand in the late summer months, together with refinery strikes and declining producer stocks, were responsible for the increase. Two half-cent decreases in December brought the yearend price to 12 cents. The average for the year was 12.21 cents a pound.

Quotations on the London Metal Exchange ranged from a low of £65¾ per long ton on March 31 (equivalent to 8.26 cents a pound U.S. currency, computed on the average monthly rate of exchange) to a high of £75¼ (9.40 cents a pound) on December 29. The bid quotation on December 31 was £73¾ a long ton (9.21 cents a pound) and the average for the year £70.79 (8.88 cents a pound).

FOREIGN TRADE

Imports.—General imports of lead, which had increased each year since 1954, dropped 29 percent in 1959. Ore and concentrate imports declined 31 percent and metal imports, 29 percent. The decreases were attributed largely to the restrictions imposed by the quotas on imports of metal and concentrates. About 64 percent of the lead imported was pigs and bars, 34 percent was ores and concentrates, and the remaining 2 percent was scrap and lead bullion. Mexico supplied 33 percent of the pigs and bars imported, Australia 18 percent, Canada 16 percent, Yugoslavia 12 percent, and Peru 11 percent. The remaining 10 percent represented small entries from many countries. Peru supplied 27 percent of the total ores and concentrates imported, Canada 23 percent, Union of South Africa 20 percent, and Australia

18 percent. The remaining 12 percent was supplied collectively by many other countries.

The principal suppliers of imported pigs and bars, and also ores and concentrates, were the same as in 1958, but several of the major suppliers changed places in order of importance. The changes were believed to reflect to some extent the size of the allotments assigned to the various countries under the quota system.

Exports.—Exports of lead, although slightly larger than in 1958, totaled only 2,756 tons.

Tariff.—The duties on pig lead and lead content of ores and concentrates remained 1 1/16 cents and 3/4 cent a pound, respectively.

TABLE 29.—Total lead imported into the United States in ore, matte, base bullion, pigs, bars, and reclaimed, by countries, in short tons, in terms of lead content [1]

[Bureau of the Census]

Country	1950–54 (average)	1955	1956	1957	1958	1959
Ore, flue dust and matte:						
North America:						
Canada-Newfoundland and Labrador	21,717	33,090	30,692	25,193	[2] 22,270	32,426
Greenland	----------	----------	----------	----------	5,276	----------
Guatemala	3,258	5,208	6,904	8,965	5,019	146
Honduras	823	2,757	2,969	2,955	3,581	3,639
Mexico	2,696	2,201	3,866	3,835	1,786	489
Other North America	185	3	8	113	45	195
Total	28,679	43,259	44,439	41,061	[2] 37,977	36,895
South America:						
Bolivia	16,346	13,812	17,177	18,319	14,715	11,205
Chile	2,252	409	118	35	367	113
Colombia	131	546	1,440	[2] 1	851	622
Peru	26,549	44,223	55,174	55,756	[2] 70,757	36,996
Other South America	147	82	184	[2] 1,078	145	53
Total	45,425	59,072	74,093	75,189	[2] 86,835	48,989
Europe	243	----------	24	264	246	221
Asia:						
Philippines	1,865	2,635	2,222	783	1,169	315
Other Asia	79	----------	422	246	317	25
Total	1,944	2,635	2,644	1,029	1,486	340
Africa:						
Union of South Africa	23,641	41,575	44,208	43,916	49,215	27,879
Other Africa	568	----------	----------	25	1	----------
Total	24,209	41,575	44,208	43,941	49,216	27,879
Oceania: Australia	13,665	30,938	31,044	36,995	[2] 25,839	24,854
Total ore, flue dust and matte	114,165	177,479	196,452	198,479	[2] 201,599	139,178
Base bullion:						
North America	247	----------	31	----------	8	34
South America	83	----------	----------	84	452	46
Europe	(3)	----------	----------	----------	----------	----------
Asia	184	----------	----------	(3)	----------	----------
Oceania	900	----------	----------	----------	----------	----------
Total base bullion	1,414	----------	31	84	460	80
North America:						
Canada-Newfoundland and Labrador	75,610	34,453	16,220	28,607	40,926	41,533
Mexico	133,214	93,369	77,541	102,504	122,864	86,827
Other North America	50	----------	----------	(3)	----------	324
Total	208,874	127,822	93,761	131,111	163,790	128,684

See footnotes at end of table.

TABLE 29.—Total lead imported into the United States in ore, matte, base bullion, pigs, bars, and reclaimed, by countries, in short tons, in terms of lead content [1]—Continued

Country	1950–54 (average)	1955	1956	1957	1958	1959
Pigs and bars:						
South America:						
Peru	35,590	24,509	33,540	34,999	42,473	29,311
Other South America	173			1,601	146	
Total	35,763	24,509	33,540	36,600	42,619	29,311
Europe:						
Belgium-Luxembourg	928	231	1,206	1,852	5,872	1,503
Germany [4]	4,047	496	168	1,550	3,118	2,893
Spain	2,306	10,649	6,700	3,119	14,237	9,395
United Kingdom	1,620	47	115	2,666	8,836	988
Yugoslavia	44,891	35,659	38,901	40,262	36,789	32,731
Other Europe	2,296	2,351	2,162	2,584	2,139	4,872
Total	56,088	49,433	49,252	52,033	70,991	52,382
Asia	1,172	55				
Africa: Morocco [5]	[6] 7,242	7,800	[7] 5,428	9,018	10,537	[6] 5,384
Oceania: Australia	49,440	54,530	80,673	95,517	80,515	47,655
Total pigs and bars	358,579	264,149	262,654	324,279	368,452	263,416
Reclaimed, scrap, etc.:						
North America:						
Canada-Newfoundland and Labrador	2,498	7,598	5,898	2,558	1,908	2,251
Mexico	1,058	6,120	9,701	2,583	1,939	1,293
Other North America	1,124	1,378	1,549	652	420	245
Total	4,680	15,096	17,148	5,793	4,267	3,789
South America:						
Peru	138	166	299	4	48	[3]
Venezuela	194	1,653	230			
Other South America	44			53		120
Total	376	1,819	529	57	48	120
Europe:						
Belgium-Luxembourg	43	576	117		7	
Denmark	12	282	1,000	84		
Germany [4]	69	3	348	168		
Netherlands	196	112	157			1
Other Europe	301	567	179	32		
Total	621	1,540	1,801	284	7	1
Asia:						
Japan (including Nansei and Nanpo Islands)	3,124	2	4		19	18
Other Asia	248	24	1			
Total	3,372	26	5		19	18
Africa	3					
Oceania:						
Australia	1,365	2,099	1,255	3,079	2,229	4,351
Other Oceania	106					
Total	1,471	2,099	1,255	3,079	2,229	4,351
Total reclaimed, scrap, etc	10,523	20,580	20,738	9,213	6,570	8,279
Grand total	484,681	462,208	479,875	532,055	[2] 577,081	410,953

---

[1] Data are "general imports," that is, they include lead imported for immediate consumption plus material entering the country under bond.

[2] Revised figure.

[3] Less than 1 ton.

[4] West Germany, effective Jan. 1, 1952.

[5] French Morocco prior to Jan. 1, 1957.

[6] Includes 90 tons from Northern Rhodesia in 1950–54 (average) and 1,052 tons from the Federation of Rhodesia and Nyasaland in 1959.

[7] Includes material classified by Bureau of the Census as being from Algeria but believed by Bureau of Mines to be from French Morocco.

TABLE 30.—Total lead imported for consumption in the United States, in ore, matte, base bullion, pigs, bars, reclaimed and sheets, pipe, and shot, by countries, in short tons, in terms of lead content [1]

[Bureau of the Census]

Country	1950–54 (average)	1955	1956	1957	1958	1959
Ore, flue dust and matte:						
North America:						
Canada-Newfoundland and Labrador	18,502	41,164	26,733	30,302	31,394	28,644
Greenland	----------	----------	----------	----------	5,276	----------
Guatemala	3,438	2,916	5,613	12,129	4,944	157
Honduras	496	699	3,018	6,108	[2] 3,577	3,649
Mexico	2,584	1,592	2,829	6,602	3,167	627
Other North America	209	1	1	16	12	8
Total	25,229	46,372	38,194	55,157	[2] 48,370	33,085
South America:						
Bolivia	12,701	9,131	19,771	14,874	22,501	10,820
Chile	3,935	5,654	2,957	1,758	88	113
Colombia	50	409	852	1,000	850	422
Peru	21,485	42,280	58,363	50,506	[2] 92,027	38,979
Other South America	356	121	152	676	465	56
Total	38,527	57,595	82,095	68,814	[2] 115,931	50,390
Europe	225	----------	24	----------	21	107
Asia:						
Philippines	1,865	2,635	2,227	816	1,169	293
Other Asia	79	----------	187	308	311	25
Total	1,944	2,635	2,414	1,124	1,480	318
Africa:						
Union of South Africa	20,955	28,008	35,417	65,289	[2] 37,993	28,939
Other Africa	1,397	7	----------	25	1	1,821
Total	22,352	28,015	35,417	65,314	[2] 37,994	30,760
Oceania:						
Australia	11,152	21,816	32,999	44,207	33,829	22,036
Other Oceania	----------	----------	159	----------	----------	----------
Total	11,152	21,816	33,158	44,207	33,829	22,036
Total ore, flue dust, and matte	99,429	156,433	191,302	234,616	[2] 237,625	136,696
Base bullion:						
North America	220	----------	31	----------	8	34
South America	38	----------	----------	25	408	----------
Europe	(3)	----------	----------	[2] (3)	----------	----------
Asia	184	----------	----------	----------	----------	----------
Oceania	534	----------	----------	----------	----------	----------
Total base bullion	976	----------	31	25	416	34
Pigs and bars:						
North America:						
Canada-Newfoundland and Labrador	75,610	34,453	16,220	28,607	40,926	41,478
Mexico	130,123	93,313	76,242	99,208	117,938	82,762
Other North America	96	----------	----------	----------	----------	261
Total	205,829	127,766	92,462	127,815	158,864	124,501
South America:						
Peru	35,546	24,393	33,540	34,999	42,533	29,311
Other South America	173	----------	----------	1,601	146	----------
Total	35,719	24,393	33,540	36,600	42,679	29,311
Europe:						
Belgium-Luxembourg	928	231	1,206	1,852	4,604	1,569
Denmark	1,065	2,296	1,389	1,916	1,452	187
Germany [4]	4,047	496	168	1,550	3,008	2,613
Spain	2,306	10,649	6,700	3,119	9,505	11,270
United Kingdom	1,620	47	115	2,666	8,556	1,035
Yugoslavia	44,891	35,659	38,901	40,262	36,789	32,376
Other Europe	1,227	55	773	667	507	2,984
Total	56,084	49,433	49,252	52,032	64,421	52,034

See footnotes at end of table.

TABLE 30.—Total lead imported for consumption in the United States, in ore, matte, base bullion, pigs, bars, reclaimed and sheets, pipe, and shot, by countries, in short tons, in terms of lead content [1]—Continued

Country	1950–54 (average)	1955	1956	1957	1958	1959
Pigs and bars—Continued						
Asia	1,178	55	----------	----------	----------	----------
Africa:						
Morocco [5]	7,152	7,800	[6] 5,428	9,018	9,760	5,032
Other Africa	110	----------	849	726	----------	703
Total	7,262	7,800	6,277	9,744	9,760	5,735
Oceania: Australia	49,439	54,530	80,673	95,517	76,035	51,051
Total pigs and bars	355,511	263,977	262,204	321,708	351,759	262,632
Reclaimed, scrap, etc.:						
North America:						
Canada-Newfoundland and Labrador	2,528	7,598	5,881	2,558	1,787	2,396
Mexico	1,058	6,120	10,109	4,000	2,433	1,350
Other North America	1,131	1,412	1,542	645	228	602
Total	4,717	15,130	17,532	7,203	4,448	4,348
South America:						
Peru	157	166	299	4	274	(3)
Venezuela	194	1,653	230	----------	----------	----------
Other South America	148	----------	----------	53	34	120
Total	499	1,819	529	57	308	120
Europe:						
Belgium-Luxembourg	43	576	117	----------	7	----------
Denmark	12	282	1,000	84	----------	----------
Germany [4]	69	3	348	168	278	1
Netherlands	196	112	157	----------	----------	----------
Other Europe	299	567	179	32	172	----------
Total	619	1,540	1,801	284	457	1
Asia	3,507	26	4	----------	19	17
Africa	3	----------	----------	----------	----------	----------
Oceania:						
Australia	1,117	375	598	32	3,387	3,411
Other Oceania	94	54	----------	----------	----------	----------
Total	1,211	429	598	32	3,387	3,411
Total reclaimed, scrap, etc	10,556	18,944	20,464	7,576	8,619	7,897
Sheets, pipe, and shot:						
North America:						
Canada	90	321	136	101	252	452
Canal Zone	----------	----------	----------	19	----------	----------
Mexico	13	1,295	6,830	4,770	559	----------
Total	103	1,616	6,966	4,890	811	452
South America	14	----------	----------	----------	----------	----------
Europe	89	432	688	1,027	1,813	3,156
Asia	4	----------	----------	----------	1	(3)
Total sheets, pipe, and shot	210	2,048	7,654	5,917	2,625	3,608
Grand total	466,682	441,402	481,655	569,842	[2] 601,044	410,867

---

[1] Excludes imports for manufacture in bond and export, which are classified as "imports for consumption" by the Bureau of the Census.

[2] Revised figure.

[3] Less than 1 ton.

[4] West Germany, effective Jan. 1, 1952.

[5] French Morocco prior to Jan. 1, 1957.

[6] Includes material classified by the Bureau of the Census as being from Algeria but believed by the Bureau of Mines to be from French Morocco.

TABLE 31.—Lead imported for consumption in the United States, by classes[1] [2]

[Bureau of the Census]

Year	Lead in ores, flue dust or fume, and mattes, n.s.p.f.		Lead in base bullion		Pigs and bars		Sheets, pipe, and shot		Not otherwise specified value (thousands)	Total value (thousands)
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)		
1950-54 (average)	99, 429	[3] $25,072	976	$327	355, 511	[3] $99,349	210	[3] $79	[3] $173	[3] $127,307
1955	156, 433	[3] 38, 143	--------	--------	263, 977	73, 032	2, 048	535	[3] 164	[3] 115, 805
1956	191, 302	50, 621	31	11	262, 204	[3] 77, 719	7, 654	2, 017	[3] 184	[3] 135, 820
1957	234, 616	62, 284	25	8	321. 708	85, 146	5, 917	1, 377	[3] 360	[3] 150, 816
1958	[4] 237, 625	[4] 50, 772	416	136	351, 759	71, 404	2, 625	596	446	[4] 124, 795
1959	136, 696	26, 921	34	19	262, 632	54, 667	3, 608	850	586	84, 347

[1] Excludes imports for manufacture in bond and export, which are classified as "imports for consumption" by Bureau of the Census.

[2] In addition to quantities shown (value included in total value), "reclaimed, scrap, etc.," imported as follows—1950-54 (average): 10,556 tons, [3] $2,306,823; 1955: 18,944 tons, [3] $3,930,668; 1956: 20,464 tons, [3] $5,268, 423; 1957: 7,576 tons, [3] $1,640,902; 1958: 8,619 tons, $1,440, 639; 1959: 7,897 tons, $1,304,107.

[3] Data known to be not comparable with other years.

[4] Revised figure.

TABLE 32.—Miscellaneous products containing lead, imported for consumption in the United States

[Bureau of the Census]

Year	Babbitt metal, solder, white metal, and other combinations containing lead			Type metal and antimonial lead		
	Gross weight (short tons)	Lead content (short tons)	Value (thousands)	Gross weight (short tons)	Lead content (short tons)	Value (thousands)
1950-54 (average)	2, 420	1, 529	[1] $1, 891	8, 612	7, 409	$2, 921
1955	2, 286	1, 283	[1] 1, 911	14, 579	13, 213	4, 379
1956	4, 106	2, 526	[1] 3, 381	9, 544	8, 500	2, 763
1957	3, 502	2, 100	[1] 3, 049	5, 275	4, 858	1, 527
1958	4, 244	2, 049	4, 677	5, 170	4, 525	1, 190
1959	11, 840	3, 751	16, 820	5, 612	5, 020	1, 204

[1] Data known to be not comparable with other years.

WORLD REVIEW[5]

World mine and smelter production declined about 3 percent below 1958. The reduced output was attributed largely to voluntary limitations on production by the major free-world producing countries and U.S. import quotas. Most of the lead entering international trade was mined in Australia, Canada, Mexico, Morocco (Northern and Southern Zones), Peru, South-West Africa, and Yugoslavia. The U.S.S.R. and Bulgaria of the Sino-Soviet bloc also were large producers. Most of the lead recovered in Australia, Canada, Mexico, and Yugoslavia was refined within those countries, but the bulk of that mined in Morocco, Peru, and South-West Africa was exported in the form of ores and concentrates.

---

[5] When zinc or copper were coproducts with lead, additional information on mines and countries may be found in the Zinc and Copper chapters of the Minerals Yearbook 1959.

NORTH AMERICA

Canada.—Lead was recovered from complex lead-zinc and lead-zinc-copper ores at 19 mines.[6] Mine production reached 186,500 tons and refinery output 141,000 tons, compared with 185,800 and 139,000 tons in 1958. Exports of lead in ores and concentrates totaled 53,726 tons and exports of pig lead, 92,252 tons.

TABLE 33.—Total lead exported from the United States in ore, matte, base bullion, pigs, bars, anodes and scrap, by destination, in short tons [1]

[Bureau of the Census]

Destination	1950–54 (average)	1955	1956	1957	1958	1959
Ore, matte, base bullion (lead content):						
North America:						
Canada	516	12	6	54		3
Mexico		1,322	1,049	851	912	108
Total	516	1,334	1,055	905	912	111
Europe	(2)				30	
Asia	17			1	70	113
Total ore, matte, base bullion	533	1,334	1,055	906	1,012	224
Pigs, bars, anodes:						
North America:						
Canada	107	13	38	266	19	11
Cuba	42	36	44	62	33	37
Mexico	11	16	2	18	4	28
Other North America	112	25	53	136	79	153
Total	272	90	137	482	135	229
South America	640	167	306	194	96	93
Europe	27	13	2,128	560	3	9
Asia:						
Japan	7		1,176	2,305		5
Nansei and Nanpo		5	5	16	7	3
Philippines	200	96	180	451	427	473
Taiwan	16	5	2	224	566	1,916
Other Asia	268	27	688	106	125	27
Total	491	133	2,051	3,102	1,125	2,424
Africa	5		6	1		1
Oceania	(2)				(2)	
Total pigs, bars, anodes	1,435	403	4,628	4,339	1,359	2,756
Scrap:						
North America	132	1	11		5	7
South America						(2)
Europe:						
Belgium-Luxembourg	27	754	20			
Germany [3]	95	495	563	264	292	51
Netherlands		148	788	304	157	460
United Kingdom	881	880	554	125	382	513
Other Europe	64	219	14	55	178	110
Total	1,067	2,496	1,939	748	1,009	1,134
Asia:						
Japan	570	486	186	137		
Other Asia					1	
Total	570	486	186	137	1	
Total scrap	1,769	2,983	2,136	885	1,015	1,141
Grand total	3,737	4,720	7,819	6,130	3,386	4,121

[1] In addition foreign lead was reexported as follows: Ore, matte, base bullion 1950–54 (average): 1 ton; 1955: 3 tons; 1956: 6 tons; 1957: 4 tons; 1958–59: none. Pigs, bars, anodes, 1950–54 (average): 171 tons; 1955: none; 1956: 50 tons; 1957: 300 tons; 1958: 25 tons; 1959: 83 tons. Scrap: 1950–54 (average): 24 tons; 1955–58: none; 1959: 11 tons.

[2] Less than 1 ton.

[3] West Germany, effective Jan. 1, 1952.

---

[6] Buck, W. K., Review of Lead, Zinc, and Copper: Metals, vol. 29, No. 12, June 1959, pp. 7, 9, 18.

TABLE 34.—World mine production of lead (content of ore), by countries, in short tons[1] [2]

[Compiled by Augusta W. Jann and Berenice B. Mitchell]

Country	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada[3]	180,994	202,762	188,854	181,484	186,680	181,610
Cuba	2	88	120	90	[4] 70	-------
Greenland	-------	-------	5,000	8,000	9,150	11.200
Guatemala	4,394	5,084	8,967	12,535	8,788	6,381
Honduras	708	1,961	2,315	[5] 2,955	3,380	[5] 3,639
Mexico	253,034	232,383	220,029	236,860	222,582	210,188
United States[3]	375,443	338.025	352,826	338,216	267,377	255,586
Total	814,575	780,303	778,111	780,140	698,027	668,604
South America:						
Argentina	21,458	26,500	31,250	32,100	32,000	33,600
Bolivia (exports)	29,489	21,080	23,777	28,948	25,149	24,293
Brazil[6]	3,272	4,028	3,869	3,878	4,781	[4] 8,300
Chile	5,853	4,374	3,598	3,237	2,848	[4] 2,200
Ecuador	131	93	128	121	132	118
Peru	102,489	130,900	142,281	151,184	147,888	130,918
Total	162,692	186,975	204,903	219,468	212,798	199,429
Europe:						
Austria	5,351	5,286	5,281	5,969	6,012	5,906
Bulgaria	40,586	53,250	63,600	69,600	[4] 77,900	[4] 88,700
Czechoslovakia[4]	1,650	5,500	6,600	6.600	6,600	7,006
Finland	233	853	1,554	2,623	2,482	2,120
France	13,099	10,063	9,780	13,541	13,600	17,600
Germany:						
East[4]	3,460	6,600	6,600	6,600	6,600	6,608
West	61,263	74,334	72,181	78,395	67,146	57,887
Greece[7]	5,864	9,500	11,400	16,200	15,500	[4] 19,806
Ireland	1,152	2,931	2,560	2,074	412	1,702
Italy	44,555	56,100	53,200	59,300	61,700	54,600
Norway	505	783	887	990	2,351	1,667
Poland[6]	29,300	37,700	38,800	39,354	39,488	42,645
Portugal	1,831	1,614	1,365	1,518	994	[4] 1,100
Rumania[4] [6]	10,500	12,200	13,200	13,200	13,200	13,200
Spain	51,067	68,994	66,765	72,224	76,710	72,720
Sweden	26,055	35,459	36,097	40,200	46,594	53,322
U.S.S.R.[4]	173,000	[6] 255,000	[6] 290,000	310,000	330,000	340,000
United Kingdom	6,832	8,336	8,139	9,069	4,814	2,632
Yugoslavia	91,059	99,297	96,259	99,305	99,035	101,908
Total[4]	567,400	743,800	784,300	846,800	871,200	891,100
Asia:						
Burma	[4] 6,230	18,879	17,456	16,366	21,180	21,200
China[4]	10,400	32,000	40,000	43,000	52,000	72,000
Hong Kong	216	220	110	80	20	-------
India	1,835	2,948	3,183	3,666	4,356	5,292
Iran[4] [8]	12,300	19,900	18,700	18,700	18,700	16,500
Japan	18,240	28,852	32,545	39,533	40,448	39,640
Korea:						
North	2,000	8,800	16,000	18,700	18,700	18,700
Republic of	91	753	1,600	1,016	1,343	256
Philippines	1,766	2,555	2,360	897	1,415	391
Thailand	2,561	5.862	4,419	3,346	1,032	1,455
Turkey	[4] 1,160	3,000	5,042	4,465	3,250	770
Total[4]	56,800	123,800	141,400	149,800	162,400	176,200
Africa:						
Algeria	6,078	11,645	11,746	11,349	11,095	11,291
Belgian Congo	51	91	[4] 110	[4] 220	-------	-------
Congo, Republic of	3,477	3,673	3,316	2,034	3,611	5,448
Egypt	120	143	132	280	[4] 330	[4] 330
Morocco:						
Northern zone	532	900	670	897	102,410	100,834
Southern zone	80,076	98,000	95,502	101,288		
Nigeria	19	18	49	504	546	424
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia[6]	14,955	17,975	17,024	16,800	14,196	16,128
South-West Africa[9]	56,210	100,707	[3] 89,100	[3] 88,763	[3] 83,796	[3] 77,551
Tanganyika (exports)	2,111	4,033	5,730	5,433	5,001	6,917

See footnotes at end of table.

TABLE 34.—World mine production of lead (content of ore), by countries, in short tons [1] [2]—Continued

Country	1950–54 (average	1955	1956	1957	1958	1959
Africa—Continued						
Tunisia	25,071	29,390	25,848	25,371	24,814	19,997
Uganda (exports)	29	90	128	17	256	59
Union of South Africa	604	564	911	1,223	36	168
Total	189,333	267,229	250,266	254,179	246,091	239,147
Oceania: Australia	270,131	331,458	335,423	373,256	366,652	351,962
World total (estimate)	2,060,000	2,430,000	2,490,000	2,620,000	2,560,000	2,530,000

[1] Data derived in part from United Nations Statistical Yearbook, Yearbook of the American Bureau of Metal Statistics, annual issues of the Statistical Summary of the Mineral Industry (Overseas Geological Surveys, London), and Metal Statistics (Metallgesellschaft) Germany.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Recoverable.

[4] Estimate.

[5] U.S. imports.

[6] Smelter production.

[7] Includes lead content of zinc-lead sulfides.

[8] Year ended March 21 of year following that stated.

[9] Includes lead content of lead-vanadium concentrates.

Refined lead production, as in previous years, came from Canada's only primary lead smelter, a unit of the smelting and refining works of the Consolidated Mining & Smelting Co. of Canada, Ltd., at Trail, British Columbia. Smelter feed came from the company-owned Sullivan, H. B., and Bluebell mines in British Columbia and from purchased concentrates.[7]

Other lead producers in British Columbia included Reeves-McDonald at Remac, which shipped lead concentrate to Bunker Hill Co. at Kellogg, Idaho,[8] Canadian Exploration Ltd., at Salmo,[9] and Western Mines, Ltd., at Ainsworth.[10] Buchans Mining Co., Ltd., at Red Indian Lake, Newfoundland, and United Keno Hills Mines, Ltd., operated the Hector and Calumet mines in the Mayo district of Yukon Territory at a reduced rate. The reduction was attributed largely to U.S. import quotas.

Mexico.—American Smelting and Refining Co. operated its lead mines throughout 1959. Concentrates were smelted at company plants at San Luis Potosi and Chihuahua, and the smelter products were refined at Monterrey.

Cía. Metalurgica Penoles, S. A. (a subsidiary of American Metal Climax, Inc.) at Torreón and Monterrey produced 68,000 tons of refined and antimonial lead—17 percent below the 1958 output.[11]

The Fresnillo Co. recovered lead from the Naica, Fresnillo, and Plateros mines. Ore from the Plateros mine was concentrated at the Fresnillo mill. The Fresnillo mill recovered 26,593 tons of 53.4-percent lead concentrate and the Naica mill, 42,979 tons of 57.7-percent lead concentrate.[12]

---

[7] Consolidated Mining & Smelting Co. of Canada, Ltd., 54th Annual Report 1959, pp. 3–4.

[8] World Mining, British Columbia: Vol. 13, No. 1, January 1960, p. 66.

[9] Mining Magazine (London), Nelson: Vol. 102, No. 2, February 1960, p. 108.

[10] Mining Magazine (London), Ainsworth: Vol. 102, No. 2, February 1960, p. 108.

[11] American Metal Climax, Inc., Annual Report, 1959, p. 16.

[12] The Fresnillo Co., Annual Report, 1959, pp. 10–11.

TABLE 35.—World smelter production of lead, by countries where smelted, in short tons [1] [2]

[Compiled by Augusta W. Jann and Berenice B. Mitchell]

Country	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada	169,840	149,795	149,262	144,017	134,827	140,881
Guatemala	[3] 310	------	147	------	------	------
Mexico	245,048	224,474	213,947	231,745	218,290	206,134
United States (refined)[4]	469,295	478,995	542,272	533,473	469,381	340,886
Total	884,493	853,264	905,628	909,235	822,498	687,901
South America:						
Argentina	22,375	19,800	26,800	28,600	36,200	34,200
Bolivia (exports)[5]	756	2,329	1,681	2,482	877	250
Brazil	3,272	4,028	3,869	3,878	4,781	[3] 8,300
Chile	[6] 49	554	------	------	321	------
Peru	53,682	67,365	66,546	76,231	71,045	62,575
Total	80,134	94,076	98,896	111,191	113,224	105,325
Europe:						
Austria [7]	12,433	12,673	12,293	13,156	13,756	13,610
Belgium [7]	79,956	91,242	112,715	109,423	105,685	97,489
Bulgaria	3,178	5,612	6,600	21,300	28,700	36,000
Czechoslovakia [3]	6,950	8,800	9,900	9,900	9,900	10,000
France	61,058	73,385	69,809	81,345	77,871	76,941
Germany:						
East [3] [7]	21,800	33,000	33,000	33,000	33,000	33,000
West	99,950	118,593	128,417	151,945	147,985	164,833
Greece	3,006	2,776	3,814	3,987	4,300	[3] 5,500
Italy	40,393	46,845	43,118	43,703	52,912	49,638
Netherlands [3]	3,300	------	------	------	------	------
Poland	29,300	37,700	38,800	39,354	39,488	42,645
Portugal	941	2,167	938	829	743	877
Rumania [3]	10,500	12,200	13,200	13,200	13,200	13,200
Spain	53,283	68,132	72,491	64,981	77,729	75,542
Sweden	16,232	23,397	25,553	27,421	36,453	40,619
U.S.S.R.[3]	172,950	255,000	290,000	320,000	340,000	350,000
United Kingdom [3]	5,660	6,800	7,200	7,800	4,400	1,600
Yugoslavia	70,983	83,348	83,509	86,536	92,904	94,132
Total [3]	691,900	881,700	951,400	1,027,900	1,079,000	1,105,600
Asia:						
Burma	6,067	21,378	21,889	21,816	19,150	21,768
China [3]	[8] 11,000	24,000	28,000	31,000	40,000	63,000
India	1,367	2,502	2,797	3,556	3,735	4,363
Iran [9]	[10] 681	1,366	1,580	[3] 770	1,047	[3] 1,000
Japan	17,601	31,918	41,151	50,214	42,412	66,800
Korea, North [3]	1,100	8,800	16,000	18,700	18,700	18,700
Turkey [3]	595	1,750	2,000	2,000	3,000	2,200
Total [3]	38,400	91,700	113,400	128,100	128,000	177,800
Africa:						
Morocco: Southern zone	26,153	29,421	30,991	34,441	36,513	31,361
Rhodesia and Nyasaland, Federation of: Northern Rhodesia	14,955	17,975	17,024	16,800	14,196	16,128
Tunisia	27,871	30,123	27,357	29,669	31,548	26,912
Total	68,979	77,519	75,372	80,910	82,257	74,401
Oceania: Australia:						
Refined lead	191,699	209,591	218,500	215,516	214,451	209,637
Pb content of lead bullion	40,051	41,879	46,657	52,518	64,032	56,745
Total	231,750	251,470	265,157	268,034	278,483	266,382
World total (estimate)	1,995,000	2,250,000	2,410,000	2,525,000	2,500,000	2,420,000

[1] Data derived in part from United Nations Statistical Yearbook, Yearbook of the American Bureau of Metal Statistics, annual issues of Statistical Summary of the Mineral Industry (Overseas Geological Surveys, London), and Metal Statistics (Metallgesellschaft) Germany.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Estimate.

[4] Figures cover lead refined from domestic and foreign ores; refined lead produced from foreign base bullion not included.

[5] Lead bars only; does not include lead contained in solders or in antimonial lead bars.

[6] 1 year only, as 1954 was first year of commercial production.

[7] Includes scrap.

[8] Refined lead production.

[9] Year ended March 21 of year following that stated.

[10] Average for 1952–54.

San Francisco Mines of Mexico, Ltd., at San Francisco del Oro, Chihuahua, milled 808,400 metric tons of lead-zinc-copper-silver ore during the year ended September 30, 1959. A total of 59,485 tons of 65.58-percent lead concentrate was recovered. Production came from the Frisco and Clarines mines, the former reporting an increase in output over the 1958 total.[13]

El Potosi Mining Co. (subsidiary of Howe Sound Co.), which operated its El Potosi mine in Chihuahua, and Minas de Iquala, S. A. (subsidiary of Eagle Picher Co.) at Parral, Chihuahua, were other significant lead producers in Mexico. The El Carmen mine of El Potosi Mining Co., had shut down late in 1958 and did not operate in 1959.

SOUTH AMERICA

Argentina.—Cía. Minera Aguilar, S. A., in the Province of Jujuy, a wholly owned subsidiary of St. Joseph Lead Co., produced 28,483 tons of lead concentrate, all of which was sold in Argentina.[14] In addition Cía. Minera Castano Viejo, S. A., in San Juan Province, a National Lead Co. subsidiary, produced 96,934 tons of crude ore that yielded 7,501 tons of 78.6-percent lead concentrate. Concentrate from the Castano Viejo mine was reduced at the National Lead Co. smelter at Puerto Villelas. Total output of the Puerto Villelas smelter in 1959 was 16,308 tons of pig lead, all derived from Argentine ores and all consumed domestically.

Bolivia.—Production in Bolivia declined because of voluntary limitations on output by the free-world producing companies and unsettled political and industrial conditions within the country.

Two companies, Fundicion Metabol and Fundicion Oruro, with smelters at Oruro, produced metallic lead. The latter company, primarily a tin producer, reported lead output in terms of lead content of solder.

Brazil.—Lead metal was produced by the Cía. Plumbum, S. A., at the Pamelas smelter, by the Instituta de Pesquisas Technologicas at the Apiai smelter in São Paulo, and by Accumulatores Prest-O-Lite at the Santa Amaro smelter in Bahia.

Peru.—Cerro de Pasco Corp. produced 62,260 tons of lead at its Oroya refinery. A decline from the 1958 output was attributed largely to a 14-day strike and to curtailment of production because of an indicated oversupply of lead in world markets.[15] Modernization of the lead sinter plant, which was completed in 1959, will reduce operating costs by improving the productivity of labor. The annual capacity of the lead smelter was increased to 200,000 tons of bullion and that of the refinery to 170,000 tons of metal. Cía. Minerales Santander, Inc., a partially owned subsidiary of St. Joseph Lead Co., produced 5,864 tons of lead concentrate, all of which was sold to European markets.[16] Other significant lead producers in Peru were Cía. Minera Atacocha, S. A., Northern Peru Mining Corp., Hochschild Mines, Compagnie des Mines de Huaron, Cía. Mineral Milpo, and Volcan Mines Co.

---

[13] San Francisco Mines of Mexico, Ltd., Annual Report, 1958–59, p. 7.
[14] St. Joseph Lead Co., Annual Report, 1959, pp. 10–11.
[15] Cerro de Pasco, Annual Report, 1959, p. 10.
[16] Work cited in footnote 14, p. 11.

EUROPE

Austria.—Bleiberg-Bergwerks Union, the only producer in Austria, recovered 5,906 tons of lead from ore. Enough domestic scrap lead also was treated to yield 13,610 tons of lead metal.

Bulgaria.—Bulgaria, traditionally a large producer of lead and zinc concentrates, only recently had begun to produce lead metal. Production of a 70-percent lead concentrate totaled 111,245 tons in 1958 and 55,821 tons in the first half of 1959 (the latest available figure). Metal outputs for the same periods were 28,737 tons and 19,597 tons.[17] Improvement also was reported in recovering the lead content of lead ores. In 1958 lead recovery at the Madan flotation plant was 95.27 percent; at the Rudozen plant, 94.96 percent; and at Chiprovtsi State Mining Enterprise, 90.11 percent.[18]

France.—Construction of the new lead blast furnace of the Société Minière et Metallurgique de Penarroya at Noyelles-Godault, begun in 1959, was to be completed in 1960 and begin operation in 1961.

Germany, West.—Production of lead in West Germany was 11 percent above 1958. The State-owned Gewerkschaft Mechernick Werke lead mine had closed in 1958 because of excessive production costs and remained closed in 1959; however, the privately owned Stolberg Company, mining a similar ore, continued working at a profit.

United Kingdom.—Lead production declined from the 1958 total. It was reported that the Grunside mine in the north of England, one of the largest in England, would close in 1960 because of the depletion of reserves.[19]

Yugoslavia.—The Trepca, Mexica, and Platovo lead-zinc mines accounted for about 85 percent of the total lead-zinc output. As a result of additional prospecting and development in the Trepca area, production was begun at several new mines and an extension of the Trepca ore body.

ASIA

Burma.—The Burma Corp., Ltd., a joint Government venture in which there is a 25-percent U.S. interest, continued operations at the Bawdwin lead-zinc-silver mine in northern Burma. For the year ended June 30, 1959, the company's refinery at Namtu produced 20,823 tons of refined lead and 544 tons of refined antimonial lead.

India.—An agreement was concluded between Rio Tinto Company of Great Britain and Metal Corporation of India, the sole producer of pig lead and zinc concentrate in India, under which the British firm will provide technical and financial assistance for expanding the Zawar lead-zinc mine at Udaipor and erecting a zinc smelter. Zinc concentrate had been shipped to Japan for smelting, as there was no zinc smelter in India. Production of lead increased considerably over 1958.

---

[17] Statisticheski Izvestiya [Industry and Materials]: Nos. 2 and 3, February and March 1959, pp. 19–24.

[18] Sofia Naruchnik na Agitatora-Promishlenost, Stroitelstvo, Transporte i Turgoviya [Extraction and Beneficiation of Nonferrous Metals]: No. 19, October 1959, pp. 3–9.

[19] Chemical Trade Journal and Chemical Engineering (London), Cumberland Lead Mine to Close: Vol. 145, No. 3765, July 31, 1959, p. 25.

Iran.—Near the end of May, Soviet trade representatives signed contracts to purchase lead and zinc concentrates from Iranian mines. The prices agreed upon were 12 to 15 percent lower than those fixed for 1958 but were higher than prices obtainable in European markets. Near the end of the year the Iranian Ministry of Mines and Industry started efforts to establish, through a joint foreign-Iranian venture, modern ore concentrating plants to be located in the principal lead-zinc districts.

Japan.—Production of 66,800 tons of crude lead represented a 58-percent increase over the 1958 total. Refined lead production was 70,892 tons. Domestic ores accounted for 62 percent of the total lead output; the remainder was supplied by imported ores and scrap. Consumption in 1959 reached 76,400 tons.

AFRICA

Morocco.—The Oued el Hunia smelter near Oujda, the only lead-zinc smelter in Morocco, produced 31,589 short tons of soft lead for export.

Rhodesia and Nyasaland, Federation of.—The Rhodesian Broken Hill Development Co., Ltd., the only lead and zinc metal producer in the Federation, treated 175,289 tons of ore containing an average of 17.9 percent lead. A total of 23,988 tons of 78.3-percent lead concentrate was smelted. Recovery of refined lead of 99.99-percent purity was 16,128 tons. The reserves reported on December 31, 1959, were 2.7 million tons of proven ore containing 17.7 percent lead and 3 million tons of indicated ore containing 11.3 percent lead. Plans were developed at the end of the year to install a new Imperial smelting furnace and auxiliary plant to reduce production costs and improve the combined production of lead and zinc.[20]

South-West Africa.—The Tsumeb Corp., Ltd., mined and milled 625,000 tons of ore averaging 23.7 percent combined copper, lead, and zinc during the year ending June 30, 1959. The reserve above the 30th level was estimated at 8.2 million tons averaging 14.30 percent lead, 4.33 percent zinc, and 5.41 percent copper. Diamond drilling below the 30th level indicated a minimum of 2 million tons of additional probable ore averaging about 7.1 percent lead.[21]

OCEANIA

Australia.—On the basis of mine production, Australia again was the leading lead producer in the world. Output, however, was less than in 1958 because of voluntary restrictions placed on production. The Broken Hill district in New South Wales, with four companies (New Broken Hill Consolidated, Ltd., Zinc Corp., Ltd., Broken Hill South, Ltd., and North Broken Hill, Ltd.) was the leading Australian lead-producing district. More lead metal was produced by New Broken Hill Consolidated, Ltd., and Zinc Corp., Ltd., than in 1958; however, Broken Hill South, Ltd., and North Broken Hill, Ltd., reported decreases in output. Because of increased productivity and

---

[20] The Rhodesian Broken Hill Development Co., Ltd., 50th Annual Report, 1959, pp. 4, 6, 11.

[21] American Metal Climax, Inc., Annual Report, 1959, p. 29.

higher overall grade of ore, metal production increased at New Broken Hill Consolidated, Ltd., despite a reduction in quantity of ore mined. The proven lead ore reserve on December 31, 1959, totaled 3 million tons containing 13 percent lead.[22]

In the fiscal year ending June 30, 1959, Mount Isa Mines, Ltd., produced 1,030,000 tons of crude lead-zinc ore, which yielded 63,879 tons of lead bullion and 5,023,000 troy ounces of silver.[23]

The Lake George Mines Pty., Ltd., during the fiscal year ended June 30, 1959, recovered 236,720 tons of copper-lead-zinc ore from the Elliot's, Keating's, and Central ore bodies in the Captain's Flat district of New South Wales. The mill recovered 19,046 tons of 61.49-percent lead concentrate. Copper and zinc concentrates and some gold and silver were also recovered. Exports of lead concentrate totaled 19,453 tons.[24]

Electrolytic Zinc Co. of Australia, Ltd., in the fiscal year ended June 30, 1959, produced 221,685 short tons of ore from its mines in the Read-Roseberry district on the west coast of Tasmania. The ore yielded 84,407 tons of zinc, lead, and copper concentrates. Lead concentrate accounted for 10,071 tons.[25]

TECHNOLOGY

An extensive research program was started by the Lead Industries Association to develop engineering data on the use of lead in controlling vibration and in protecting steel from corrosion. Other projects involved new or continuing work in organolead compounds; powder metallurgy; the mixing of molten lead with finely divided solid metals, such as cobalt, iron, molybdenum, nickel, and tungsten; fiber-reinforced lead; and lead coatings on steel by vacuum deposition or improved electroplating.[26]

In the search for suitable alloys for the positive grids of lead-acid storage batteries it was reported that small additions of barium and tin to lead should give excellent results. The tin and barium were reported to improve castability, stiffness, creep strength, and resistance to storage anodic stress corrosion.[27]

The Federal Bureau of Mines, at Rolla, Mo., developed a method for concentrating lead sulfide slimes from tailings. From feed material averaging 0.20 percent lead (about 70 percent finer than 400-mesh), a recovery of as much as 45 percent could be effected by flotation in rougher concentrate analyzing up to 6.5 percent lead.[28]

The possibility of refining lead containing a high percentage of impurities, such as antimony, silver, and bismuth, using a sulfanino electrolyte was tested in a laboratory in the U.S.S.R.[29]

---

[22] New Broken Hill Consolidated, Ltd., Annual Report, 1959, pp. 10–11.

[23] American Smelting and Refining Co., Annual Report, 1959, p. 16.

[24] Lake George Mining Corp., Ltd., Annual Report, 1959, pp. 13–14.

[25] Electrolytic Zinc Co. of Australia, Annual Report, 1959, p. 22.

[26] Battelle Technical Review, Research Program is Giving the Lead Industry a Boost: Vol. 8, No. 18, July 23, 1959, p. 11.

Chemical Engineering, Battelle Develops New Lead-Cemented Alloy: Vol. 66, No. 17, Aug. 24, 1959, p. 166.

[27] Foundry, Lead Battery Alloy: Vol. 87, No. 12, December 1959, p. 126.

[28] Frommer, D. W., and Fine, M. M., Experiments in Concentrating Lead Sulfide Slime: Bureau of Mines Rept. of Investigations 5444, 1959, 13 pp.

[29] Pliteneva, N. B., The Use of a New Electrolyte in Nonferrous Metallurgy: Repts. of the Fourth Soviet Conf. on Electro-Chemistry, Oct. 1–6, 1956, Battelle Tech. Review, vol. 8, No. 6, June 1959, pp. 332A–333A.

Patents were issued on a pyrotechnic method for increasing the basicity of lead sulfate-containing pigments,[30] the manufacture of a lead dioxide electrode,[31] the removal of lead in the electrowinning of chromium,[32] and the continuous tapping of a lead blast furnace during the smelting operation.[33]

The effect of small quantities of impurities in solid solution on the recrystallization behavior of single crystals of zone-refined lead was investigated.[34] The rate of motion of single grain boundaries in crystals of zone-refined lead with various additions of tin was studied, and the results were discussed in relation to the formation of annealing textures.[35]

The formation of lead sulfide films, using the lead tartrate or lead acetate method, and the formation of optical light filters, using thiourea and lead acetate solutions in an acid medium, were reported.[36] Information on the working of the Mendip lead mines of Somerset, England, in Roman times and the quality of the pig-lead output was gained from four lead pigs recently recovered in ploughing a field. The lead pigs weighed about 200 pounds each. One contained no silver, two only a trace, and one about 18 ounces a ton.[37]

A method for simultaneously smelting lead and zinc in a blast furnace was reported. The quantities of impurities in the refined product, economic aspects, and future possibilities were discussed.[38]

The use of lead-silver alloy anodes in cathodic protection of ships was reported as having many advantages over the platinum and graphite systems used for permanent unit anodes and various advantages over steel and magnesium anodes.[39]

The possibility of producing lead metal from ore in one step was reported from the U.S.S.R. The process involved electrical smelting of lead concentrates using soda as a flux.[40]

The Federal Bureau of Mines completed a study on the application of electrical-resistivity surveys to exploration for zinc-lead deposits in western Newton County, Mo.[41]

---

[30] Adams, C. H., Pyrotechnic Method for Increasing the Basicity of Lead Sulfate Containing Pigments: U.S. Patent 2,872,333, Feb. 3, 1959.

[31] Miller, H. C., and Grigger, J. C. (assigned to Pennsalt Chemicals Corp.), Lead Dioxide Electrode: U.S. Patent 2,872,405, Feb. 3, 1959.

[32] Carosella, M. C., and Jacobs, J. H. (assigned to Union Carbide Corp.), Lead Removal in the Electrowinning of Chromium: U.S. Patent 2,872,395, Feb. 3, 1959.

[33] Roy, J. T. (assigned to American Smelting and Refining Co.), Continuous Tapping of Metallurgical Furnace: U.S. Patent 2,890,951, June 16, 1959.

[34] Aust, K. T., and Rutter, J. W., Grain Boundary Migration in High Purity Lead and Dilute Lead-Tin Alloys: Trans. of the Met. Soc. of AIME, vol. 214, No. 1, February 1959, pp. 119–127.

[35] Gifkins, R. C., Boundary Migration of High Purity Lead During Creep and Grain Growth: Trans. Met. Soc. of AIME, vol. 215, No. 6, December 1959, pp. 1015–1022.

Aust, K. T., and Rutter, J. W., Temperature Dependence of Grain Migration of High-Purity Lead Containing Small Additions of Tin: Trans. Met. Soc. AIME, vol. 215, No. 5, October 1959, pp. 820–831.

[36] Wein, S., Lead Sulfide Films: Glass Industry, vol. 40, No. 7, July 1959, pp. 359–361, 393–396.

[37] Metal Bulletin (London), Roman Lead Unearthed: No. 4379, Mar. 17, 1959, p. 19.

[38] Erzmetall, Smelting Lead and Zinc in One Operation: Vol. 12, No. 10, October 1959, pp. 479–486.

[39] Corrosion, Service Experience with Lead-Silver Alloy Anodes: Vol. 15, No. 11, November 1959, pp. 5811–5861.

[40] Mirkina, A. [As told by Kazakhstan Scientists]: Naukaizhizn, vol. 26, No. 8, August 1959, pp. 2–8.

[41] Chester, J. W., Application of Electrical-Resistivity Surveys to Exploration for Zinc-Lead Deposits, Racine-Spargeon Area, Newton County, Mo.: Bureau of Mines Rept. of Investigations 5503, 1959, 57 pp.

Lime

By C. Meade Patterson [1] and James M. Foley [2]

⁂

LIME production in the United States established a record in 1959; 18 percent more lime was reported than for the previous record year of 1956. Much of this resulted because the Bureau increased its coverage of captive lime. Had it not been for the depressing effect of the steel strike on refractory lime or dead-burned dolomite production, an even higher national lime total would have resulted.

TABLE 1.—Salient statistics of lime sold or used in the United States [1]

	1950–54 (average)	1955	1956	1957	1958	1959
Active plants	159	150	153	146	146	156
Sold or used by producers:						
By types:						
Quicklime……thousand short tons	4, 586	6, 113	5, 967	5, 942	5, 538	7, 756
Hydrated lime……do	1, 942	2, 238	2, 186	2, 081	2, 014	2, 766
Dead-burned dolomite……do	1, 894	2, 129	2, 424	2, 251	1, 659	1, 986
Total lime:						
Thousand short tons	8, 422	10, 480	10, 577	10, 274	9, 211	12, 508
Value [2] (thousands)	$97, 859	$127, 144	$135, 727	$135, 323	[3] $121, 193	$164, 211
Average per ton	$11. 61	$12. 13	$12. 83	$13. 17	[3] $13. 16	$13. 13
Total open-market lime thousand short tons	7, 525	8, 930	9, 004	8, 516	7, 388	8, 405
Total captive tonnage lime……do	[4] 897	[4] 1, 550	[4] 1, 573	[4] 1, 758	[4] 1, 823	4, 103
Imports for consumption……do	33	40	42	50	26	35
Exports……do	66	82	83	65	46	53

[1] Includes Puerto Rico.
[2] Selling value, f.o.b. plant, excluding cost of containers.
[3] Revised figure.
[4] Incomplete figures; before 1959 coverage of captive plants was only partial.

DOMESTIC PRODUCTION

Reported lime production was 36 percent above 1958, or 12.5 million short tons. Open-market lime output increased 14 percent, and that of captive lime 125 percent because of more complete coverage. Thirty-three percent of the total lime production was captive. All major-use categories increased except agriculture, which remained nearly the same.

Thirty-three States and Puerto Rico manufactured lime in 1959. The three leading lime-producing States, in descending order, con-

---

[1] Commodity specialist.
[2] Supervisory statistical assistant.

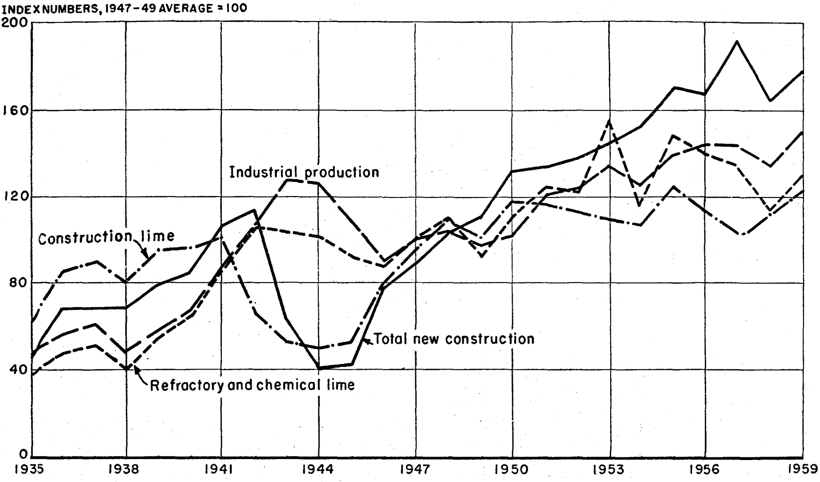

FIGURE 1.—Production of construction lime compared with physical volume of total new construction, and output of refractory and chemical lime compared with industrial production, 1935–59. Units are reduced to percentages of the 1947–49 average. Statistics on new construction from U.S. Department of Commerce and on industrial production from Federal Reserve Board.

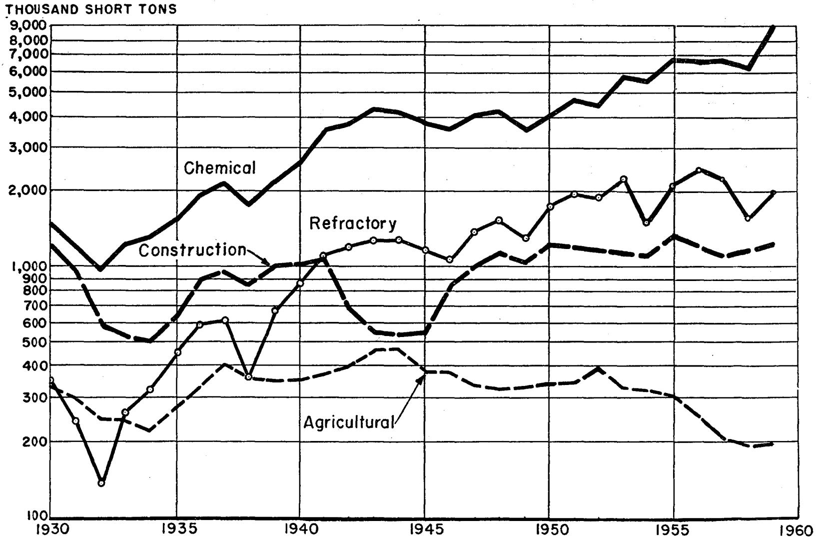

FIGURE 2.—Trends in major uses of lime, 1930–59.

tinued to be Ohio, Missouri, and Pennsylvania. Together they produced 46 percent of the total lime. In descending order of production, the next five States were New York, Michigan, Texas, Virginia, and Illinois.

Preliminary Bureau of the Census lime shipment statistics for 1958 were:[3] Quicklime, 4.7 million short tons valued at $46.8 million; hydrated lime, 1.9 million tons valued at $28.5 million; dead-burned dolomite, 1.9 million tons valued at $30.8 million; unspecified and other lime (tonnage not stated) valued at $5 million. Containers for lime products cost $3.1 million, giving a total value of $114.2 million. In 1958 there were 7,200 workers in the lime industry, of whom 6,100 were production workers. Total value of shipments (including interplant transfers) was $131.4 million, and capital expenditures were $6.3 million.

TABLE 2.—Lime (quick, hydrated, and dead-burned dolomite) sold or used by producers in the United States

State or commonwealth	1958 Active plants	1958 Short tons	1958 Value	1959 Active plants	1959 Short tons	1959 Value
Alabama	8	520,170	[1] $5,851,469	8	579,082	$6,847.329
Arizona	5	125,851	1,816,678	5	122,856	1,666,104
Arkansas	2	(2)	(2)	2	(2)	(2)
California	5	261,807	4,469,723	6	357,668	5,817,367
Colorado	2	(2)	(2)	2	(2)	(2)
Connecticut	1	28,996	464,180	1	(2)	(2)
Florida	2	(2)	(2)	4	111,287	1,238,234
Hawaii	1	8,106	260,050	2	(2)	(2)
Illinois	5	(2)	(2)	5	(2)	(2)
Iowa	1	(2)	(2)	1	(2)	(2)
Louisiana	1	(2)	(2)	1	(2)	(2)
Maine	1	(2)	(2)	----------	----------	----------
Maryland	3	(2)	(2)	3	(2)	(2)
Massachusetts	3	139,062	2,120,677	3	143,567	2,289,250
Michigan	4	(2)	(2)	6	861,808	11,747,657
Minnesota	1	(2)	(2)	1	(2)	(2)
Missouri	6	1,172,862	14,136,475	6	1,324,458	15,714,479
Montana	2	(2)	(2)	2	(2)	(2)
Nevada	4	(2)	(2)	4	(2)	(2)
New Jersey	2	(2)	(2)	2	(2)	(2)
New Mexico	1	21,454	259,593	1	16,286	209,275
New York	3	(2)	(2)	4	(2)	(2)
Ohio	18	2,410,504	32,470,838	20	3,190,432	45,121,149
Oklahoma	1	(2)	(2)	1	(2)	(2)
Oregon	1	(2)	(2)	1	(2)	(2)
Pennsylvania	22	1,003,058	[1] 14,160,639	23	1,263,180	18,260,836
Puerto Rico	2	(2)	(2)	2	9,816	321,102
South Dakota	1	(2)	(2)	1	(2)	(2)
Tennessee	2	(2)	(2)	3	(2)	(2)
Texas	9	690,661	7,146,240	10	808,777	8,529,654
Utah	4	79,640	1,512,565	4	90,151	1,773,037
Vermont	3	(2)	(2)	2	(2)	(2)
Virginia	9	471,313	5,532,833	10	765,240	8,168,412
West Virginia	4	(2)	(2)	4	(2)	(2)
Wisconsin	7	141,287	2,192,649	6	(2)	(2)
Undistributed[2]	----------	2,136,201	28,798,338	----------	2,863,619	36,506,635
Total	146	9,210,972	[1] 121,192,947	156	12,508,227	164,210,520

[1] Revised figure.
[2] Included with "Undistributed" to avoid disclosing individual company confidential data.

---

[3] U.S. Department of Commerce, Bureau of the Census, 1958 Census of Manufacturers, Lime Industry: Industry and Product Repts. MC(P)–32D–2 (Subject to Revision), April 1960, 4 pp.

TABLE 3.—Lime sold or used by producers in the United States,[1] by types and major uses, in short tons

	1958			1959		
	Sold	Used	Total	Sold	Used	Total
By type:						
Quicklime	5,545,874	1,651,021	7,196,895	6,373,027	3,369,650	9,742,677
Hydrated lime	1,842,357	171,720	2,014,077	2,032,482	733,068	2,765,550
Total lime	7,388,231	1,822,741	9,210,972	8,405,509	4,102,718	12,508,227
By use:						
Agricultural:						
Quicklime	76,150		76,150	83,325		83,325
Hydrated lime	119,975		119,975	112,229		112,229
Total	196,125		196,125	195,554		195,554
Construction:						
Quicklime	103,210	48,358	151,568	111,046	44,321	155,367
Hydrated lime	1,025,665	15,654	1,041,319	1,107,962	52,017	1,159,979
Total	1,128,875	64,012	1,192,887	1,219,008	96,338	1,315,346
Chemical and other industrial:						
Quicklime	3,725,442	1,584,551	5,309,993	4,217,596	3,299,828	7,517,424
Hydrated lime	696,717	156,066	852,783	812,291	681,051	1,493,342
Total	4,422,159	1,740,617	6,162,776	5,029,887	3,980,879	9,010,766
Refractory (dead-burned dolomite)	1,641,072	18,112	1,659,184	1,961,060	25,501	1,986,561

[1] Includes Puerto Rico.

TABLE 4.—Distribution of lime (including refractory) plants, according to size of production[1]

Size group (short tons)	1958			1959		
	Plants	Production		Plants	Production	
		Short tons	Percent of total		Short tons	Percent of total
Less than 1,000	12	4,048	(2)	9	3,971	(2)
1,000 to less than 5,000	16	45,179	(2)	21	53,464	(2)
5,000 to less than 10,000	10	74,983	1	13	94,767	1
10,000 to less than 25,000	26	484,894	5	21	395,748	3
25,000 to less than 50,000	27	1,012,015	11	27	977,319	8
50,000 to less than 100,000	25	1,719,412	19	29	1,941,127	16
100,000 and over	30	5,870,441	64	36	9,041,831	72
Total	146	9,210,972	100	156	12,508,227	100

[1] Includes captive tonnage.
[2] Less than 1 percent.

The Gibsonburg Lime Products Co., Gibsonburg, Ohio, installed another rotary kiln to produce 240 additional tons of dolomitic quicklime daily to meet increasing demand for building lime. United States Gypsum Co. planned a lime plant at New Orleans, La., to produce high-calcium quicklime and hydrated lime from Gulf of Mexico oystershell. The planned output was intended for use in the production of paper, oil, sugar, petrochemicals, and aluminum. Pelican State Lime Corp. built a $240,000 lime plant at Englewood, near

Morgan City, La. for the production of lime and for agricultural and other uses.[4]

M. J. Grove Lime Co., Lime Kiln, Md., with lime plant at Stephens City, Va., celebrated its centennial. In 1859 Manasses Grove built some potkilns in Frederick County, Va., to supply agricultural lime locally. In 1959 M. J. Grove Lime Co. still manufactured agricultural lime but also produced lime for steel and for such chemical-process industries as paper and pulp manufacture. G. & W. H. Corson, Inc., Plymouth Meeting, Pa., and the Warner Co., Philadelphia, Pa., are two other U.S. lime companies that have operated for more than a century.

Lee Lime Corp., Lee, Mass., more than doubled its lime-producing capacity by installing a new rotary kiln. Additional lime was needed to manufacture lime-fly ash pozzolanic cement (Pozament) for concrete blocks at a Bridgeport, Conn., plant.[5]

Utah Lime & Stone Div., a subsidiary of The Flintkote Co., constructed a new $1 million lime plant near Salt Lake City, at Dolomite, Utah. G. & W. H. Corson, Inc., Plymouth Meeting, Pa., licensed the new plant to employ its patented hydration process in making lime to be used in building construction. A similar process was in use at Flintkote's U.S. Lime Products Division at Henderson, Nev.

GasprO, Ltd., rebuilt its lime plant at Waianae, 32 miles from Honolulu, in 1957 and 1958, to manufacture lime for juice clarification in the sugar industry of Oahu, Kauai, and Hawaii. Their oil-fired, 6- by 90-foot rotary kiln with a daily capacity of 50 tons of quicklime, calcined limestone and coral feed at 2,200° F. Quicklime was hydrated, air separated, and pulverized. The only other commercial lime plant in Hawaii, The Hawaiian Commercial & Sugar Co., Ltd., on Maui, supplied lime locally. Expanding construction was expected to increase demand for lime.[6]

Chemical Lime Co's. plant at Baker, Oreg., reopened November 5, after a 2½-month shutdown. Portland and Seattle steel firms were the principal markets, but new Oregon and Washington consumers in the chemical, pulp, and metallurgical industries were secured. The Aluminum Co. of America's plant at Point Comfort, Tex., had a 360-foot rotary kiln that produced 200 tons of lime daily from purchased shell.

Late in October, Allis-Chalmers Manufacturing Co., Milwaukee, Wis., began building the largest capacity limekiln in the world at Ludington, Mich., for The Dow Chemical Co. This first Allis-Chalmers-Lepol traveling-grate kiln in the lime industry was expected to produce 600 tons of chemical quicklime daily from northern Michigan limestone and to double Dow's lime-producing capacity by equaling the combined capacity of two adjacent rotary kilns. The design of its preheating stage, and not its ordinary size (11½-foot diameter by 160-foot length), warranted anticipating a record daily output after completion in late summer of 1960.

---

[4] Pit and Quarry, vol. 51, No. 8, February 1959, p. 41.

[5] Pit and Quarry, Lee Lime Adds Kiln, Forms Pozament Corporation With McNeil Brothers: Vol. 52, No. 2, August 1959, p. 37.

[6] Renton, Allen H., GasprO, Ltd., Expansion, Our 50th State's New Lime Plant: Pit and Quarry, vol. 51, No. 12, June 1959, pp. 132–133, 136.

Basic Chemical Corp.'s lime plant, Glenwood Springs, Colo., burned down April 24, and the operation of the new limekiln was begun July 1. Quicklime was sold to American Metal Climax, Inc., New Jersey Zinc Co., and various uranium mills. American-Marietta Co., Chicago, Ill., planned to expand its lime and dead-burned dolomite capacity in 1960.[7]

Northern Ohio was a dolomitic lime center. Basic, Inc., (Cleveland, Ohio) produced dead-burned dolomite, quicklime, and hydrated lime products from dolomitic and high-calcium limestone in its four Ohio plants at Bettsville, Gibsonburg, Maple Grove, and White Rock. Dolomitic quicklime, glassmaker's lime, and dolomitic hydrated lime also were manufactured at Gibsonburg by Gibsonburg Lime Products Co. At Carey, National Lime and Stone Co. (Findlay, Ohio) produced dolomitic quicklime for glassmaking and dolomitic hydrated lime for neutralizing acidic wastes. Ohio Lime Co. at Woodville manufactured several dolomitic limes: Lump quicklime; ground quicklime, 16-mesh to dust; and three hydrated limes—normal, autoclaved, and superfine. At another Woodville, Ohio, plant, Woodville Lime Products Co. (Toledo, Ohio) produced high-magnesium quick and hydrated lime, consistently low in iron, as it had for more than 55 years.[8]

CONSUMPTION AND USES

Seventy-two percent of the lime production was used by chemical and industrial plants, 16 percent as refractory material, 10 percent in construction, and 2 percent in agriculture.

---

[7] Chemical and Engineering News., vol. 37, No. 48, Nov. 30, 1959, p. 34.

[8] American Ceramic Society Bulletin, Corporation Members of the American Ceramic Society: Vol. 39, No. 1, January 1960, pp. 36, 44, 50, 52, 68.

TABLE 5.—Lime (quick, hydrated, and dead-burned dolomite) sold or used by producers in the United States, by uses, in short tons

Use	1958			1959		
	Open-market	Captive	Total	Open-market	Captive	Total
Agriculture	196,125	----------	196,125	195,554	----------	195,554
Construction:						
Finishing lime	525,977	3,533	529,510	548,763	4,122	552,885
Mason's lime	366,881	[1]1,227	[1]368,108	401,672	1,539	403,211
Soil stabilization	130,621	----------	130,621	167,967	460	168,427
Other (including masonry mortars)	105,396	[1]59,252	[1]164,648	100,606	90,217	190,823
Total	1,128,875	64,012	1,192,887	1,219,008	96,338	1,315,346
Chemical and other industrial:						
Alkalies (ammonium, potassium and sodium compounds)	6,562	735,632	742,194	10,326	2,683,409	2,693,735
Brick, sand-lime and slag	5,724	----------	5,724	6,749	----------	6,749
Brick, silica (refractory)	20,794	----------	20,794	22,435	----------	22,435
Calcium carbide and cyanamide	607,540	328,000	935,540	664,415	358,635	1,023,050
Calcium carbonate (precipitated)	24,181	----------	24,181	(2)	(2)	73,595
Coke and gas (gas purification and plant byproducts)	18,903	----------	18,903	(2)	(2)	20,519
Explosives	3,287	----------	3,287	1,939	----------	1,939
Food and food byproducts	17,438	----------	17,438	11,410	----------	11,410
Glass	230,212	----------	230,212	244,373	----------	244,373
Glue	4,384	----------	4,384	(2)	----------	(2)
Grease, lubricating	11,359	----------	11,359	(2)	----------	(2)
Insecticides, fungicides, and disinfectants	49,858	----------	49,858	39,739	----------	39,739
Medicines and drugs	(2)	----------	(2)	(2)	----------	(2)
Metallurgy:						
Steel (open-hearth, oxygen-jet, and electric furnace flux)	1,218,547	96,910	1,315,457	1,377,052	60,691	1,437,743
Ore concentration [3]	168,334	222,560	390,894	232,824	398,623	631,447
Wire drawing	9,395	----------	9,395	3,991	----------	3,991
Other [4]	75,045	----------	75,045	206,960	51,469	258,429
Oil well drilling	1,364	----------	1,364	6,921	----------	6,921
Paint	(2)	(2)	23,805	(2)	(2)	61,185
Paper and pulp	(2)	(2)	661,185	717,666	45,822	763,488
Petrochemicals (glycol)	(2)	----------	(2)	(2)	(2)	142,829
Petroleum refining	40,432	----------	40,432	40,076	----------	40,076
Rubber	2,533	----------	2,533	5,549	----------	5,549
Salt refining	(2)	----------	(2)	250	----------	250
Sewage and trade-wastes treatment	(2)	(2)	107,521	128,944	9,611	138,555
Sugar and refining	(2)	(2)	37,628	35,298	1,904	37,202
Tanneries	64,032	----------	64,032	67,972	----------	67,972
Water softening and purification	614,884	24,656	639,540	686,492	68,591	755,083
Wood distillation	----------	----------	----------	(2)	----------	(2)
Undistributed [5]	1,227,351	332,859	730.071	518,506	302,124	522,502
Total	4,422,159	1,740,617	6,162,776	5,029,887	3,980,879	9,010,766
Refractory lime (dead-burned dolomite)	1,641,072	18,112	1,659,184	1,961,060	25.501	1,986,561
Grand total	7,388,231	1,822,741	9,210,972	8,405,509	4,102,718	12,508,227

---

[1] Revised figure.

[2] Included with "Undistributed" and "Total" columns to avoid disclosing individual company confidential data.

[3] Includes flotation, cyanidation, bauxite purification, and magnesium manufacture.

[4] Includes various metallurgical uses.

[5] Includes alcohol, asphalt, medicine and drugs, paint, paper and pulp, sewage, polishing compounds, salt, sugar, sulfur, petrochemicals, miscellaneous, and unspecified uses.

TABLE 6.—Lime (quick, hydrated, and dead-burned dolomite) sold or used by producers in the United States,[1] by major uses

Use	1958			1959		
	Short tons	Value [2]		Short tons	Value [2]	
		Total	Average		Total	Average
Agricultural	196,125	$2,580,906	$13.16	195,554	$2,468,465	$12.62
Construction:						
Finishing lime	529,510	8,698,248	16.43	552,885	10,981,720	19.86
Mason's lime	[3] 368,108	[3] 5,798,013	[3] 15.75	403,211	6,838,176	16.96
Soil stabilization	130,621	1,639,712	12.55	168,427	1,975,939	11.73
Other (including masonry mortars)	[3] 164,648	[3] 2,011,145	[3] 12.21	190,823	2,527,581	13.25
Total construction	1,192,887	18,147,118	15.21	1,315,346	22,323,416	16.97
Chemical and industrial uses	6,162,776	[3] 73,087,160	[3] 11.86	9,010,766	106,369,570	11.80
Refractory (dead-burned dolomite)	1,659,184	27,377,763	16.50	1,986,561	33,049,069	16.64
Grand total	9,210,972	[3] 121,192,947	[3] 13.16	12,508,227	164,210,520	13.13

[1] Includes Puerto Rico.
[2] Selling value, f.o.b. plant, excluding cost of container.
[3] Revised figure.

Excluding refractory lime or dead-burned dolomite, quicklime and hydrated lime were used in chemical and industrial processing and products, in construction, and in agriculture. Chemical and industrial uses consumed 86 percent, construction 12 percent, and agriculture 2 percent of the total lime sold and used.

Most uses of lime showed increases over 1958. Significant gains were reported in the quantities of lime used in soil stabilization, ore concentration, oil-well drilling, and manufacturing alkalies, sand-lime and slag brick, precipitated calcium carbonate, paint, paper and pulp, rubber, and refractories. Complete coverage of captive lime production in alkali plants for the first time increased the reported figure for this use tremendously over past years. Lime consumption increased in softening and purifying water and in treating sewage and trade wastes. In agriculture, plastering, petroleum and sugar refining, and in glass, glue, and leather manufacture, lime consumption remained virtually the same. Not as much lime was consumed in wire drawing, food and food byproducts, or in manufacturing explosives, grease, insecticides, and fungicides.

PRICES

The average price of open-market and captive quicklime and hydrated lime, f.o.b. plant, excluding cost of the container, was $13.13 per ton, compared with $13.16 in 1958. Oil, Paint and Drug Reporter[9] quoted the following prices per ton throughout 1959: Quicklime, $14.25; hydrated lime, $17.25; and spray lime, $18.25. Quicklime was quoted in bulk carlots of 25 tons, and hydrated and spray lime in bagged carlots of 25 tons, both at Eastern lime plants.

---

[9] Oil, Paint and Drug Reporter, vol. 175, Nos. 1–27; vol. 176, Nos. 1–27; Jan. 5–Dec. 28, 1959.

TABLE 7.—Apparent consumption of lime sold and used in the United States, in short tons

	1958			1959		
	Apparent consumption		Total	Apparent consumption		Total
	Quicklime	Hydrated lime		Quicklime	Hydrated lime	
Alabama	237,897	30,369	268,266	268,485	65,008	333,493
Alaska	------------	190	190	------------	821	821
Arizona	119,327	13,686	133,013	112,477	17,418	129,895
Arkansas	32,799	9,200	41,999	52,449	10,290	62,739
California	256,569	90,588	347,157	389,663	96,590	486,253
Colorado	16,004	7,737	23,741	18,010	9,174	27,184
Connecticut	24,725	27,970	52,695	31,936	29,508	61,444
Delaware	38,165	7,620	45,785	34,783	14,115	48,898
District of Columbia	50	6,945	6,995	110	9,546	9,656
Florida	105,343	72,004	177,347	198,216	73,188	271,404
Georgia	68,899	26,366	95,265	68,850	23,383	92,233
Hawaii	19	8,102	8,121	(1)	(1)	(1)
Idaho	3,906	1,545	5,451	2,681	2,030	4,711
Illinois	341,454	133,195	474,649	435,543	143,912	579,455
Indiana	440,651	36,715	477,366	459,168	45,563	504,731
Iowa	80,160	18,447	98,607	77,669	13,207	90,876
Kansas	33,335	21,797	55,132	35,728	16,146	51,874
Kentucky	437,662	21,444	459,106	475,969	20,014	495,983
Louisiana	305,679	62,302	367,981	306,224	58,876	365,100
Maine	35,660	10,478	46,138	35,361	9,737	45,098
Maryland	141,112	27,164	168,276	162,343	30,852	193,195
Massachusetts	70,973	44,505	115,478	66,084	46,345	112,429
Michigan	390,680	55,521	446,201	463,305	560,524	1,023,829
Minnesota	74,424	21,941	96,365	88,211	21,961	110,172
Mississippi	42,910	11,050	53,960	41,908	7,880	49,788
Missouri	116,067	56,476	172,543	120,016	65,862	185,878
Montana	86,661	3,726	90,387	53,570	1,783	55,353
Nebraska	4,202	8,038	12,240	12,363	8,582	20,945
Nevada	[2] 918	[2] 25,037	25,955	779	24,979	25,758
New Hampshire	2,748	7,211	9,959	4,443	7,700	12,143
New Jersey	29,384	98,175	127,559	40,838	100,262	141,100
New Mexico	1,804	27,671	29,475	24,097	38,527	62,624
New York	291,652	110,844	402,496	1,128,817	100,020	1,228,837
North Carolina	62,124	30,840	92,964	90,631	34,924	125,555
North Dakota	6,184	2,701	8,885	7,391	1,899	9,290
Ohio	1,205,681	123,935	1,329,616	2,045,901	183,015	2,228,916
Oklahoma	79,104	14,530	93,634	8,216	7,770	15,986
Oregon	40,679	12,007	52,686	38,868	12,641	51,509
Pennsylvania	932,986	189,191	1,122,177	1,131,980	208,518	1,340,498
Rhode Island	4,536	5,156	9,692	5,917	5,356	11,273
South Carolina	5,836	5,304	11,140	10,443	7,414	17,857
South Dakota	10,045	2,280	12,325	7,415	1,205	8,620
Tennessee	120,133	22,182	142,315	98,259	303,885	402,144
Texas	344,262	229,788	574,050	307,030	121,502	428,532
Utah	72,725	27,322	100,047	70,075	24,692	94,767
Vermont	247	1,401	1,648	3	1,955	1,958
Virginia	69,288	37,225	106,513	302,110	42,943	345,053
Washington	22,244	9,943	32,187	20,932	12,503	33,435
West Virginia	212,969	20,327	233,296	221,018	19,949	240,967
Wisconsin	75,930	43,792	119,722	96,277	53,702	149,979
Wyoming	148	3,567	3,715	71	4,073	4,144
Total	[2] 7,096,960	[2] 1,885,550	[2] 8,982,510	9,672,633	2,721,749	12,394,382

[1] Figures withheld to avoid disclosing individual company confidential data, not included in total.

[2] Revised figure.

New York City prices were $6.29 higher to include the freight charge.

Delivered 1959 prices per ton, in paper bags, carlots, for hydrated finishing lime, hydrated lime, and pulverized or lump quicklime throughout the United States are shown in table 8.[10]

---

[10] Engineering News-Record, vol. 163, No. 22, Nov. 26, 1959, p. 74.

TABLE 8.—Delivered prices of lime in the United States, per ton, in paper bags, carlots, 1959

[Engineering News-Record]

Destination	Hydrated finishing lime	Common hydrated lime	Pulverized or lump quicklime
Atlanta, Ga	$36.50	$28.50	$28.50
Baltimore, Md	35.60	23.20	----------
Birmingham, Ala	38.28	20.87	[1] 26.72
Boston, Mass	42.00	34.00	----------
Chicago, Ill	38.00	[2] 35.20	----------
Cincinnati, Ohio [3]	29.10	25.10	29.10
Cleveland, Ohio [3]	32.75	28.00	----------
Dallas, Tex	41.80	24.58	28.50
Denver, Colo.[3]	48.00	42.00	46.00
Detroit, Mich	38.00	30.00	40.00
Kansas City, Mo	36.26	34.26	29.76
Los Angeles, Calif	38.00	38.00	39.00
Minneapolis, Minn.[4]	49.00	38.00	52.00
New Orleans La	44.00	32.00	32.00
New York, N.Y.[3]	40.00	38.00	----------
Philadelphia, Pa	39.50	21.50	21.50
Pittsburgh, Pa	38.00	33.00	34.00
San Francisco, Calif	29.24	29.24	31.74
Seattle, Wash.[4]	52.00	38.00	----------

[1] Lump quicklime was $26.72.

[2] Mason's double-hydrated or pressure-hydrated lime.

[3] Prices for trucklots or over.

[4] Prices for less than carlots.

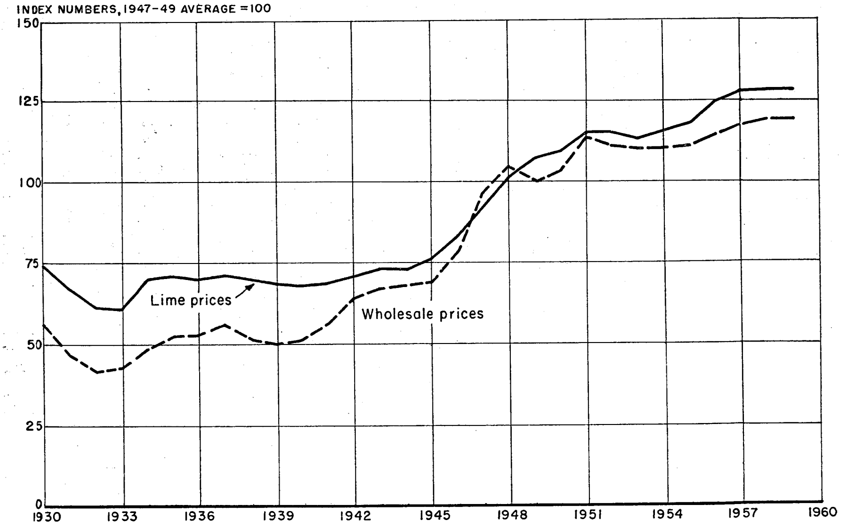

FIGURE 3.—Average price of lime per ton, compared with wholesale prices of all commodities, 1930–59. Units are reduced to percentages of the 1947–49 average. Wholesale prices from U.S. Department of Labor.

FOREIGN TRADE[11]

Imports.—Lime was imported from Canada into bordering States from Maine to Washington. Leading import markets were Washington and New York. Puerto Rico imported lime from Colombia.

Exports.—Lime was exported to 33 countries. Canada, Costa Rica, Panama, Mexico, Honduras, and Nicaragua, in that order, received 94 percent of the lime exported by the United States. The remaining 6 percent went to other countries in North America, Asia, South America, Europe, Africa, and Oceania, in decreasing amounts.

WORLD REVIEW

NORTH AMERICA

British West Indies.—During 1958 the Bahama Islands produced 3,970 short tons of lime valued at $76,400.[12]

Canada.—Output of lime reached a record high in 1958 as a result of increased requirements in the construction and uranium industries. Total 1958 production was 1,596,422 short tons valued at Can$19,465,823. The preliminary total for 1959 indicated another record of 1,668,230 short tons valued at Can$19,707,437.[13]

Delivered prices per ton, in paper bags, carlots, of hydrated finishing lime, hydrated lime, and pulverized or lump quicklime were, respectively, $39, $22, and $13.25 in Montreal, Quebec, and $37 to $38, $34.50, and $32.50 to $33.50 in Toronto, Ontario, in 1959.[14]

TABLE 9.—Lime imported for consumption in the United States

[Bureau of the Census]

	Hydrated lime		Other lime		Dead-burned dolomite [1]		Total	
	Short tons [2]	Value	Short tons [2]	Value	Short tons [2]	Value	Short tons [2]	Value
1950–54 (average)	1,186	$19,565	28,940	$500,160	3,163	$188,464	33,289	$708,189
1955	1,359	17,983	30,264	559,216	7,993	557,554	39,616	1,134,753
1956	757	12,312	31,903	549,290	9,031	586,754	41,691	1,148,356
1957	245	4,603	39,002	687,421	10,419	639,741	49,666	1,331,765
1958	1,000	20,646	18,822	318,495	5,686	322,386	25,508	661,527
1959	530	9,346	26,374	442,330	8,474	498,337	35,378	950,013

[1] Dead-burned basic refractory material consisting chiefly of magnesia and lime.
[2] Includes weight of immediate container.

---

[11] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

[12] U.S. Consulate, Nassau, British West Indies, State Department Dispatch 115: May 1, 1959, p. 1.

[13] Dominion Bureau of Statistics (Industry and Merchandising Division, Mineral Statistics Section, Ottawa), Preliminary Estimate of Canada's Mineral Production, 1959: Jan. 4, 1960, p. 4.

[14] Engineering News-Record, vol. 162, No. 22, May 28, 1959, p. 62; vol. 163, No. 14, Oct. 1, 1959, p. 81; vol. 163, No. 22, Nov. 26, 1959, p. 74.

TABLE 10.—Lime exported from the United States

[Bureau of the Census]

Year	Short tons	Value	Year	Short tons	Value
1950-54 (average)	66,384	$1,172,498	1957	65,195	$1,328,575
1955	82,461	1,464,036	1958	45,844	1,047,310
1956	82,737	1,546,127	1959	52,780	1,000,337

The Beachville, Ontario, plant of Cyanamid of Canada, Ltd., (formerly North American Cyanamid, Ltd.), installed a 10½- by 350-foot, coal-fired rotary kiln rated at 335 tons per day, although nearly 360 tons per day was sometimes produced. Its principal pebble quicklime markets were uranium mines, mills, and processing plants in the Blind River district of Ontario. Limestone feed from the upper 75 feet of the quarried Devonian formation averaged higher than 99 percent $CaCO_3$.[15]

Gypsum, Lime and Alabastine, Canada, Ltd., another plant near Beachville, calcined Lower Devonian limestone of 97 to 98 percent $CaCO_3$. About 7,000 short tons of lime was produced weekly for the Blind River uranium industry, foundries, papermills, gold mines, metallurgical plants, and other chemical industries, by two coal-fired rotary kilns and six gas-fired shaft kilns. Lime stabilization of subbases for hardtop roads was investigated.[16]

Costa Rica.—Estimated 1958 lime production was 3,086 short tons valued at $22,932.[17]

Nicaragua.—Lime production in 1958 was 25,136 short tons valued at $251,635.[18]

SOUTH AMERICA

Brazil.—Annual production of quick and hydrated lime was estimated at 1.5 million short tons. Leading producers were in the State of São Paulo: S. A. I. F. Matarazzo, S. A., with two plants at Santana de Parnaiba and Itapeva; S. A. Industrias Votorantim and Cía. Nitroquimica Brasileira plant at Sorocaba; Industrias Quimica Sorocal, S. A., plant at Sorocaba; and Cía. de Melhoramentos de São Paulo plant at Franco da Rocha. In the State of Rio de Janeiro, Cía. Siderurgia Nacional operated two lime plants at Campo Belo and Barroso that produced 129,462 short tons of lime in 1957 and showed a 15-percent increase for the first half of 1958 over the same period of 1957.[19]

Paraguay.—Lime production in 1958 was 7,998 short tons valued at $130,630. Cambrian and Ordovician formations along the Rio Paraguay from San Salvador to the Rio Apa constituted a virtually inexhaustible supply of limestone. Some lime was imported from Argen-

---

[15] Meschter, Elwood, Canadian Lime Plant Boosts Quarry Capacity 500 Percent: Rock Products, vol. 62, No. 4, April 1959, pp. 94–97.

[16] Cox, G. A., A Limestone Operation in Ontario: Mine and Quarry Eng. (London), vol. 25, No. 6, June 1959, pp. 256–262.

[17] U.S. Embassy, San Jose, Costa Rica, State Department Dispatch 545: Apr. 30, 1959, p. 1.

[18] U.S. Embassy, Managua, Nicaragua, State Department Dispatch 281: Mar. 25, 1959, encl. 1, p. 1.

[19] Bureau of Mines, Mineral Trade Notes: Vol. 48, No. 5, May 1959, pp. 27–28.

tina, but most limestone was mined from small quarries and calcined in charcoal-fired kilns at Puerto Fonciere and Itapucumi. Lime was shipped in metal drums by boat to Asuncion.[20]

Peru.—Lime production was 56,768 short tons in 1958: Construction, 27,557 tons; mineral concentration, 16,535 tons; agricultural, 11,023 tons; and chemical and industrial, 1,653 tons.[21]

Venezuela.—Production of lime was 42,539 short tons in 1958. The last previous report on production was 46,452 short tons in 1955.[22]

EUROPE

Czechoslovakia.—The shaft-kiln plant at Prachovice began producing lime in October 1958. Capacity was 175 short tons a day or 53,000 tons a year. Daily output was expected to rise to 220 tons.[23] Foamed concrete was manufactured at Plavecky Stvrtek with foaming agents produced from fats plants waste, contained lime, sand, and cement. In 1958, 2.1 million short tons of lime was produced. This was 100 percent of plan fulfillment and a 6-percent increase over 1957.

Denmark.—Estimated quicklime production in 1958 was 99,000 short tons.[24]

France.—The 1958 production of high-calcium lime was 2,535,000 short tons and of dolomitic lime, 162,000 short tons.[25]

Germany, West.—Knapsack Griesheim A. G., of Knapsack, near Cologne, started its $3.6 million, fully automatic, continuous carbide plant, September 1, 1958, and reduced lime consumption 4 percent, coke 8 percent, electrodes 50 percent, electricity per ton of carbide 20 percent, and labor costs 80 percent. Lime sales were 783,000 short tons in 1957–58.[26]

Luxembourg.—Quicklime production was 51,422 short tons in 1958 valued at $8.56 to 14.52 a short ton.[27]

Malta.—Lime production was approximately 25,500 short tons in 1957.[28]

Poland.—Fly ash was used as an aggregate for both cement and lime. Fly ash was heated to 900° C. and mixed with 20 percent by weight of hydrated lime to give best results. Test specimens had a compressive strength of about 1,500 p.s.i. Production of hydrated lime in 1958 was 1.7 million tons.[29]

---

[20] Eckel, Edwin B., Geology and Mineral Resources of Paraguay—A Reconnaissance: Geol. Survey Prof. Paper 327, 1959, pp. 11, 87.
U.S. Embassy, Asuncion, Paraguay, State Department Dispatch 379: Mar. 5, 1959, p. 1.

[21] U.S. Embassy, Lima, Peru, State Department Dispatch 896, Apr. 6, 1959, p. 2.

[22] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 3, September 1959, p. 48.

[23] U.S. Embassy, Prague, Czechoslovakia, State Department Dispatch 427 : Mar. 4, 1959, encl. 1, p. 4.

[24] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 2, August 1959, p. 49.

[25] U.S. Embassy, Paris, France, State Department Dispatch 2024: Apr. 28, 1959, encl. 1, p. 1.

[26] U.S. Consulate, Duesseldorf, Germany, State Department Dispatch 242: Apr. 28, 1959, p. 16.
Chemical Trade Journal and Chemical Engineer (London), Largest Carbide Furnace: Vol. 145, No. 3766, Aug. 7, 1959, p. 92.

[27] U.S. Embassy, Luxembourg, State Department Dispatch 167: Apr. 24, 1959, encl. 1, p. 1.

[28] Bureau of Mines, Mineral Trade Notes: Vol. 48, No. 5, May 1959, p. 28.

[29] East Europe, vol. 8, No. 4, April 1959, p. 46.
Rock Products, vol. 62, No. 8, August 1959, p. 14.

Sweden.—In 1958 quicklime output by continuous calcining was 849,487 short tons and by batch calcining 106,231 tons. Quicklime exports were 4,512 tons and imports were 4,960 tons.[30]

United Kingdom.—Imperial Chemical Industries, Ltd., combined its lime and alkali divisions, effective January 1, 1960, as the Buxton Lime Works of the Alkali Division. Its lime division of 1,100 employees was descended from the Buxton Lime Firms Co., Ltd., formed in 1891 by amalgamating 13 quarrying and lime-burning companies in the Buxton (England) area. Brunner, Mond & Co., Northwich, acquired controlling interest in the Buxton Lime Firms Co. in 1917 and merged it into Imperial Chemical Industries, Ltd., in 1926.[31] Their quicklime and hydrated lime (trade-name Limbux) was supplied to metal, chemical, paper, textile, and building industries.

The House of Commons approved a 5-year extension of the Agricultural Lime Schemes on July 2. A subsidy of 70 percent of their liming costs had been paid to farmers each year during the summer to encourage the liming of hilly, grassy, and marshy lands, and 60 percent during the remainder of the year. As a result, most liming had been done in the summer to obtain the greater subsidy. Annual cost to the Government was between $25 and $28 million, and 3.3 million tons of lime was added to the soil by spreading about 6.5 million tons of pulverized limestone. Over 2 million tons of lime was withdrawn from the soil each year, and 4.5 million tons of lime was needed annually to replace the lime lost and to raise the soil to the desired lime levels.[32] Chemical-grade hydrated lime sold for $16.80 a ton at lime plants in December.[33]

ASIA

India.—Batch "flare" kilns or mixed-feed kilns were proposed to calcine the low-quality limestone from deposits at Birmitrapur. The Central Building Research Institute developed a method of waterproofing mud huts by painting the dry mud wall with a slurry of cement, hydrated lime, and fine sand mixed with a soap solution.[34]

Israel.—Hydraulic lime plaster made of crushed, unslaked lime had been used since Solomon's time. In 1959 Lime and Stone Production Co., Ltd., of Haifa produced about 60 percent of the domestic lime and was constructing additional kilns.[35]

---

[30] U.S. Embassy, Stockholm, Sweden, State Department Dispatch 20: July 10, 1959, encl. 1, p. 2; encl. 2, p. 3.

[31] Chemical Age (London), New Merger For I.C.I. Division: Vol. 82, No. 2089, July 25, 1959, p. 66.

Chemistry and Industry (London), I.C.I. Alkali Division and Lime Division To Merge: No. 30, July 25, 1959, pp. 959–960.

Mine and Quarry Engineering (London), Buxton Lime: Vol. 25, No. 10, October 1959, p. 440.

[32] Chemical Age (London) Fertiliser Subsidy 1958–59: Vol. 81, No. 2080, May 23, 1959, p. 855.

Chemical Trade Journal and Chemical Engineer (London), Agricultural Lime: Vol. 145, No. 3763, July 17, 1959, p. 1503.

Fertiliser and Feeding Stuffs Journal (London), vol. 50, No. 10, May 20, 1959, pp. 462, 467; vol. 51, No. 1, Aug. 12, 1959, pp. 23, 47.

[33] Chemical Trade Journal and Chemical Engineer (London), vol. 145, No. 3786, Dec. 25, 1959, p. 1271.

[34] Knibbs, N. V. S., India's Lime and Limestone Industry: Pit and Quarry, vol. 51, No. 5, 1958, pp. 86–89.

Engineering Journal (Quebec), Waterproofing Mud: Vol. 42, No. 5, May 1959, p. 114.

[35] Mine and Quarry Engineering (London), Lime and Stone in Israel: Vol. 25, No. 8, August 1959, p. 376.

Kuwait.—The Government's sand-lime brick plant had a daily capacity of 225 short tons of quicklime and 160,000 brick. Quicklime constituted 6 to 9 percent of the brick by weight and 33 million brick were produced in 1958. A hydrator to produce hydrated lime for soil stabilization was planned.[36]

Lebanon.—Production of lime was 4,960 short tons valued at $63,679 in 1958.[37]

Philippines.—Lime production in 1958 included hydrated lime (20,777 short tons valued at $200,205), quicklime (6,956 tons, valued at $194,038), and industrial lime (914 tons valued at $27, 478).[38]

United Arab Republic (Syria Region).—Lime production in 1958 was 13,228 short tons valued at $217,877. Average lime content was 96.5 percent.[39]

AFRICA

Ethiopia.—Three old-fashioned limekilns were operated below capacity at Agere Hiwot, Ambo.[40]

Libya.—Lime output in 1958 was 14,330 short tons, valued at $464,000.[41]

Mozambique.—Lime imports from all countries not members of the Organization for European Economic Cooperation were prohibited in September.[42]

Tanganyika.—Lime production was 4,632 short tons valued at $52,562 in 1958. Lime exports for the first third of 1959 were 44 short tons valued at $582, compared with 220 short tons valued at $3,052 for the same period of 1958.[43]

Tunisia.—Building lime production was 79,767 short tons in 1958. Lime production for the first half of 1959 was 40, 018 tons, compared with 33,954 tons for the first half of 1958.[44]

Union of South Africa.—Total lime and limestone production was 7,992,005 short tons in 1958. Lump quicklime sales in 1958 were 545,370 tons valued at $4,075,860, and air-separated hydrated lime sales were 205,784 tons valued at $2,105,788. Exports of lime and limestone were 9,572 tons valued at $87,128 in 1958. The Umzimkulu

---

[36] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 5, November 1959, p. 51.

[37] U.S. Embassy, Beirut, Lebanon, State Department Dispatch 620: Apr. 24, 1959, encl. 1, p. 1.

[38] U.S. Embassy, Manila, Philippines, State Department Dispatch 719: Apr. 16, 1959, encl. 1, pp. 3–4.

[39] U.S. Consulate, Damascus, Syria Region, United Arab Republic, State Department Dispatch 377: May 9, 1959, p. 2.

[40] U.S. Embassy, Addis Ababa, Ethiopia, State Department Dispatch 188: Dec. 22, 1958, encl. 1, p. 15.

[41] U.S. Embassy, Tripoli, Libya, State Department Dispatch 248: Mar. 4, 1959, p. 1.

[42] Foreign Commerce Weekly, Mozambique Bans Some Imports: Vol. 62, No. 19, Nov. 9, 1959, p. 11.

[43] U.S. Consulate, Dar es Salaam, Tanganyika, State Department Dispatch 300: Apr. 13, 1959, encl. 1, p. 1.

South African Mining and Engineering Journal (Johannesburg), Tanganyika Mineral Eports : Vol. 70, No. 3462, June 19, 1959, p. 1479.

[44] U.S. Embassy, Tunis, Tunisia, State Department Dispatch 744 : Apr. 15, 1959, p. 14, encl. 1, p. 7.

U.S. Embassy, Tunis, Tunisia, State Department Disptach 67: July 24, 1959, encl. 1, p. 8.

U.S. Embassy, Tunis, Tunisia, State Department Dispatch 222: Oct. 16, 1959, encl. 1, p. 7.

lime plant near Port Shepstone was damaged extensively by floods causing temporary suspension of operations.[45]

The Northern Lime Co., Ltd., Johannesburg, had been South Africa's leading lime producer for over 50 years. Named after England's famous lime district, its Buxton plant was established in 1920 at Taungs, 80 miles north of Kimberley. Buxton produced 20,000 tons of quicklime monthly from 22 mixed-feed shaft kilns in 1954. Only four shaft kilns operated at Buxton during 1959, but their capacity was 10,000 tons of quicklime monthly using a 5:1 lime-coal ratio. Output at Buxton diminished when The Northern Lime Co's. Lime Acres plant began producing in 1954. Monthly production was 30,000 tons at Lime Acres, which was the only rotary-kiln lime plant in the Southern Hemishere. Each of three coal-fired, 10- by 340-foot rotary kilns averaged 420 tons of quicklime daily, and provision was made for a fourth rotary kiln. One kiln set a world's record, for its size, of 570 tons of quicklime a day.

Two continuous hydrators at the Buxton plant had a total monthly capacity of 6,000 tons of hydrated lime that was air-separated, stored in maturing silos, and bagged. The Northern Lime Co. manufactured quicklime (93.7 to 95.6 percent CaO) from the purest limestone in South Africa (97 to 98 percent $CaCO_3$). Over half of its output was used by the uranium industry, and in declining percentages the balance was use in the gold, carbide, steel, sugar, and paper industries and in water treatment and agriculture. None of this high-calcium lime was used in building because ample dolomitic lime was available. As a result of improved operating methods, the only price increases during the past 20 years were occasioned by higher coal prices and freight rates.[46]

In South-West Africa, lime production was 3,665 short tons valued at $63,017 in 1958. The producers were E. Höring at Usakos and South-West Africa Co., Ltd., at Grootfontein.[47]

United Arab Republic (Egypt Region).—In 1957, 2,507 short tons of lime valued at $29,658 were produced.[48]

TECHNOLOGY

PROCESSING

Calcination.—Daily output of lime per unit area of cross-section in a shaft kiln was shown to be directly proportional to the height of the calcining zone and inversely proportional to calcining time.[49]

---

[45] South African Mining and Engineering Journal, vol. 70, No. 3463, June 26, 1959, p. 1573.
U.S. Consulate, Johannesburg, Union of South Africa, State Department Dispatch 52: Aug. 28, 1959, encl. 1, p. 1, encl. 2, p. 1, and encl. 3, p. 1.
Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 4, October 1959, p. 43.

[46] Lowther, R. E., Remote Lime Plant Proves Progressive: Rock Products, vol. 62, No. 5, May 1959, pp. 120–121, 124–125.
South African Mining and Engineering Journal (Johannesburg), Production At South Africa's Largest Lime Plant, 500,000 Tons of Lime A Year: Vol. 70, No. 3461, June 12, 1959, pp. 1405–1407.
South African Mining and Engineering Journal, vol. 70, No. 3464, pt. 2, July 3, 1959, p. 56.

[47] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 4, October 1959, p. 43.
U.S. Consulate, Johannesburg, Union of South Africa, State Department Dispatch 93: Oct. 13, 1959, encl. 1, p. 1.

[48] U.S. Embassy, Cairo, Egypt, State Department Dispatch 469: Jan. 5, 1959, encl. 1, p. 1

[49] Eigen, Hans. [The High-Output Shaft Lime Kiln]: Tonindustrie Zeitung and Keramische Rundschau (Goslar), vol. 83, No. 2, Jan. 25, 1959, pp. 25–30.

Limestone feed was heated on an intermittently shaken, perforated trough that caused the feed to move through the calcining zone at the proper speed.[50] An improved rotary kiln with at least two tire sections supported on sets of rolling elements was patented.[51] Only one tire section was driven, the other rolling elements were synchronously driven by the kiln itself.

An apparatus was designed to remove dust particles from the exit gases of a kiln by a combination of a rotating drum, filtration, and scrubbing.[52] A fluid-cooled preheater for rotary limekilns was designed.[53] A two-step process of desulfurizing calcium sulfate to produce quicklime consisted of grinding at between 1,000° and 2,000° F., and, after sulfur content had been reduced by half, heating the pulverized particles between 2,100° and 2,700° F. Quicklime with less than 0.1 percent sulfur was produced.[54]

Hydration.—A safer method of pressure-hydrating dolomitic lime was patented.[55] Dolomitic quicklime and atmospherically hydrated dolomitic lime were mixed and hydrated under at least 80 p.s.i. with enough water to convert all the calcium and magnesium oxides to hydroxides. This two-step process eliminated the violence and hazards of one-step pressure hydration and produced completely hydrated dolomitic limes having improved consistencies.

Two partially hydrated dolomitic limes from northwestern Ohio gave Emley plasticity values of about 120, which increased to about 310 after soaking. Another highly hydrated dolomitic lime had an Emley plasticity value of 274 that rose to 340 after soaking. These plasticity increases were correlated with higher $Mg(OH)_2$ content and higher percentages of fine particles.[56]

Mixed with excess water, dolomitic quicklime was fed at a controlled rate through an elongated, horizontal hydrator at atmospheric pressure and passed by a jacketed, heat-transfer liquid, which (though not in direct contact with it) exchanged heat with the hydrating mixture. The liquid absorbed heat from the hydrating dolomitic lime at the inlet end of the hydration zone (where CaO was hydrated) and yielded heat to the hydrating lime at the discharge end (where MgO was hydrated).[57] Another continuous process for hydrating lime and producing it as a thick paste of constant predetermined consistency, more conducive to optimum slaking efficiency than the usual

---

[50] Kaufmann, Otto, Improvements in or Relating to Treating Materials by a Heat Transfer Process Such as Roasting, Sintering, Calcining, Drying and the Like: U.S. Patent 2,900,179, Aug. 18, 1959.

[51] Taylor, John H. (assigned to Vulcan Iron Works, Wilkes-Barre, Pa.), Rotary Kiln: U.S. Patent 2,908,179, Oct. 13, 1959.

[52] Peterson, Louis (assigned to F. L. Smidth & Co., New York, N.Y.), Apparatus For Cooling Hot Kiln Gases: U.S. Patent 2,911,061, Nov. 3, 1959.

[53] Reaney, Warford A., and Reaney, David W., Preheater For Rotary Kiln: U.S. Patent 2,889,143, June 2, 1959.

[54] Horn, Knud S., Two-Step Method of Making Calcium Oxide from Calcium Sulfate: U.S. Patent 2,901,321, Aug. 25, 1959.

[55] Volk, Joseph (assigned to National Gypsum Co., Buffalo, N.Y.), Pressure Hydrated Lime: U.S. Patent 2,902,346, Sept. 1, 1959.

[56] Deadmore, D. L., and Machin, J. S., Some Plastic Properties of Pastes Made From Hydrated Dolomitic and High-Calcium Limes: Illinois State Geol. Survey Circ. 261, 1958, 9 pp.

[57] Allen, Alan R. (assigned to Kennedy-Van Saun Manufacturing & Engineering Corp., New York, N.Y.), Method and Apparatus For Hydrating Calcitic and Dolomitic Quicklimes: U.S. Patent 2,888,324, May 26, 1959.

diluted slurry, was also patented.[58] A tertiary amine reduced the slaking of lime exposed to a humid atmosphere.[59]

Reuse.—Since 1957 Buckeye Cellulose Corp., Foley, Fla., a Proctor & Gamble subsidiary, had produced nearly all of the 50 tons of chemical lime a day needed for water softening and replenishing lime lost in its pulp-liquor causticizing system. The company recovered and calcined about 100 tons of sludge daily. By reducing 40 million gallons a day of intake water containing over 220 p.p.m. hardness to 80 p.p.m., a sludge containing 7 to 10 percent of solids was formed. The sludge was carbonated by exhaust CO_2 from the lime kilns, purified to a degree, and dewatered to 60–65 percent solid calcium carbonate by continuous, centrifugal classifiers feeding a rotary kiln. Washed lime mud from the pulpmill causticizing circuit was calcined with the dewatererd sludge obtained from water softening, and a second rotary kiln calcined only lime mud. Centrifuging sludge before calcining removed magnesium and iron, 20 percent of the lime, and some aluminum and manganese. About 80 percent of the lime was recovered and recycled to water softening and causticizing. This use of the lime content of intake water not only saved up to $5,000 a month and eliminated lime-sludge disposal, but income of $1,000 a month was anticipated from surplus lime sales.[60]

Savings and income from the $1.5 million lime-recovery system at the Dayton, Ohio, municipal water-softening plant were expected to pay its cost in about 20 years, and a difficult waste-lime disposal problem had been eliminated as well. Exhaust gas from the rotary kiln recarbonated the lime sludge before preheating, centrifuging, and calcining. A chain system 45 feet long inside the kiln accelerated heat transfer from the gas stream to the wet feed. Calcining temperature was 2,000° F.[61] Lime production in 1958 was 22,000 tons, of which 2,000 tons was sold. Net profit from lime recovery was $150,000 in 1958. Recovered lime cost $10.50 a ton, and the daily capacity of the rotary kiln was 150 tons.[62]

The rotary-kiln lime-recovery plant at the Miami, Fla., waterworks had a daily capacity of 80 tons. The recovered lime cost $8.08 a ton. San Diego, Calif., was constructing a 25-ton-a-day rotary-kiln lime-recovery unit at its water-treatment plant. FluoSolids kilns recalcined lime sludges from water softening at Lansing, Mich. (30 tons a day) and Gainesville, Fla. (6 tons a day). Flash calciners recovered lime at the municipal water-treatment plants at Salina, Kans. (25 tons a day), and Marshalltown, Iowa (10 tons a day).[63]

---

[58] Booth, George M. (assigned to Wallace & Tiernan, Inc., Belleville, N.J.), Viscosity Control Method and Apparatus For Hydrating Lime: U.S. Patent 2,904,401, Sept. 15, 1959.

[59] High, LeRoy B. (assigned to The Udylite Research Corp., Detroit, Mich.), Lime Buffing Compositions and Method for Reducing Slaking Thereof: U.S. Patent 2,899,289, Aug. 11, 1959.

[60] Chemical and Engineering News, Buckeye Bolsters Pulp Position: Vol. 37, No. 20, May 18, 1959, pp. 26–28.
Chemical Engineering, Water Softening Yields Process Lime: Vol. 66, No. 11, June 1, 1959, p. 35.
Cronan, C. S., Hard Water Supplies Process Lime Needs: Chem. Eng., vol. 66, No. 13, June 29, 1959, pp. 46–48.
Chemical Age (London), Hard Water Supplies Process Lime Needs, Unique Source of Lime: Vol. 82, No. 2089, July 25, 1959, p. 70.
Rock Products, Firm Gets Lime Supply From Ground Water: Vol. 62, No. 8, August 1959, p. 32.

[61] Stout, R. C., and Mertz, E. C., Lime Recovery Transforms Waste to Income: American City, vol. 74, No. 5, May 1959, pp. 101–103.

[62] National Lime Association, Limeographs: Vol. 26, July–August 1959, p. 5.

[63] Work cited in footnote 62.

USES

Agriculture.—Most soils in coastal areas of California, Oregon, and Washington, and in all States east of a wavy "lime line" through Minnesota, Nebraska, Kansas, Oklahoma, and Texas, required liming. For all liming materials, soil liming reached its zenith in the United States in 1947 and had decreased one-third since. Maximum consumption of agricultural lime occurred in 1914 and declined afterwards as crushed limestone took its place. Additional processing made lime more expensive than limestone. Yet, where all liming materials had to be shipped in from distant origins, quicklime and hydrated lime became less expensive than crushed limestone because of higher calcium concentrations and relatively lower freight rates. Air slaking was not considered detrimental for agricultural lime.

Sometimes quicklime damaged foliage and temporarily produced an over-limed soil. Whenever a rapid decrease of soil acidity was desirable (for truck crops having high lime requirements or a lime-requiring crop after potatoes), quicklime or hydrated lime was advantageous. A liming material was evaluated both on its total capacity to counteract soil acidity and on its rate of eliminating soil acidity. There were no Federal laws, and most States regulated the sales of liming materials. Chemical and sieve analyses were required on bag labels and on certificates accompanying bulk shipments. More frequent liming at reduced rates was recommended for quick and hydrated lime. Ordinarily a hopper-truck with an endless or a screw-type conveyor under the lime was used for field spreading. An experiment in New York showed that 257 pounds of calcium was leached from each acre of soil annually, and the same experiment in Florida demonstrated an annual loss of 98 pounds of calcium per acre.[64]

Lime-slag fertilizer was produced from exposed, moist blast-furnace slag piles. Coarse slag, containing 5 to 30 percent water, was dried by thoroughly mixing it with quicklime, which became hydrated. Then the dry mixture (at least 45 percent CaO) was finely ground for spreading.[65]

Building.—After calcining at high temperatures, dolomitic lime became difficult to hydrate. Unsoundness of dolomitic building lime was usually the result of incomplete hydration and indicated continuing hydration and expansion of lime after it was part of the building. Popping and pitting, expanding and bulging of plaster, and the slow growth of mortar leading to masonry cracking were signs of unsoundness of lime in buildings. To overcome unsoundness of dolomitic lime, hydration in steam under pressure was recommended.[66]

Some impurities in building lime reduced the slaking rate. Reduction of lime expansion in plasters and mortars depended upon the additional of granular materials, their properties, and their grading. Rotational viscometers determined the flow properties of lime pastes,

---

[64] Whittaker, C. W., Anderson, M. S., and Reitemeier, R. F., Liming Soils, An Aid To Better Farming: U.S. Department of Agriculture, Farmers' Bull. 2124, June 1959, 32 pp.

[65] Kippe, Otto (assigned to Paul Tobeler, Trans-Oceanic, Los Angeles, Calif.), Method of Making Lime-Containing Fertilizers and Especially Slag Lime: U.S. Patent 2,904,425, Sept. 15, 1959.

[66] Mine and Quarry Engineering (London), Pressure Hydration of Dolomitic Lime: Vol. 25, No. 9, September 1959, p. 423.

and shear-box tests measured the flow properties of mortars. Yield values proportional to the Emley plasticity index were quickly determined for 1-ounce lime samples.[67]

A plaster and wall-spakle composition contained calcium hydrosilicate produced by autoclaving lime with fine-grained silica.[68] Quick-drying interior-finish plaster consisted of ground marble, hydrated lime, gypsum, and small amounts of zinc stearate and a pigment. This plaster finished hard, wore well, and did not need painting, as it was colored already.[69] A highly plastic hydrated lime, useful as a finish-coat plaster or a brick mortar, consisted of smaller than 5-micron lime particles clustered into 5- to 44-micron aggregates. Its Emley plasticity index was above 200.[70]

Chemical and Industrial.—The Food and Drug Administration included quicklime and hydrated lime in its list of 182 chemicals safe for use as food additives. Quicklime was used in food as a buffer, a neutralizing agent, and a nutrient. Hydrated lime was used in food as a buffer and a neutralizing agent.[71] To reduce water percolating through slowly soluble radioactive tailings to a safe minimum, AEC recommended precipitating the slimes with lime and spreading them properly in the tailings dam.[72] Manufacturing calcium carbide by heating coke with lime or limestone in a shaft furnace was improved, and shell formation eliminated by diminishing lime concentration from the center of the furnace outwards to the furnace wall.[73]

High-purity sodium and potassium were obtained in the U.S.S.R. by reducing their chlorides with lime, a fluoride, and ferrosilicon in a vacuum at 800° to 950° F.[74] Byproduct hydrated lime from acetylene generators was made into an aqueous slurry and activated by vigorous agitation so that it would react with chlorine to yield calcium hypochlorite.[75] An improved catalyst for better cracking of hydrocarbons was made by calcining titanium dioxide and quick lime at 1,200° F.[76]

Reacting hydrated lime and silica in water at an elevated pressure and a temperature between 450° and 650° F. produced calcium silicate needles, which were dried and mixed with cellulose fibers to make paper sheets.[77] A slurry suitable for molding consisted of asbestos, finely divided lime, and such finely divided siliceous material as

---

[67] South African Council For Scientific and Industrial Research (Pretoria), Building Lime: 13th Ann. Rept., 1957–58, Apr. 1, 1958, pp. 147–148.

[68] Schmidt, Bertil J. M., and Olsson, Karl G. (assigned to Casius Corp., Ltd., Montreal, Quebec), Plaster Composition: U.S. Patent 2,905,566, Sept. 22, 1959.

[69] Lemmon, Edward M. (assigned to James L. Palsgrove, Columbus, Ohio), Interior Plaster: U.S. Patent 2,868,660, Jan. 13, 1959.

[70] Rikard, Mack A., Bartlett, Eugene A., and Coleman, Robert B., Jr., (assigned to American-Marietta Co., Chicago, Ill.), Method of Producing Agglomerated Lime Hydrate: U.S Patent 2,894,820, July 14, 1959.

[71] Chemical and Engineering News, FDA Lists Safe Food Additives: Vol. 37, No. 48, Nov. 30, 1959, p. 32.

[72] Chemical and Engineering News, Meeting Uranium Safety Standards: Vol. 37, No. 43, Oct. 26, 1959, pp. 88, 90.

[73] Koopal, S. (assigned to Stamicarbon N. V., Heerlen, Netherlands), Manufacture of Calcium Carbide in Shaft Furnace: U.S. Patent 2,880,069, Mar. 31, 1959.

[74] Chemical and Engineering News, vol. 37, No. 37, Sept. 14, 1959, p. 48.

[75] Horn, H., and Gloss, G. H. (assigned to International Minerals and Chemical Corp., Chicago, Ill.), Activation of Lime: U.S. Patents 2,869,987, and 2,869,988, Jan. 20, 1959.

[76] Baker, Edward G (assigned to Esso Research and Engineering Co., New York, N.Y.). Titanium Dioxide-Calcium Oxide Catalyst for Cracking Hydrocarbons: U.S. Patent 2,886,513, May 12, 1959.

[77] Allen, Edward M. (assigned to Columbia-Southern Chemical Corp., Pittsburgh, Pa.), Calcium Silicate and Method of Producing Same: U.S. Patent 2,888,377, May 26, 1959.

diatomite.[78] Lightweight, heat-insulating shapes were cast from an aqueous slurry of hydrated lime, pulverized diatomite, and asbestos. Adding sodium silicate or potassium silicate to the slurry accelerated the lime-silica reaction and reduced shrinkage in the mold.[79] Lime, silica, and asbestos formed porous, monolithic fillers for cylinders to store acetylene.[80]

Hydrated lime was used in making insulating material.[81] One improved buffing composition contained lime with fatty acid, petrolatum, tallow, and a tertiary amine;[82] another buffing compound consisted of Vienna lime with stearic acid, acidless tallow, and an antislaking additive.[83] Another attempt was made to dead-burn high-calcium quicklime for use in high-temperature refractories ordinarily made from dolomitic lime and magnesia. Quicklime, iron oxide, and magnesia were mixed, wet-milled, pressed or extruded, and fired at about 3,000° F. until some of the quicklime had fused with the iron oxide and magnesia to form a protective matrix for the remaining unfired quicklime.[84]

Clays containing up to 30 percent lime were used in ceramics only if very fine. Powdered quicklime, added to rectify overwatered clay, had to be in the finest form, and was not used if it had been stored long. The dissociation of calcium carbonate to quicklime during firing and the action of moisture in the final ware, converting quicklime to hydrated lime, were important reactions. The intensity of dissociation increased with finer sized calcium carbonate. More finely divided lime increased CO_2 evolution at a given temperature, and consequently promoted the formation of pores and blisters. By virtue of the endothermic dissociation of calcium carbonate, more fuel was needed for firing limy clays. Volume increase from quick to hydrated lime was calculated as 21.9 percent.[85]

To encourage research on all aspects of lime manufacturing, on chemical and physical properties of lime, and on testing methods, the National Lime Association announced an annual award for the best technical paper.[86]

Soil Stabilization.—Kansas State Highway Commission used 5,350 short tons of hydrated lime to stabilize swelling subgrade clay soils for 15.5 miles of U.S. Route 40 near Topeka. Subgrade width of 48

---

[78] Ayers, Osborn, and Homiak, Michael (assigned to Johns-Manville Corp., New York, N.Y.), Method of Molding Foundry Core Drier Supports: U.S. Patent 2,873,480, Feb. 17, 1959.

[79] Hoopes, Harry P., Weber, Horst L., and Neal, Jesse R., Jr. (assigned to Fibreboard Paper Products Corp., San Francisco, Calif.), Method of Making Calcareous-Siliceous Insulating Material: U.S. Patent 2,904,444, Sept. 15, 1959.

[80] Pater, Anton S., and Houser, John W, (assigned to Union Carbide Corp., New York, N.Y.), Monolithic Porous Filler for Cylinders and Method of Producing Same: U.S. Patent 2,883,040, Apr. 21, 1959.

[81] Bowditch, William R., Jr. (assigned to Taylor Fibre Co., Norristown, Pa.), Insulating Material: U.S. Patent 2,879,827, Mar. 31, 1959.

[82] Work cited in footnote 59.

[83] Riegler, Werner L., and Dybalski, Jack N. (assigned to Armour and Co., Chicago, Ill.), Anti-Slaking Buffing Compositions: U.S. Patent 2,899,290, Aug. 11, 1959.

[84] McAllister, Robert W., High-Calcium Lime Refractories and Method for Making Them: U.S. Patent 2,916,389, Dec. 8, 1959.
National Lime Association, Limeographs: Vol. 26. January 1960, p. 48.

[85] Homayr, J., [Lime in Clay]: Ziegelindustrie, (Wiesbaden), vol. 11, No. 18, 1958, pp. 523–527.

[86] National Lime Association, Azbe Lime Award: Limeographs, vol. 26, October 1959, p. 21.

feet was stabilized 6 inches deep with hydrated lime constituting 5 percent of the weight of the soil.[87]

Shipping lime slurry by barge was introduced. Barges, carrying 200,000 gallons each, went from Freeport, Tex., to Wallisville, Tex., by way of the Intracoastal Canal to stabilize an 18-mile segment of Interstate Highway No. 10 between Houston and Port Arthur, Tex. Slurry was pumped from the barges into tank trucks that conveyed it to the construction site, where it was applied by spreaders. The 13,000 tons of hydrated lime required for this large stabilization project was calcined from oyster shell dredged from Galveston Bay.

The slurry contained at least 31 percent solid, hydrated lime, analyzing 95 percent $Ca(OH)_2$. Settling of lime in the barge tanks was prevented by constantly agitating the slurry with air. By using slurry instead of dry hydrated lime, the cost was reduced from $30 to $28.45 a ton at the project, and savings of $3 to $4 a ton were anticipated on completion. The Texas Highway Department specified slurry because it distributed lime better in the soil, prevented waste by wind, and eliminated the nuisance of air-dispersed lime. Application rate was 28.4 pounds of hydrated lime per square yard, or 3.5 percent by weight of clay subbase.[88]

The "Lime Stabilization Construction Manual" was published by the American Roadbuilder's Association after a national survey of current practices.[89] It was the first detailed manual of soil-stabilization procedures.

---

[87] Roads and Streets, Lime Stabilized Subgrade for Kansas "I" Project: Vol. 102, No. 2, February 1959, pp. 112–115.

[88] Roads and Streets, Lime Slurry Upgrades Poor Subgrade Soils: Vol. 102, No. 12, December 1959, pp. 82–84.
National Lime Association, Barging Lime Slurry: Limeographs, vol. 26, January 1960, p. 53.

[89] American Roadbuilder's Association, Lime Stabilization Construction Manual: Tech. Bull. 243, 1959, 36 pp.

Lithium

By Albert E. Schreck[1]

◆

THE DOMESTIC lithium industry in 1959 was characterized by keen competition, concentrated efforts to expand existing markets, and development of new uses for lithium products. This activity reflected the threefold problem confronting the industry: (1) Excess plant capacity to produce lithium compounds; (2) termination of Atomic Energy Commission (AEC) contracts; and (3) accumulation of lithium hydroxide (depleted in lithium-6), which probably will have to be absorbed by commercial markets.

DOMESTIC PRODUCTION

The uncertainty of the immediate future of lithium was evidenced by production cutbacks and other economy moves. Production of both minerals and compounds was reduced. Domestic output of lithium minerals in 1959 (55 percent less than in 1958) came primarily from North Carolina; California and South Dakota supplied the remainder.

Foote Mineral Co. continued to recover spodumene concentrate from its Kings Mountain (N.C.) quarry but production was reduced. American Potash & Chemical Corp. recovered dilithium sodium phosphate from brines from Searles Lake, Calif.; and Maywood Chemical Works produced spodumene from the Etta mine, Pennington County, S. Dak.

TABLE 1.—Shipments of lithium ores and compounds from mines in the United States

Year	Ore		Li_2O, Short tons
	Short tons	Value	
1950	9,306	$579,922	747
1951	12,897	896,000	956
1952	15,611	1,052,000	1,088
1953	27,240	$2,134,000	1,767
1954	37,830	3,126,000	2,459
1955–59	(1)	(1)	(1)

[1] Figures withheld to avoid disclosing individual company confidential data.

---

[1] Commodity specialist.

Lithium Corp. of America announced that it would reopen its North Carolina spodumene mines in 1960. In August 1959 Lithium Corp. of America, notified Quebec Lithium Corp. of Canada that it would not accept further shipments of spodumene concentrates from them. The Canadian firm claimed that their contract did not expire until March 1962 and that Lithium Corp. of America was violating the contract. Quebec Lithium then instituted an estimated $4-million suit in Minneapolis for contract damages. An out-of-court settlement was reached early in 1960.

Lithium Corp. also transferred its entire St. Louis Park manufacturing and research facilities to newly constructed quarters adjacent to its lithium hydroxide plant at Bessemer City, N.C. After January 1, 1960, all products formerly made at St. Louis Park, Minn. were to be made at the new location. Plans also call for transferring the home office from Minneapolis to the metropolitan New York City area. Consolidation of manufacturing operations was expected to result in substantial savings in freight cost.

Maywood Chemical Works, the country's oldest producer of lithium minerals and compounds, was acquired in 1959 by Stepan Chemical Co. Maywood will retain its name and operate as a subsidiary of Stepan Chemical Co.

Texas Gulf Sulphur Co. obtained a 5-year option on the lithium properties of Basic Atomics, in the Lincolnton area of North Carolina, and on a recovery method patented by Basic Atomics. Evaluation of both the property and the process was underway.[2]

CONSUMPTION AND USES

Lithium minerals and concentrates were consumed primarily in manufacturing lithium chemicals, ceramics, and glass. Spodumene, lepidolite, and dilithium sodium phosphate were consumed by the chemical industry; lepidolite, petalite, and (to a smaller degree) spodumene were used by the ceramics and glass industry.

Most lithium minerals were consumed in manufacturing various lithium compounds, such as carbonate, hydroxide, chloride, and bromide, to serve a wide variety of uses.

According to a report of the Chemical and Rubber Division of Business and Defense Services Administration (BDSA), these uses, in order of importance distribution in 1958, were:[3]

Greases and other lubricants.
Ceramics and glass.
Organic synthesis and propellants.
Miscellaneous.
Humidity control and air conditioning.
Exports.
Other metallurgical uses.
Storage batteries.
Welding and brazing aluminum.
Dealers.
Dry cells.

---

[2] Engineering and Mining Journal, vol. 160, No. 11, November 1959, p. 152.

[3] Business and Defense Services Administration, U.S. Dept. of Commerce, Chemical and Rubber Industry Report: Vol. 6, No. 12, December 1959, pp. 5–8.

The BDSA report showed domestic commercial consumption of lithium compounds (as lithium carbonate equivalents) to be about 7.7 million pounds in 1958, an approximate increase of 1.5 million pounds over 1957. Greases and lubricants accounted for 1.6 million pounds of the total in 1957 and 2.4 million pounds in 1958.

Lithium minerals are being consumed in increasing quantities in the glass and ceramics industries, imports being the major raw-material source. It is estimated that 70 percent of the total consumption of lithium minerals in the glass industry is used in electronic and television glass, 20 percent in borosilicate glass, and slightly less than 10 percent in miscellaneous glass.[4]

Lithium metal was used as a degassifier and deoxidizer in copper refining, also in the production of improved types of stainless steel.

The lithium-containing aluminum alloy X2020, developed by ALCOA, was used in the new Navy attack bomber, A3J, *Vigilante*.[5]

PRICES

In 1959 the price of 99.5-percent-pure lithium metal, as quoted in E&MJ Metal and Mineral Markets, was $9 to $11 per pound.

TABLE 2.—Range of prices on selected lithium compounds, in 1959, in pounds

[Oil, Paint and Drug Reporter]

Compound	January–December 1959	Compound	January–December 1959
Lithium benzoate, drums	$1.65–$1.67	Lithium hydride, powder, drums, 500-pound lots or more, works	$9.50
Lithium bromide, NF, gran. works, freight equalized	2.60	Lithium hydroxide monohydrate, drums, carlots, tonlots, freight allowed	.72
Lithium carbonate, technical, drums, carlots, tonlots, freight allowed	.67	Less than carlots, same basis	.73
Drums, tonlots, same basis	.73	Lithium nitrate, technical, drums, 100-pound lots	1.15– 1.25
Drums, smaller lots, same basis	.79	Lithium stearate, drums, carlots, works	.47½
Lithium chloride, technical, anhydrous, drums, carlots, tonlots, delivered or works, freight allowed	.87	Tonlots, works	.48½
Less than carlots, same basis	.88– .92	Less than tonlots, works	.53½

FOREIGN TRADE

Imports of lithium minerals from Canada and the Federation of Rhodesia and Nyasaland continued to be an important factor in raw-material supply.

Data on imports of lithium minerals and compounds are not separately classified by the U.S. Department of Commerce.

No imports of lithium metal were reported in 1959.

---

[4] Glass Industry, Ten Years of Progress in the Glass Industry, Raw Materials: Vol. 40, No. 11, November 1959, pp. 626–627, 661–662.

[5] Chemical Week, vol. 85, No. 22, Nov. 28, 1959, pp. 58–60.

WORLD REVIEW

NORTH AMERICA

Canada.—Quebec Lithium Corp. began construction of a lithium chemical plant at its Val d'Or (Quebec) property.[6] The plant has an initial capacity of 50 tons per day of spodumene concentrate; however, to provide for future expansion the equipment installed will be capable of handling 150 tons per day of concentrate. Initially, only lithium carbonate, at a rate of approximately 12,000 pounds per day, will be produced.

TABLE 3.—World production of lithium minerals, by countries, in short tons

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country	Mineral produced	1955	1956	1957	1958	1959
North America:						
Canada [1]	Spodumene	57	2,395	2,570	1,927	1,249
United States	Lithium minerals	(2)	(2)	(2)	(2)	(2)
South America:						
Argentina	do	110	165	22	186	(3)
Brazil	Spodumene (exports).	1,047			160	[4] 500
	Amblygonite (exports).	789		552		[4] 900
Europe:						
Portugal	Amblygonite	4				
Spain	do	125	57	7		
Africa:						
Belgian Congo (includes Ruanda-Urundi).	do	1,491	1,996	2,317	11	(3)
	Spodumene (exports).	28	72	1		
Mozambique	Lepidolite		1,105	379	96	99
	Amblygonite		39			
Rhodesia and Nyasaland Federation of. Southern Rhodesia	Eucryptite	12		56	398	(3)
	Amblygonite	180	646	122	1,835	
	Lepidolite	57,714	84,599	93,545	64,699	
	Petalite	24,210	13,524	9,934	13,166	
	Spodumene	50	4,445	5,599	5,238	
South-West Africa	Amblygonite	1,414	831	535	534	242
	Lepidolite	1,832	1,139	882	1,043	2,168
	Petalite	5,278	3,675	5,325	7,405	2,787
Uganda	Amblygonite			6		
Union of South Africa	do	426	713	30		10
Oceania: Australia	Spodumene	4				
	Petalite				76	
Total		94,771	115,401	121,882	96,774	(3)

[1] Tons of lithia in spodumene concentrate.
[2] Figure withheld to avoid disclosing individual company confidential data
[3] Data not available and no estimates included in total.
[4] Estimate.

As a result of Lithium Corporation of America's refusal to accept further shipments of spodumene concentrate, Quebec Lithium suspended operations at its mine and mill in late November.[7] A sufficient stockpile of concentrate is on hand to supply the new chemical plant and the requirements of glass producers.

Montgary Explorations reopened its Bernic Lake (Ontario) property on a limited scale. An agreement with Metallgesellschaft, A. G., of Frankfurt, Germany, called for the delivery of several thousand

---

[6] Northern Miner, Quebec Lithium Building Plant to Produce Lithium Chemicals: Vol. 44, No. 49, Feb. 26, 1959, pp. 1, 8.

[7] Northern Miner, Quebec Lithium Shuts Mine, Mill to Start Refinery: Vol. 45, No. 35, Nov. 19, 1959, p. 7.

tons of amblygonite.[8] Several smaller agreements for spodumene, amblygonite, lepidolite, and pollucite have also been negotiated.

Marketing of Montgary's mineral products will be handled by W. R. Grace & Co., of New York, and Metallgesellschaft.

EUROPE

Germany, West.—Germany exported an increased amount of lithium metal; 5 tons was exported in 1958 and 3 tons in 1957.[9]

AFRICA

Rhodesia and Nyasaland, Federation of.—Bikita Minerals, Ltd., acquired the adjacent lithium mine of George H. Nolan during the year.[10] The Nolan property is part of the same ore body being worked by Bikita. However, the Bikita ore is mainly lepidolite with some spodumene and amblygonite, whereas the Nolan property contains a large reserve of petalite in addition to spodumene and eucryptite. The acquisition has enabled Bikita to supply a full range of lithium minerals. Marketing was handled by American Potash & Chemical Corp.

The Bikita deposit, discovered in 1910, was operated intermittently as a source of cassiterite from 1916 to 1950. In 1950 major lithium-mineral production was started. A detailed description of the mining at this open pit and a flow sheet of the handpicking plant was published.[11] A short discussion of the geology, exploration, and development of the deposit and marketing and shipping procedures were also included.

Senegal.—Lithium-bearing pegmatite deposits were discovered in the Bougouni region of the French Sudan, about 100 miles from Bamako. A reserve of 1.3 million tons of ore containing about 250,000 tons of spodumene was estimated for the five deposits examined. Other lithium pegmatites are believed to exist in the area.[12]

South-West Africa.—The following firms reportedly produced lithium minerals in 1958: P. J. Human, Omaruru; S.W.A. Lithium Mines, Windhoek; and Tantalite Valley Minerals (Pty.), Ltd., Karasburg.

TECHNOLOGY

The properties of lithia-bearing porcelain enamels, recent data on the thermal coefficient of expansion of lithia, and information on the use of lithium fluoride and complex lithium compounds in porcelain enamels and ceramics were discussed.[13]

---

[8] Northern Miner, Montgary to Start Small Scale Output, Sells Lithium Ores: Vol. 45, No. 4, Apr. 16, 1959, pp. 1, 7.

[9] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 5, November 1959, p. 51.

[10] Mining Journal (London), Bikita Acquires New Lithium Property: Vol. 253, No. 6488, Dec. 25, 1959, p. 665.

[11] Symons, R., A Description of Bikita Mineral's Mining Operations: Chamber of Mines Jour. (Rhodesia), vol. 1, No. 8, December 1959, pp. 23–26.

[12] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 6, December 1959, pp. 44–45.

[13] Huppert, Paul A., Lithia in Porcelain Enamels: Bull., Am. Ceram. Soc., vol. 38, No. 2, February 1959, pp. 57–60.

TABLE 4.—Exports of lithium ores from the Federation of Rhodesia and Nyasaland, by countries of destination[1]

[Compiled by Corra A. Barry]

Country	1958		1959[2]	
	Short tons	Value[3]	Short tons	Value[3]
Australia	6	$202	--------	--------
France	598	8,401	454	$4,328
Germany, West	1,081	27,868	1,671	42,152
Japan	622	14,794	556	14,423
Netherlands	4,813	97,073	1,713	39,315
United Kingdom	3,468	81,608	2,704	51,471
United States	156,432	2,077,563	38,527	625,070
Total	167,020	2,307,509	45,625	776,759

[1] Compiled from Customs Returns of the Federation of Rhodesia and Nyasaland.
[2] January through June, inclusive.
[3] Converted to U.S. currency at the rates of £1 equals US$2.7932 (1958) and US$2.8088 (1959).

TABLE 5.—Exports of lithium ores from South-West Africa, by countries of destination[1]

[Compiled by Corra A. Barry]

Country	Amblygonite		Lepidolite		Petalite	
	Short tons	Value[2]	Short tons	Value[2]	Short tons	Value[2]
1958						
Belgium	--------	--------	60	$1,165	586	$11,455
Germany, West	417	$17,882	58	1,165	125	2,735
Italy	124	6,466	--------	--------	--------	--------
Netherlands	115	5,383	283	5,654	1,307	27,321
United Kingdom	46	2,864	--------	--------	3,250	78,739
Total	702	32,595	401	7,984	5,268	120,250
1959[3]						
Germany, West	108	5,238	208	4,155	--------	--------
Japan	23	84	6	160	23	878
Netherlands	--------	--------	442	8,843	275	5,597
Union of South Africa	--------	--------	208	4,298	122	1,847
United Kingdom	--------	--------	--------	--------	694	16,902
Total	131	5,322	864	17,456	1,114	25,244

[1] Compiled from Customs Returns of South-West Africa.
[2] Converted to US currency at the rate of SA£1 equals US$2.7993 (1958 and US$2.7983 (1959).
[3] January through September, inclusive.

A new refractory containing petalite reduced kiln maintenance costs in the clay-products industries.[14] The refractory developed at the Robinson Clay Products research department at Parral, Ohio, has a low thermal expansion and excellent resistance to heat shock. The firm estimated that an overall savings of $80,000 per year on direct and indirect kiln maintenance costs will result from the use of this new ceramic material.

A method was patented[15] for recovering lithium as the chloride from spodumene. A finely ground mixture of spodumene, potassium

---

[14] Brick and Clay Record, Top Block Breakage Cut With Petalite Additions: Vol. 135, No. 4, October 1959, pp. 63, 84.

[15] Peterson, J. A., and Glass, G. H. (assigned to International Minerals & Chemical Corp.), Lithium Values Recovery Process: U.S. Patent 2,893,828, July 7, 1959.

chloride (equaling at least 7 molar equivalents of the lithium), and a refractory material inert to the potassium-chloride-lithium reaction, is heated between about 980° and about 1,100° C. until substantially all of the lithium has been converted to the chloride. The mass is cooled and the lithium chloride leached from it. The refractory should comprise 40 to 100 percent by weight of the spodumene and have a melting point at least as high as spodumene.

The large reserve of domestic lithium ore, increasing quantities of which will become available for use in ceramics and glass, resulted in numerous research projects on the basic nature of lithia in glass and ceramics. These projects were directed toward providing basic knowledge to the industry, thus enabling better use of lithium oxide and lithium ores in glass of various composition.

Mechanical properties of beta-eucryptite were studied and results published.[16] Some of the research to provide basic knowledge involved studies of the lithium oxide systems. Several reports were published[17] on the work conducted at the Pennsylvania State University.

A new three-step lithium metal purification process was developed at Oak Ridge National Laboratory. The method, designed to remove the several hundred to several thousand parts per million of nitrogen and oxygen found in commercial high-purity lithium, involves filtration, gettering, and cold trapping.[18] The resulting metal contains less than 100 p.p.m. each of nitrogen and oxygen.

The method of degassing stainless steel by lithium and argon purging, used by Jones & Laughlin Steel Corp., was described in an article.[19] A specially designed capsule of steel pipe containing 2 ounces of lithium was introduced into the bottom of the furnace. Addition of lithium and argon for purging continued until there were no signs of gas in the furnace. After tapping, lithium capsules were also introduced into the ladle to insure complete degassification.

---

[16] Bush, A. E., and Hummel, F. A., High-Temperature Mechanical Properties of Ceramic Materials: II, Beta Eucryptite, Jour. Am. Ceram. Soc., vol. 42, No. 8, August 1959, pp. 388–391.

[17] Sastry, B. S. R., and Hummel, F. A., Studies in Lithium Oxide Systems: III, Liquid Immiscibility in the System Li_2O–B_2O_3–SiO_2: Jour. Am. Ceram. Soc., vol. 42, No. 2, February 1959, pp. 81–88.

Hummel, F. A., and Tien, Tseng-Ying, Studies in Lithium Oxide Systems: IV, Note on Effect of Li_2O on Sintering of TiO_2: Jour. Am. Ceram. Soc., vol. 42, No. 4, April 1959, pp. 206–207.

Sastry, B. S. R., and Hummel, F. A., Studies in Lithium Oxides Systems: V, Li_2O–$Li_2O \cdot B_2O_3$: Jour. Am. Ceram. Soc., vol. 42, No. 5, May 1959, pp. 216–218.

Kim, K. H., and Hummel, F. A., Studies in Lithium Oxide Systems: VI, Progress Report on the System Li_2O–SiO_2–TiO_2: Jour. Am. Ceram. Soc., vol. 42, No. 6, June 1959, pp. 286–291.

[18] Chemical Week, Lithium Cleanup: Vol. 85, No. 21, Nov. 21, 1959, pp. 166–168.

[19] Iron Age, Degas Steel With Lithium: Vol. 184, No. 25, Dec. 17, 1959, pp. 168–169.

Magnesium

By H.B. Comstock[1] and Jeannette I. Baker[2]

⁂

THE IMPORTANCE of magnesium as the lightest structural metal was highlighted in 1959 by its use in the skins, framework, and instrument cases of the Nation's Vanguard weather satellites. New magnesium alloys with improved physical properties were developed and used in 1959, and improvements continued to be made in forming and fabricating techniques.

Although there was virtually no change in world production of magnesium, consumption in the United States increased 17 percent above 1958, and exports rose more than 100 percent. New military and civilian uses of magnesium for structural applications were noted.

TABLE 1.—Salient statistics of magnesium

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Domestic production:						
Primary magnesium..short tons..	65,047	61,135	68,346	81,263	30,096	31,033
Secondary magnesium......do....	10,532	10,246	10,529	10,658	[1] 8,707	10,090
Imports.......................do....	1,628	1,844	630	982	537	593
Exports.......................do....	1,609	8,230	3,388	1,219	[2] 207	[2] 1,601
Consumption..................do....	36,051	46,463	53,610	44,442	35,352	41,200
Price per pound..............cents..	24.9	29.5	33.9	35.25	35.25	35.25
World: Primary production..short tons..	118,400	[1] 132,800	[1] 141,600	155,000	[1] 103,900	104,300

[1] Revised figure.

[2] Effective Jan. 1, 1958, some material formerly included with metals and alloys in crude form, and scrap included with semifabricated forms, not elsewhere specified.

DOMESTIC PRODUCTION

Primary.—Commercial production of primary magnesium in the United States in 1959 remained below that of 1958 until the fourth quarter, when output rose to show a gain of 3 percent for the year. The Dow Chemical Co. increased production capacity of its electrolytic plant at Freeport, Tex., to 36,000 tons. This plant and the Government-owned 5,000-ton silicothermic plant at Canaan, Conn., produced magnesium throughout the year. Titanium Metals Corp. of America continued to recycle magnesium as an integrated operation of its production of titanium at Henderson, Nev.

---

[1] Commodity specialist.

[2] Research assistant.

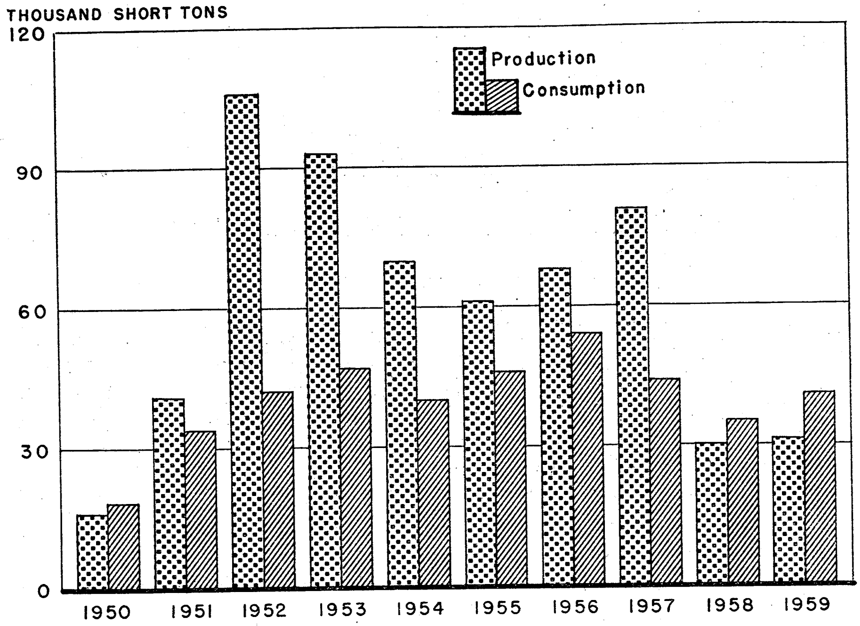

FIGURE 1.—Domestic production and consumption of primary magnesium, 1950–59.

Alabama Metallurgical Corp. began producing magnesium in November 1959 at its new 6,000-ton silicothermic plant at Selma, Ala. This plant brought primary production capacity of operating domestic commercial plants to 47,000 tons. The Dow Chemical Co. continued to hold on standby its 46,000-ton electrolytic plant at Velasco, Tex., which was closed in March 1958. General Services Administration completed preparations in 1959 to dispose of the five Government-owned magnesium plants at Wingdale, N.Y., Painesville and Luckey, Ohio, Manteca, Calif., and Spokane, Wash., which were shut down in 1953 after producing during the Korean war.

Secondary.—The increase of 1,383 tons above 1958 in total recovery of magnesium from scrap reflected the rise of more than 200 percent in recovery from old aluminum scrap. Use of secondary magnesium for cathodic protection has declined steadily from the peak of 3,619 tons in 1955. Use in aluminum alloys has increased steadily to a new record of 3,507 tons.

CONSUMPTION AND USES

Consumption of primary magnesium for distributive and sacrificial purposes continued to exceed its use in structural products; however, structural uses increased substantially over 1958. Although the drop in use of the metal for sand castings offset the increases for die and permanent mold castings, the rise in consumption for sheet and plate, extrusions and forgings, raised total consumption for structural prod-

TABLE 2.—Production and shipments of primary magnesium in the United States, by month, in short tons

Month	1950–54 (average)		1955		1956	
	Production	Shipments	Production	Shipments	Production	Shipments
January	5,332	5,415	5,090	4,238	6,337	6,052
February	5,070	4,957	4,647	4,933	5,908	4,932
March	5,725	5,348	4,942	4,295	6,347	6,329
April	5,551	5,346	1,859	4,162	6,081	6,564
May	5,567	5,026	4,277	3,942	6,359	5,400
June	5,167	5,655	4,757	5,534	6,098	3,846
July	5,223	4,741	5,112	5,412	1,136	4,127
August	5,325	5,401	5,881	3,947	3,314	4,736
September	5,125	4,944	5,923	5,225	6,128	5,760
October	5,463	5,079	6,287	4,392	6,735	6,726
November	5,612	6,367	6,130	5,673	6,818	5,382
December	5,887	5,482	6,230	4,418	7,085	3,408
Total	65,047	63,761	61,135	56,171	68,346	63,262

Month	1957		1958		1959	
	Production	Shipments	Production	Shipments	Production	Shipments
January	7,391	7,529	5,272	3,367	1,877	2,976
February	6,617	7,776	3,526	2,060	1,725	3,671
March	7,383	5,318	3,235	2,260	1,925	3,681
April	7,222	4,251	2,772	3,043	1,808	4,176
May	7,227	3,870	2,469	2,415	2,668	3,995
June	6,718	4,668	1,784	2,844	2,778	4,271
July	6,777	2,596	1,799	2,645	2,850	4,559
August	7,152	3,097	1,845	2,610	2,967	4,367
September	6,486	5,130	1,791	2,942	2,846	3,026
October	6,468	3,147	1,927	3,151	3,018	3,556
November	5,995	2,114	1,814	2,911	3,042	4,718
December	5,827	2,074	1,862	3,908	3,529	4,536
Total	81,263	51,570	30,096	34,156	31,033	47,532

TABLE 3.—Magnesium recovered from scrap processed in the United States, in short tons[1]

	1950–54 (average)	1955	1956	1957	1958	1959
Kind of scrap:						
New scrap:						
Magnesium-base	3,255	3,712	3,099	3,360	2,280	3,073
Aluminum-base	1,652	1,981	2,071	2,237	[2] 1,653	779
Total	4,907	5,693	5,170	5,597	[2] 3,933	3,852
Old scrap:						
Magnesium-base	4,952	3,926	4,662	4,350	4,156	4,133
Aluminum-base	673	627	697	711	[2] 618	2,105
Total	5,625	4,553	5,359	5,061	[2] 4,774	6,238
Grand total	10,532	10,246	10,529	10,658	[2] 8,707	10,090
Form of recovery:						
Magnesium-alloy ingot[1]	5,209	3,342	4,072	4,200	[2] 2,976	3,881
Magnesium-alloy castings (gross weight)	1,124	256	206	75	78	219
Magnesium-alloy shapes	63	5	5	---------	[2] 3	2
Aluminum alloys	2,935	2,976	3,188	3,383	[2] 2,701	3,507
Zinc and other alloys	33	47	85	22	[2] 30	21
Chemical and other dissipative uses	60	1	11	29	[2] 53	600
Cathodic protection	1,108	3,619	2,962	2,949	[2] 2,866	1,860
Total	10,532	10,246	10,529	10,658	[2] 8,707	10,090

---

[1] Figures include secondary magnesium content of both secondary and primary magnesium alloy ingot.

[2] Revised figure.

ucts to 3,559 tons above 1958. Use of these products was divided almost equally between military and civilian consumers.

New and expanded applications for magnesium and its alloys in 1959[3] included aircraft, automotive and materials handling equipment, portable tools, tooling jigs and fixtures, ladders, office machines. luggage, and photoengraving plate.

TABLE 4.—Stocks and consumption of new and old magnesium scrap in the United States in 1959, gross weight in short tons

Scrap item	Stocks, beginning of year	Receipts	Consumption			Stocks, end of year
			New scrap	Old scrap	Total	
Cast scrap	937	5, 910	725	5, 165	5, 890	957
Solid wrought scrap	143	1, 506	1, 529	----------	1, 529	120
Borings, turnings, drosses, etc	49	1, 702	1, 606	----------	1, 606	145
Total	1, 129	9, 118	3, 860	5, 165	9, 025	1, 222

TABLE 5.—Domestic consumption of primary magnesium (ingot equivalent and magnesium content of magnesium-base alloys), by uses, in short tons

Product	1950–54 (average)	1955	1956	1957	1958	1959
For structural products:						
Castings:						
Sand	10, 327	6, 872	6, 478	6, 076	5, 698	4, 657
Die	1, 631	2, 619	1, 875	1, 649	1, 553	[1] 1, 772
Permanent mold	845	876	1, 034	571	889	981
Wrought products:						
Sheet and plate	4, 394	6, 424	5, 496	4, 916	4, 061	6, 128
Extrusions (structural shapes, tubing)	3, 476	4, 106	6, 223	5, 081	2, 624	3, 074
Forgings	197	307	473	7	141	1, 913
Total	20, 870	21, 204	21, 579	18, 300	14, 966	18, 525
For distributive or sacrificial purposes:						
Powder	778	681	918	386	352	456
Aluminum alloys	7, 344	11, 104	13, 323	11, 236	10, 746	14, 752
Other alloys	427	364	98	587	446	840
Scavenger and deoxidizer	707	654	865	867	708	292
Chemical	362	124	63	325	148	351
Cathodic protection (anodes)	2, 884	3, 941	3, 036	2, 997	2, 028	3, 005
Reducing agent for titanium, zirconium, hafnium, uranium, and beryllium	(2)	8, 056	13, 303	9, 695	5, 953	2, 965
Other [3]	1, 400	335	425	49	5	14
Total	15, 181	25, 259	32, 031	26, 142	20, 386	22, 675
Grand total	36, 051	46, 463	53, 610	44, 442	35, 352	41, 200

[1] Includes primary metal to produce small quantities of investment castings.

[2] This use which was very small before 1954, was included in the figure for other distributive purposes. In 1954 it was 6,386 short tons.

[3] Includes primary metal consumed for experimental purposes, debismuthizing lead, and producing nodular iron and secondary magnesium alloys.

Increased consumption of magnesium alloys in die castings reflected experience gained in large-scale manufacturing operations.[4] Magnesium castings used in missiles were described.[5] In addition to

---

[3] Kirkpatrick, James S., Magnesium's Markets: Modern Metals, vol. 15, No. 11, December 1959, pp. 60, 62, 64.

[4] Hanawalt, J. D., Annual Magnesium Survey: Eng. Min. Jour., vol. 161, No. 2, pp. 103–104.

[5] Jakubowski, J. W., Cast Magnesium Structures in Reentry Vehicles: Missile Design and Development, vol. 5, No. 8, August 1959, pp. 32–34.

primary structural components, the cast alloys were used for instrumentation boxes and telemetry equipment. Magnesium extrusions and sheet were used more extensively than in 1958 for skin structures in aircraft and intercontinental ballistic missiles.[6] The structural stiffness and high damping capacity of the magnesium alloys helped to avert high-frequency vibrations at low amplitude that might cause electrical-mechanical malfunctions in the 20 types of missiles in which they were used during the year.[7] Each Discoverer satellite fired in 1959 weighed from 1,300 to 1,700 pounds and contained more than 600 pounds each of magnesium-thorium alloys that were serviceable to about 900° F.[8] The Vanguard weather satellite, circling the earth in 1959, had a skin, internal framework, and an instrument case made entirely of magnesium alloys.[9]

STOCKS

At the close of 1959, producers' and consumers' stocks were 36,765 tons of primary magnesium and 4,100 tons of primary magnesium alloy ingot—decreases of 15,235 tons of primary magnesium and 1,900 tons of primary magnesium alloy ingot below stocks at the close of 1958. Government agencies continued to retain quantities of primary ingot, as provided by the Strategic and Critical Materials Stockpiling Act.

PRICES

The base price of primary magnesium ingot in standard 42-pound pig form remained at 35.25 cents per pound, f.o.b. plant.[10] The last change was on August 13, 1956, when the price was increased from 33.75 cents per pound.

FOREIGN TRADE [11]

Imports of magnesium in 1959 increased 83 tons over 1958. About 60 percent of the total 645 tons was scrap metal. These imports came from six countries; 237 tons came from Canada, 2 tons from the Dominican Republic, 23 tons from Taiwan, 337 tons from Japan, 46 tons from the United Kingdom, and less than 1 ton from West Germany. Throughout 1959 the duty on magnesium metal remained at 50 percent ad valorem. For magnesium powder, sheets, tubing, manufactures, and so forth, the duty was 17 cents per pound plus 8.5 percent ad valorem. Suspension of duty on magnesium scrap was extended to June 30, 1960.

---

[6] Modern Metals, Titan ICBM Uses Magnesium-Thorium Alloys: Vol. 15, No. 6, July 1959, p. 74.

[7] Leontis, T. E., Magnesium in Missiles and Aircraft: Metal Progress, vol. 76, No. 5, November 1959, pp. 82–87.

[8] Modern Metals, Satellite Has Large Quantities of Magnesium-Thorium Alloys: Vol. 15, No. 7, August 1959, p. 74.

[9] Steel, Magnesium Takes to Space: Vol. 144, No. 9, Mar. 2, 1959, p. 194.

[10] E&MJ Metal and Mineral Markets, Magnesium: Vol. 30, No. 53, Dec. 31, 1959, p. 4.

[11] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

Exports.—More than twice as much magnesium was exported from the United States in 1959 as in 1958. The countries that received the metal are given in table 7.

TABLE 6.—Magnesium imported for consumption and exported from the United States

[Bureau of the Census]

Year	Imports					
	Metallic and scrap		Alloys (magnesium content)		Sheets, tubing, ribbons, wire, and other forms (magnesium content)	
	Short tons	Value	Short tons	Value	Short tons	Value
1950–54 (average)	1,628	$502,576	6	$16,365	33	$70,095
1955	1,844	1,034,241	9	52,254	4	[3] 24,526
1956	630	303,586	24	202,675	2	8,715
1957	982	479,855	35	283,099	8	16,952
1958	537	280,316	9	38,096	16	97,194
1959	593	303,307	26	154,775	26	120,630

Year	Exports					
	Metal and alloys, in crude form, and scrap		Semifabricated forms, n.e.c.		Powder	
	Short tons	Value	Short tons	Value	Short tons	Value
1950–54 (average)	1,609	$931,458	[1] 199	[1] $412,712	(2)	(2)
1955	8,230	4,556,229	[1] 236	[1] 514,986	14	$33,911
1956	3,388	2,239,577	[1] 487	[1] 901,924	56	98,635
1957	1,219	1,122,164	[1] 355	[1] 767,656	22	39,469
1958	[4] 207	[4] 225,522	[4] 834	[4] 1,053,844	11	16,147
1959	[4] 1,601	[4] 881,514	[4] 776	[4] 1,146,180	12	31,536

[1] Owing to changes in items included in each classification 1954–57, data are not strictly comparable with earlier years.

[2] Not separately classified before 1952; 1952–43 tons ($59,843); 1953–21 tons ($41,591); 1954–34 tons ($44,605).

[3] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable with other years.

[4] Effective Jan. 1, 1958, some material formerly included with "metals and alloys, in crude form, and scrap" included with "semifabricated forms, not elsewhere classified."

WORLD REVIEW

There was little change from 1958 in world production of magnesium.

Canada.—In October 1959, Aluminum Co. of Canada indefinitely suspended operation of its 4,000-ton electrolytic plant at Arvida, Quebec, and arranged to obtain from Dominion Magnesium, Ltd., and The Dow Chemical Co. its requirements for magnesium as an alloying constituent for aluminum.[12] The 8,000-ton silicothermic plant of Dominion Magnesium, Ltd., at Haley, Ontario, remained the only active primary magnesium producer in Canada.

China.—Production of magnesium from sea water was reported at Tientsin in 1959.[13]

---

[12] Modern Metals, Alcan Closes Magnesium Plant: Vol. 15, No. 9, October 1959, p. 102.

[13] Chemical Week, Chemicals in China: Vol. 84, No. 6, Feb. 7, 1959, p. 28.

TABLE 7.—Magnesium exported from the United States, by classes and countries, in short tons

[Bureau of the Census]

Country	1958			1959		
	Primary metal, alloys, and scrap	Semifabricated forms, n.e.c.	Powder	Primary metal, alloys, and scrap	Semifabricated forms, n.e.c.	Powder
North America:						
Canada	26	225	7	100	231	(1)
Mexico	1	47	------	216	132	------
Netherlands Antilles	------	7	------	------	3	------
Trinidad and Tobago	34	63	------	7	3	------
Other North America	2	4	------	1	3	------
Total	63	346	7	324	372	(1)
South America:						
Colombia	------	79	------	1	3	------
Venezuela	14	70	------	11	82	1
Other South America	1	13	1	------	2	------
Total	15	162	1	12	87	1
Europe:						
Belgium-Luxembourg	17	13	1	3	8	2
Denmark	------	(1)	------	11	------	------
France	1	4	------	23	35	------
Germany, West	20	12	------	980	5	------
Italy	9	15	------	------	8	1
Netherlands	34	3	------	(1)	4	------
Spain	------	------	------	50	------	------
Sweden	48	6	------	40	27	------
Switzerland	------	9	------	(1)	7	------
United Kingdom	(1)	15	------	150	9	------
Other Europe	------	1	2	------	1	1
Total	129	78	3	1,257	104	4
Asia:						
Indonesia	------	92	------	------	48	------
Israel	------	7	------	5	13	1
Japan	------	67	------	------	133	------
Kuwait	------	27	------	------	2	------
Taiwan	------	38	------	------	2	------
Other Asia	------	6	------	1	7	6
Total	------	237	------	6	205	7
Africa	------	10	------	2	7	------
Oceania	------	1	------	------	1	------
Grand total	207	834	11	1,601	776	12

[1] Less than 1 ton.

Japan.—Production of primary magnesium rose 50 percent above 1958. Most of the output was used in domestic plants for alloying other metals.[14]

Norway.—The one primary magnesium producer, Norsk-Hydro, announced plans to increase annual production capacity of the plant to approximately 15,000 short tons.[15] When this electrolytic plant was built in 1953, its annual capacity was rated at 12,000 short tons.

United Kingdom.—On January 1, 1959, Magnesium Elektron, Ltd., reduced the price of primary magnesium about 3 cents a pound, which

---

[14] American Metal Market, Japanese Magnesium Output Rose Sharply in Past 2 Years: Vol. 67, No. 47, Mar. 10, 1960, p. 9.

[15] Metal Bulletin (London), Norsk-Hydro Increasing Production: No. 4404, June 19 1959, p. 23.

TABLE 8.—World production of magnesium metal, by countries, in short tons[1]

[Compiled by Pearl J. Thompson and Berenice B. Mitchell]

Country	1950–54 (average)	1955	1956	1957	1958	1959
Canada	4,982	[2] 7,700	9,606	8,385	6,796	5,817
China	(3)	(3)	(3)	(3)	[2] 1,100	[2] 1,100
France	989	1,670	1,660	1,750	1,897	1,931
Germany, West [4]	[5] 154	144	194	260	208	214
Italy	956	3,161	4,097	4,162	4,607	[2] 4,630
Japan	[5] 23	[6] 148	[6] 86	[6] 472	[6] 1,106	[2] 1,655
Norway	[7] 1,942	7,433	8,185	9,504	10,226	[2] 10,250
Poland	[7] 61	103	158	150	[2] 165	[2] 165
Switzerland	231	-----	-----	-----	-----	-----
U.S.S.R.[2]	38,800	45,000	45,000	45,000	45,000	45,000
United Kingdom [4]	5,081	6,054	4,009	3,831	2,691	2,458
United States	65,046	61,135	68,346	81,263	30,096	31,033
World total (estimate) [1]	118,400	132,800	141,600	155,000	103,900	104,300

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Estimate.
[3] Data not available; estimates by author of chapter included in total.
[4] Primary metal and remelt alloys.
[5] As 1954 was the first year of commercial production, 1 year only.
[6] In addition, the following amounts of remelted magnesium were produced: 1955, 401 short tons; 1956, 897 short tons; 1957, 1,906 short tons; and 1958, 2,567 short tons.
[7] Average for 1951–54.

brought the average price to approximately 32 cents.[16] The 50th anniversary of the magnesium industry in the United Kingdom was noted in 1959 with a history of development progress.[17] In November, Alcan, Ltd. (United Kingdom), reduced the price of the primary metal to 28 cents a pound.[18]

TECHNOLOGY

New magnesium alloys with improved properties at elevated temperatures were developed in 1959.[19] Tests showed that alloys containing didymium had the highest yield strength to 560° F. of any known magnesium casting alloy.[20] A new alloy containing thorium and manganese had superior mechanical properties at 800° F.[21] Sheet rolled from this alloy and tempered by the producer did not require heat treatment during or after fabrication to develop maximum strength.[22] A patent was issued covering master alloys for use in preparing magnesium-base alloys containing manganese and zirconium.[23]

Work was reported on magnesium alloys for developing forgings of improved strength and creep resistance.[24]

---

[16] Metallurgia (London), Magnesium Prices: Vol. 59, No. 351, January 1959, p. 42.
[17] Light Metals (London), Elektron—Fifty Years: Vol. 22, No. 256, July-August-September, 1959, pp. 212–214.
[18] Metal Bulletin (London), Lower Prices in U.K.: No. 4443, Nov. 6, 1959, p. 22.
[19] Materials in Design Engineering, Three Magnesium Alloys for High Temperatures: Vol. 50, No. 2, August 1959, pp. 134, 136.
[20] Work cited in footnote 7.
[21] Iron Age, Die-Cast Alloy Takes Heat: Vol. 183, No. 23, June 4, 1959, p. 9.
[22] King, C. P., New Magnesium Alloy Improves Design of Ramjets: Modern Metals, vol. 15, No. 4, May 1959, pp. 58, 62, 64, 65.
[23] Whitehead, Derek J., and Emley, Edward F. (assigned to Magnesium Elektron, Ltd., Manchester, England), Alloying of Manganese and Zirconium to Magnesium: U.S. Patent 2,919,190, Dec. 29, 1959.
[24] Materials in Design Engineering, What's New in Materials: Vol. 50, No. 2, August 1959, p. 4.

Studies were reported of strain hardening associated with creep of magnesium single crystals at room temperature.[25] Properties of single crystals of high-purity magnesium containing nitrogen were studied.[26]

The Bureau of Mines continued studies at the Rolla (Mo.) Metallurgy Research Center to evaluate damping capacity and the relation of heat treatment to physical properties of magnesium alloys of commercial composition, and to develop new magnesium alloys with improved properties. The bureau developed a process to separate magnesium and cadmium from magnesium-cadmium alloys contained in surplus bomb bodies.[27]

Research indicated improvements in desulfurizing steel with magnesium.[28] Use of about 5 pounds of magnesium powder to 1 ton of steel reduced sulfur content, improving hot-ductility properties and toughness of the steel.[29]

Fabricators of parts for automotive equipment reported increased research to develop new applications for magnesium to replace heavier metals in such component parts as steering and gearshift mechanisms and oil and fuel pumps. Casting efficiency was increased by more careful control of metal loss through improved techniques in melting and pouring the metal and more accurate design and preparation of molds.[30] Improvements were reported in producing magnesium extrusions.[31]

New and improved materials and methods were developed for protecting the surface of magnesium-alloy structural parts. A clear anodize coating was developed for use under lacquer or varnish.[32] A simplified process of nickel-plating magnesium was described.[33] Enamel coatings for magnesium were developed, which provided excellent corrosion resistance.[34] Magnesium was electroplated with tin for use in fabricating electronic housings.[35]

Reports were published covering studies to develop methods of using magnesium powder for fuel in rockets and missiles, in which the high combustion temperature of magnesium was evaluated for use in raising the temperature of missile propellants.[36]

---

[25] Conrad, H., Effect of Changes in Slip Direction on the Creep of Magnesium Crystals: Trans. AIME, vol. 215, No. 1, February 1959, pp. 58–63.

[26] Geiselman, D., and Guy, A. G., Yield Phenomena in Magnesium Single Crystals Containing Nitrogen: Trans. AIME, vol. 215, No. 5, October 1959, pp. 814–820.

[27] Caldwell, H. S., Jr., and Spendlove, M. J., Recovery of Magnesium and Cadmium from Incendiary Alloys by Vacuum Distillation: Bureau of Mines Rept. of Investigations 5476, 1959, 17 pp.

[28] Brooks, W. B., Doumas, A. C., and Romefelt, B. W., Treat Steel with Magnesium to Ease Sulfur Problem: Iron Age, vol. 185, No. 6, Feb. 11, 1960, pp. 148–149.

[29] Steel, Alloy and Technique Control Structure of Ductile Iron: Vol. 145, No. 13, Sept. 28, 1959, p. 137.

[30] Bennett, Foster C., Achieving Metal Efficiency in Magnesium Casting Operation: Foundry, vol. 87, No. 12, December 1959, pp. 152–154, 156–157.

[31] Modern Metals, Precision by Switching to Magnesium Extrusions: Vol. 15, No. 4, May 1959, p. 68.

[32] Materials in design Engineering, Clear Anodize Applied Quickly to Magnesium: Vol. 49, No. 2, February 1959, pp. 152, 155.

[33] Electronic News, Electroless Means of Nickel-Plating Magnesium Developed: Vol. 4, No. 151, June 29, 1959, p. 31.

[34] Stradley, N. H., Porcelain Enamels for Aluminum and Magnesium: Bull. Am. Ceram. Soc., vol. 38, No. 8, August 1959, pp. 401–404.

[35] Materials in Design Engineering, Tin-Plated Magnesium Is Easy to Solder: Vol. 50, No. 4, October 1959, pp. 188, 190.

[36] Metal Progress, Metal Powders for Missile Fuels: Vol. 76, No. 1, July 1959, pp. 134, 136, 138, 140.

Magnesium Compounds

By H. B. Comstock[1] and Jeannette I. Baker[2]

◆

IMPROVEMENTS in technology and production techniques encouraged wider uses of magnesium compounds in the United States in 1959. Other countries expanded their magnesia research facilities. The production of magnesia from sea water continued to rise. Stronger world trade in magnesium compounds was indicated by increases in imports and exports.

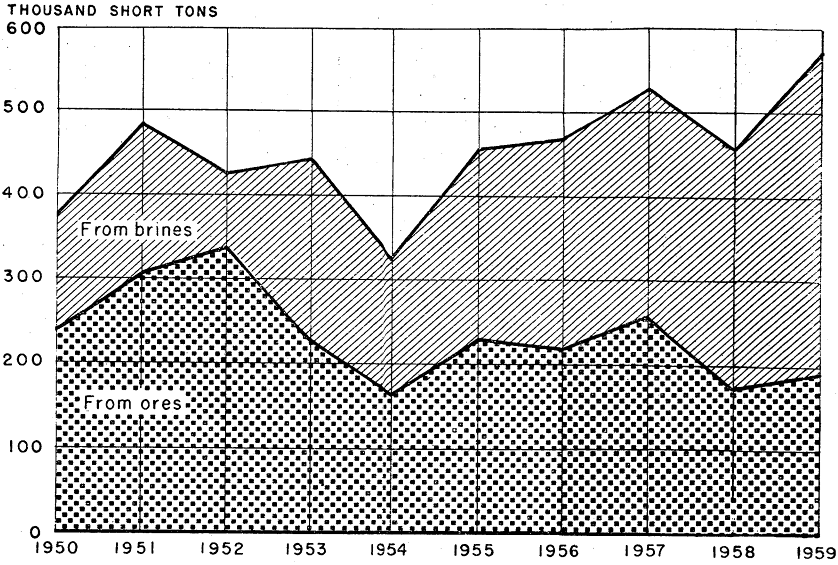

FIGURE 1.—Domestic production of magnesia from ores and brines 1950–59.

DOMESTIC PRODUCTION

Mines and plants producing magnesium compounds in the United States are listed in table 2 of the Magnesium Compounds chapter of the Minerals Yearbook, 1958. However, Keasbey & Mattison Co., Ambler, Pa., had discontinued production by the end of 1958, and Jones & Laughlin Steel Corp., Millville, W. Va., ceased dead-burning dolomite early in 1959. One new plant, which began producing, is discussed under "Magnesia." The mining of magnesite ore increased 20 percent above 1958, but the value was lower. Basic, Inc., continued expansion begun in 1958 at its refractories plant at Gabbs, Nev.

---

[1] Commodity specialist.

[2] Research assistant.

TABLE 1.—Salient statistics of magnesite, magnesia, and dead-burned dolomite

(Thousand short tons and thousand dollars)

	1950-54 (average)	1955	1956	1957	1958	1959
United States:						
Crude magnesite:						
Domestic production:						
Quantity	[1] 489	[1] 486	[2] 687	[2] 678	[2] 493	[2] 594
Value [3]	$3,017	$2,713	$2,502	$3,258	$2,409	$2,401
Caustic-calcined magnesia sold or used by producers:						
Quantity	42	36	36	61	45	54
Value [4]	$3,773	$2,241	$2,426	$3,161	$2,648	$3,533
Imports—value	$106	$144	$350	$265	$115	$264
Exports—value	(7)	$1,376	$1,501	$4,033	[5] $844	[5] $667
Refractory magnesia sold or used by producers:						
Quantity	368	419	431	468	415	518
Value	$17,897	$20,305	$22,663	$26,319	$23,375	$31,458
Imports—value	$2,000	$6,729	$6,093	$4,033	[6] $5,095	$9,606
Exports—value	(7)	$507	$451	$1,436	[5] $2,838	[5] $5,167
Dead-burned dolomite sold or used by producers:						
Quantity	1,894	2,129	2,424	2,251	1,659	1,988
Value	$25,523	$31,425	$37,745	$35,871	$27,378	$33,069
Imports—value	$189	$558	$587	$640	$322	$498
World production, crude magnesite:						
Quantity	4,200	4,700	5,450	5,600	6,000	6,150

[1] Includes crude ore, heavy-medium concentrate, and flotation concentrate.

[2] All run-of-mine material.

[3] Partly estimated: most of the crude is processed by mining companies, and very little enters the open market.

[4] Includes specialty magnesia of high unit value.

[5] Owing to changes in classification by the Bureau of the Census, data for individual classes not strictly comparable with years before 1958: however, combined values of caustic-calcined and refractory magnesias are comparable.

[6] Revised figure.

Not available.

TABLE 2.—Magnesia sold or used by producers in the United States, by kinds and sources

Magnesia	From magnesite, brucite, and dolomite		From well brines, raw sea water, and sea-water bitterns [1]		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1958						
Caustic-calcined	12,836	$277	31,785	$2,371	44,621	$2,648
Refractory	161,767	7,420	253,107	15,955	414,874	23,375
Total	174,603	7,697	284,892	18,326	459,495	26,023
1959						
Caustic-calcined	16,039	719	38,054	2,814	54,093	3,533
Refractory	176,055	8,134	341,886	23,324	517,941	31,458
Total	192,094	8,853	379,940	26,138	572,034	34,991

[1] Magnesia made from a combination of dolomite and sea water is included with that from sea water.

Magnesia.—Michigan Chemical Co. completed its new plant to produce magnesia from sea water and calcined oystershell at Port St. Joe, Fla. The plant began producing in August.

H. K. Porter Co., Inc., began producing chrome-magnesite and magnesite-chrome brick, using periclase made at its Pascagoula, Miss., refractories plant adjoining its sea-water magnesia facility completed in 1958.

At Midland, Mich., Kaiser Aluminum and Chemical Corp. began constructing a plant to produce periclase from magnesium hydroxide supplied by The Dow Chemical Co. from deep brine wells.[3] Initial annual production capacity of the plant was 45,000 tons, which Kaiser planned to use in making basic brick at its refractories plant at Columbiana, Ohio.

Dolomite.—Alabama Metallurgical Corp. began to mine magnesium-rich dolomite near Selma, Ala., for use in producing metal at its magnesium plant there.

TABLE 3.—Dead-burned dolomite sold in and imported into the United States

Year	Sales of domestic product		Imports [1]	
	Short tons	Value (thousands)	Short tons [2]	Value (thousands)
1950–54 (average)	1,893,919	$25,523	3,098	$189
1955	2,128,960	31,425	7,993	558
1956	2,423,909	37,745	9,031	587
1957	2,251,428	35,871	10,419	640
1958	1,659,184	27,378	5,686	322
1959	1,987,767	33,069	8,474	498

[1] Dead-burned basic refractory material comprising chiefly magnesium and lime.

[2] Includes weight of immediate container.

Brucite.—Basic, Inc., the only producer of brucite in the United States, increased its output to about six times that of 1958.

Olivine.—Production of olivine was more than twice the 1958 output.

Other Magnesium Compounds.—Total production of specified magnesias, U.S.P. and technical grades, both light and heavy, increased 11 percent over 1958. Production of magnesium chloride rose slightly above 1958.

CONSUMPTION AND USES

Consumption of all magnesium compounds except magnesium sulfate and precipitated magnesium carbonate increased above 1958. A 43-percent rise in consumption of magnesium hydroxide was due primarily to its increased use in refractories.

---

[3] Brick & Clay Record, Kaiser Expands Magnesia Operations: Vol. 134, No. 6, June 1959, pp. 58, 83.

Although production of steel was discontinued for several weeks in 1959, consumption of refractory magnesia increased 25 percent and that of dead-burned dolomite 20 percent. The conversion from silica brick to basic brick in roofs of steel furnaces continued.

TABLE 4.—Specified magnesium compounds produced, sold, and used by producers in the United States

Products [1]	Plants	Produced (short tons)	Sold		Used (short tons)
			Short tons	Value (thousands)	
1958					
Specified magnesias (basis, 100 percent MgO), U.S.P. and technical:					
Extra-light and light	6	1,833	1,954	$1,043	----------
Heavy	4	20,133	18,359	2,178	1,799
Total	[2] 8	21,966	20,313	3,221	1,799
Precipitated magnesium carbonate	7	25,696	7,224	1,342	18,687
Magnesium hydroxide, U.S.P. and technical (basis, 100 percent Mg $(OH)_2$)	5	213,115	65,062	1,915	129,641
Magnesium chloride	[3] 6	130,176	13,493	744	[4] 120,000
1959					
Specified magnesias (basis, 100 percent MgO), U.S.P. and technical:					
Extra-light and light	5	2,558	2,403	1,373	----------
Heavy	3	21,750	21,491	2,660	300
Total	[2] 6	24,308	23,894	4,033	300
Precipitated magnesium carbonate	5	22,278	6,850	1,449	15,479
Magnesium hydroxide, U.S.P. and technical (basis, 100 percent Mg $(OH)_2$)	5	298,406	111,101	2,886	166,444
Magnesium chloride	7	133,289	17,478	941	[4] 117,000

[1] In addition, magnesium phosphate, nitrate, sulfate, and trisilicate were produced.
[2] A plant producing more than 1 grade is counted but once in arriving at total.
[3] Revised figure.
[4] Greater part used for magnesium metal.

TABLE 5.—Domestic consumption of caustic-calcined magnesia (percent) by uses

Use	1955	1956	1957	1958	1959
Oxychloride and oxysulphate cement	34	32	30	50	49
Rayon	4	3	1	2	2
Fertilizer	1	2	(1)	(1)	(1)
85 percent MgO insulation	11	10	6	10	4
Rubber	3	8	2	4	1
Fluxes	(1)	(1)	(1)	(1)	(1)
Refractories	4	-------	29	(1)	1
Chemical processing	-------	-------	-------	[2] 2	2
Uranium processing	-------	-------	-------	[2] 6	9
Miscellaneous (including chemicals and paper industry)	43	45	32	26	32
Total	100	100	100	100	100

[1] Less than 1 percent.
[2] Previously included with miscellaneous.

TABLE 6.—Domestic consumption of U.S.P. and technical-grade magnesias (percent) by uses

Use	1955	1956	1957	1958	1959
Rayon	16	8	17	18	17
Rubber (filler and catalyst)	27	9	18	12	11
Refractories	15	42	11	11	14
Medicinal	7	1	3	(1)	(1)
Uranium processing	2	3	4	5	1
Fertilizer			(1)	1	1
Electrical				[2] 21	14
Neoprene compounds				[2] 2	
Oxychloride and oxysulfate cement					[2] 7
Miscellaneous	33	37	47	30	35
Total	100	100	100	100	100

[1] Less than 1 percent.
[2] Previously included with miscellaneous.

PRICES

The few changes in prices and net sales values of magnesium compounds follow:

On January 1 the price of Synthetic Rubber grade calcined magnesia decreased from 29.75–30.5 cents to 28.75–30 cents a pound. The price of Technical grade magnesium carbonate increased from 10.5 to 11 cents, and that of U.S.P. grade increased from 13 to 13.5 cents a pound.[4]

The price of dead-burned grain magnesite decreased from $52–$54 to $52 a ton on January 15.[5] On November 9, the price of Heavy U.S.P. grade calcined magnesia decreased from 45–52 cents to 36.5–37.5 cents a pound.[6] The average net sales value of S–90, kiln-run, 90-percent periclase increased from $60 to $62.50 a ton in 1959.

FOREIGN TRADE[7]

Imports of calcined and refractory grades of magnesia were nearly double those in 1958. The receipt of 20,259 tons from Greece represented the first deliveries from that country since 1951. Italy, after a 2 years' lapse, shipped 4,479 tons to the United States. Total imports of other magnesium compounds increased 27 percent over 1958.

The tariff on crude magnesite, based on the Geneva Agreement of 1947, remained at $^{15}/_{64}$ cent per pound, an ad valorem equivalent of 10.75 percent. Duty on dead-burned and grain magnesite and periclase was $^{23}/_{60}$ cent per pound, an ad valorem equivalent of 11.99 percent, and on caustic-calcined magnesia, $^{15}/_{32}$ cent per pound, an ad valorem equivalent of 18.83 percent. Duty on magnesium oxide was $2\frac{1}{2}$ cents per pound, an ad valorem equivalent of 19.09 percent. Duty on dead-burned dolomite was 15 percent ad valorem.

Exports of magnesite, magnesia, and manufactures (except refractories) were valued at $5,834,000—a 57-percent increase above the 1958 figure of $3,721,000.

---

[4] Oil, paint, and Drug Reporter, vol. 175, No. 1, Jan. 5, 1959, pp. 35–36.
[5] E&MJ Metal & Mineral Markets, vol. 30, No. 3, Jan. 15, 1959, p. 11.
[6] Oil, Paint, and Drug Reporter, vol. 176, No. 20, Nov. 9, 1959, p. 21.
[7] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 7.—Crude and processed magnesite imported for consumption in the United States, by countries

[Bureau of the Census]

Country	1958		1959	
	Short tons	Value	Short tons	Value
CRUDE MAGNESITE				
Europe: Netherlands			34	$1,482
Asia: India	11	$340		
Total	11	340	34	1,482
LUMP OR GROUND CAUSTIC-CALCINED MAGNESIA				
Europe:				
Austria	66	$2,623	267	$9,813
Greece			5	255
Netherlands	529	29,814	661	35,458
United Kingdom	24	5,596	62	8,146
Yugoslavia	882	33,659	1,323	46,723
Total	1,501	71,692	2,318	100,395
Asia: India	895	43,103	2,980	163,343
Grand total	2,396	114,795	5,298	263,738
DEAD-BURNED AND GRAIN MAGNESIA AND PERICLASE				
North America: Canada	814	$197,020	1,052	$245,023
Europe:				
Austria	41,251	2,743,458	68,847	4,380,511
Germany, West	2,756	158,675		
Greece			20,254	1,576,835
Italy			4,479	329,184
Switzerland	8,642	604,969	11,244	753,329
Trieste	[1] 9,611	[1] 670,449		
United Kingdom			15,829	968,842
Yugoslavia	16,203	720,405	28,597	1,352,496
Total	[1] 78,463	[1] 4,897,956	149,250	9,361,197
Grand total	[1] 79,277	[1] 5,094,976	150,302	9,606,220

---

[1] Revised figure.

TABLE 8.—Magnesium compounds imported for consumption in the United States

[Bureau of the Census]

Year	Oxide or calcined magnesia		Magnesium carbonate precipitated		Magnesium chloride (anhydrous and n.s.p.f.)		Magnesium sulfate (epsom salt)		Magnesium salts and compounds, n.s.p.f.[1]		Manufactures of carbonate of magnesia	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1950-54 (average)	1	$99	212	$59,472	117	$3,852	5,100	[2] $122,459	310	$67,044	23	$7,066
1955	113	[2] 48,598	282	[2] 58,763	220	5,999	11,613	260,275	108	[2] 17,369	21	5,135
1956	197	[2] 58,507	264	63,771	350	9,421	11,101	[2] 256,455	1,508	107,435	3	1,730
1957	412	152,395	307	59,638	431	11,778	10,570	248,948	839	33,867	23	3,769
1958	355	119,012	326	66,174	685	28,038	9,908	238,236	1,202	52,814	1	660
1959	273	71,498	351	93,721	949	28,114	12,350	302,036	1,925	66,096	1	830

[1] Includes magnesium silicofluoride or fluosilicate and calcined magnesia
[2] Data known to be not comparable with other years.

TABLE 9.—Magnesite and magnesia exported from the United States, by countries

[Bureau of the Census]

Country	Magnesite and magnesia, dead-burned				Magnesite and magnesia (except dead-burned), and manufactures, n.e.c.	
	1958		1959		1958	1959
	Short tons	Value	Short tons	Value	Value	Value
North America:						
Canada	1,615	$230,213	7,053	$605,425	$236,144	$293,178
Cuba	--------	--------	10	1,630	80,499	16,315
Honduras	--------	--------	--------	--------	21,987	4,300
Mexico	8,185	531,962	8,786	653,533	24,934	20,071
Other North America	5	604	--------	--------	30,262	50,538
Total	9,805	762,779	15,849	1,260,588	393,826	384,402
South America:						
Argentina	3	1,996	3	1,996	32,435	--------
Brazil	--------	--------	--------	--------	105,035	21,135
Chile	80	7,589	459	31,029	25,797	4,839
Venezuela	10	1,910	--------	--------	46,143	39,630
Other South America	20	2,160	597	43,365	26,204	17,731
Total	113	13,655	1,059	76,390	235,614	83,335
Europe:						
Denmark	22	14,591	58	38,629	--------	--------
France	5	961	30	4,041	22,498	17,651
Germany, West	247	38,065	248	56,777	1,463	--------
Spain	57	41,164	3	2,096	14,306	--------
Sweden	7	4,537	16	10,496	15,078	6,262
Switzerland	3	2,233	6	4,087	2,029	778
United Kingdom	32	20,209	99	59,722	--------	10,189
Other Europe	10	7,689	17	7,806	16,262	9,076
Total	383	129,449	477	183,654	71,636	43,956
Asia:						
Japan	42,736	1,891,344	68,160	3,545,001	50,062	47,802
Korea, Republic of	--------	--------	665	36,760	27,155	1,015
Philippines	--------	--------	--------	--------	31,750	17,088
Other Asia	50	3,125	--------	--------	12,411	30,360
Total	42,786	1,894,469	68,825	3,581,761	121,378	96,265
Africa:						
Belgian Congo	--------	--------	--------	--------	57,912	35,068
Mozambique	--------	--------	--------	--------	--------	19,018
Union of South Africa	7	4,719	6	4,256	3,312	5,421
Total	7	4,719	6	4,256	61,224	59,507
Oceania: Australia	47	32,621	[1]87	[1]60,162	--------	--------
Grand total	53,141	2,837,692	86,303	5,166,811	883,678	667,465

[1] Includes New Zealand: 15 tons, $10,645.

WORLD REVIEW

Although the rise in world production of crude magnesite was negligible, increased exports to the United States of caustic-calcined and dead-burned ore from several countries in Europe indicated progress in technology.

Austria.—The Austrian industry reported weakened export markets due to competition from new producers of magnesite ore, particularly Yugoslavia, and increasing production of magnesia from sea water.[8]

---

[8] Metal Bulletin (London), Austrian Domestic Price Rise?: No. 4452, Dec. 8, 1959, p. 28.

However, imports of dead-burned magnesite to the United States from Austria increased more than 60 percent.

Canada.—Canadian Refractories, Ltd., expanded laboratory facilities at Marelan, Quebec, for continued research on refractories obtained from magnesite.[9]

TABLE 10.—World production of magnesite, by countries,[1] in short tons[2]

[Compiled by Liela S. Price and Berenice B. Mitchell]

Country [1]	1950–54 (average)	1955	1956	1957	1958	1959
North America: United States	489,494	486,088	686,569	678,489	492,982	594,307
Total [1] [3]	810,000	720,000	990,000	970,000	740,000	880,000
South America:						
Brazil [3]	11,000	11,000	11,000	11,000	3,000	3,000
Venezuela	660	----------	----------	----------	----------	----------
Total [3]	11,660	11,000	11,000	11,000	3,000	3,000
Europe:						
Austria	794,178	1,093,173	1,194,502	1,292,567	1,346,133	1,324,106
Bulgaria	63,339	124,561	155,536	[3] 154,300	[3] 165,350	[3] 165,350
Czechoslovakia	[3] 214,950	(4)	(4)	(4)	(4)	(4)
Germany, West	289	----------	----------	----------	----------	----------
Greece	83,170	66,980	68,350	52,392	97,742	121,254
Italy	1,637	4,527	5,448	8,512	6,500	7,562
Norway	1,647	874	1,124	----------	----------	----------
Poland	[3] 22,597	21,639	18,673	18,850	15,432	[3] 15,000
Spain	17,304	29,973	26,891	40,455	38,442	[3] 55,000
Yugoslavia	105,557	129,114	214,260	233,983	246,032	269,851
Total [1] [3]	2,940,000	3,300,000	3,600,000	3,700,000	3,800,000	3,800,000
Asia:						
India	94,667	64,410	102,717	99,552	110,880	174,129
Korea, Republic of	73	----------	----------	----------	----------	----------
Turkey	719	----------	937	1,439	717	----------
Total [1] [3]	320,000	530,000	730,000	780,000	1,270,000	1,330,000
Africa:						
United Arab Republic (Egypt Region)	206	----------	----------	----------	----------	----------
Kenya	40	----------	----------	117	551	3,145
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	11,303	11,610	8,611	2,910	----------	----------
Tanganyika (exports)	647	367	272	284	337	118
Union of South Africa	22,538	19,753	33,485	35,414	80,200	58,883
Total	34,734	31,730	42,368	38,725	81,088	62,146
Oceania:						
Australia	46,191	64,595	72,447	93,490	77,695	[3] 71,650
New Zealand	613	434	818	675	1,344	[3] 1,300
Total	46.804	65,029	73,265	94,165	79,039	[3] 72,950
World total (estimate) [1] [2]	4,200,000	4,700,000	5,450,000	5,600,000	6,000,000	6,150,000

[1] Quantities in this table represent crude magnesite mined. Magnesite is also produced in Canada, China, Mexico, North Korea, and U.S.S.R., but data on tonnage of output are not available; estimates by senior author of chapter included in total.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Estimate.

[4] Data not available; estimate by senior author of chapter included in total.

---

[9] Brick & Clay Record, Canadian Refractories, Ltd., Opens New Research Lab.: Vol 135, No. 3, September 1959, pp. 66–67.

TABLE 11.—Exports of magnesia and magnesite brick, from Austria, by countries of destination, in short tons[1] [2]

[Compiled by Corra A. Barry]

Country	Magnesia				Magnesite brick	
	Caustic-calcined		Refractory			
	1958	1959	1958	1959	1958	1959
North America: United States	98	274	31,207	87,229	154	-----
South America:						
Argentina	70	-----	2,329	1,594	9,624	2,670
Brazil	9	13	-----	10	212	495
Chile	-----	-----	193	347	836	825
Peru	-----	-----	134	1,216	374	218
Venezuela	43	55	377	17	2,028	1,009
Europe:						
Belgium-Luxembourg	131	205	701	1,209	8,940	5,979
Bulgaria	-----	-----	40	154	774	658
Czechoslovakia	5,176	4,895	169	228	296	104
Denmark	109	126	471	1,108	4,589	1,875
Finland	-----	1	336	322	2,946	1,346
France	3,979	2,864	12,351	9,644	43,704	17,151
Germany, West	73,018	81,903	53,462	48,046	46,813	29,125
Greece	-----	-----	272	149	1,903	577
Hungary	1,391	1,314	5,800	5,784	-----	-----
Italy	3,331	3,364	9,655	12,354	17,854	7,368
Netherlands	21	1	98	116	5,072	1,071
Norway	-----	-----	333	153	2,294	1,051
Poland	-----	-----	1,422	-----	4,518	780
Rumania	-----	-----	-----	33	1,531	390
Saar	-----	-----	402	-----	6,096	-----
Spain	-----	-----	103	157	2,008	1,979
Sweden	83	122	741	887	10,736	7,173
Switzerland	2,301	2,183	728	712	1,542	1,761
United Kingdom	-----	2	13,221	2,594	5,005	4,436
Asia:						
India	-----	-----	442	597	6,581	545
Japan	-----	19	9,190	13,013	282	-----
Korea, Republic of	-----	-----	470	367	-----	628
Turkey	22	-----	162	483	2,585	3,943
Africa:						
Belgian-Congo	8	13	43	38	651	171
United Arab Republic (Egypt Region)	11	39	58	74	1,051	871
Oceania: Australia	-----	-----	220	80	6,880	2,267
Other countries	269	95	1,314	1,110	9,149	8,817
Total	90,070	97,488	146,444	189,825	207,028	105,283

[1] Compiled from Customs Returns of Austria.
[2] This table incorporates some revisions.

TABLE 12.—Exports of magnesite and calcined magnesia from Greece, by countries of destination, in short tons[1] [2]

[Compiled by Corra A. Barry]

Country	Crude magnesite		Calcined magnesia	
	1958	1959	1958	1959
Austria	7,743	-----	-----	-----
France	6,100	3,858	(3)	1,123
Germany:				
East	5,192	5,921	-----	-----
West	-----	-----	10,096	9,975
Italy	2,083	4,795	-----	-----
Netherlands	1,682	1,942	15,370	17,806
United Kingdom	-----	-----	3,491	4,398
Other countries	2,276	1,453	2,199	474
Total	25,076	17,969	31,156	33,776

[1] Compiled from Customs Returns of Greece.
[2] This table incorporates some revisions.
[3] Data not available.

TABLE 13.—Exports of refractory magnesia from the Netherlands, by countries of destination, in short tons [1][2]

[Compiled by Corra A. Barry]

Country	1958	1959	Country	1958	1959
Argentina	80	294	Saar	152	(3)
Belgium-Luxembourg	596	740	Sweden	888	845
Chile	--------	140	Union of South Africa	99	106
Denmark	665	685	United Kingdom	2,997	4,082
Finland	320	455	United States	629	708
France	259	482	Venezuela	147	57
Germany, West	5,675	5,950	Other countries	107	499
Norway	199	181			
Portugal	150	131	Total	12,963	15,355

[1] Compiled from Customs Returns of the Netherlands.
[2] This table incorporates some revisions.
[3] Data not available.

Pakistan.—Large deposits of magnesium-rich brine, similar to the Michigan brines in the United States, were discovered at Dhariala in the Jhelum district of Pakistan.[10]

United Kingdom.—Steetly Co., Ltd., reported that improvements in equipment and techniques at its Hartlepool magnesia plant had freed refractory-brick makers from previous export restrictions on their basic brick products.[11] This report covered 10 years of research.

Yugloslavia.—Active prospecting and exploration resulted in the discovery of new magnesite deposits.[12]

TECHNOLOGY

Improved magnesium hydroxide in a 60-percent concentration was developed for use in the paper industry. Formerly, 52 percent was the most concentrated form prepared for this purpose.[13]

Investigations showed the advantages of using magnesium sulfate in nickel baths to plate other metals.[14] Nickel baths held their metallic concentration better, and corrosion resistance of the nickel deposits was improved when $MgSO_4$ was added.

A report described research, sponsored by the U.S. Army Signal Corps, to develop a magnesium oxide cold cathode for use in electron tubes of various types.[15] Reproducible cathodes of good quality were obtained. Operation of the cathodes was immediate and efficient, and operating life of the tubes was increased.

---

[10] Canadian Mining Journal, Brine Deposits in Pakistan: Vol. 80, No. 8, August 1959, p. 127.

[11] Rock Products, Dolomite Unlocks Strategic Magnesia from Sea Water: Vol. 62, No. 10, October 1959, pp. 98–99, 102.

[12] Mining World, Active Prospecting and Detailed Exploration: Vol. 21, No. 12, November 1959, p. 7.

[13] Chemical Engineering, Magnesium Hydroxide: Vol. 66, No. 13, June 29, 1959, p. 68.

[14] Geneidy, Ahmad, Koehler, W. A., and Machu, Willi, The Effect of Magnesium Salts on Nickel Plating: Jour. Electrochem. Soc., vol. 106, No. 5, May 1959, pp. 394–403.

[15] Skellett, A. M., Firth, B. G., and Mayer, D. W., The Magnesium Oxide Cold Cathode and Its Application in Vacuum Tubes: IRE Proc., vol. 47, October 1959, pp. 1704–1712.

Tests by Harbison-Walker Refractories Co. to determine mineralogical changes in basic refractory brick used in copper converters showed that erosion of the brick during service was caused more by mechanical failure than by chemical attack.[16]

Improvements in design and construction of basic-refractory roofs of steel furnaces were discussed.[17] Service tests showed that the life of the basic-refractory sprung-arch and suspended roofs was longer than that of the silica roofs in steel furnaces subjected to the high temperatures associated with the use of oxygen to reduce carbon.

Investigations were conducted at Bilston, near Birmingham, to develop stronger basic brick.[18] Tests covered temperatures up to 1800° C.

Resistance of dead-burned dolomite to moisture was studied to evolve a method of measuring accurately the adverse effect of hydration upon the refractory qualities of dead-burned dolomite.[19]

---

[16] Clark, C. Burton, and McDowell, J. Spotts, Basic Brick in Copper Converters: Jour. Metals, vol. 11, No. 2, February 1959, pp. 119–124.

[17] Refractories Journal, Basic Refractories in Sprung Arch Construction: No. 1, January 1960, pp. 19–20.

[18] Richardson, H. M., Fitchett, K., and Lester, M., Bond Structure and the Behavior of Basic Bricks at High Temperatures: Refractories Jour., No. 12, December 1959, p. 352.

[19] Keim, Owen, A Study of the Hydration Resistance of Granular Dead-burned Dolomite: Bull. Am. Ceram. Soc., vol. 38, No. 7, July 1959, pp. 369–373.

Manganese

By Gilbert L. DeHuff[1] and Teresa Fratta[2]

THE GOVERNMENT'S domestic manganese-purchase program ended with termination of the carlot program in 1959. This was reflected in the production of only 229,000 short tons of manganese ore, concentrate, and nodules. In spite of the 1959 steel strike, domestic consumption of ore, 1.6 million short tons, was greater than in 1958. Imports from Brazil in 1959 accounted for more than 40 percent of the year's total ore imports.

LEGISLATION AND GOVERNMENT PROGRAMS

Financial participation in the exploration for domestic manganese deposits was continued by the Office of Minerals Exploration (OME) at 50 percent of approved exploration costs.

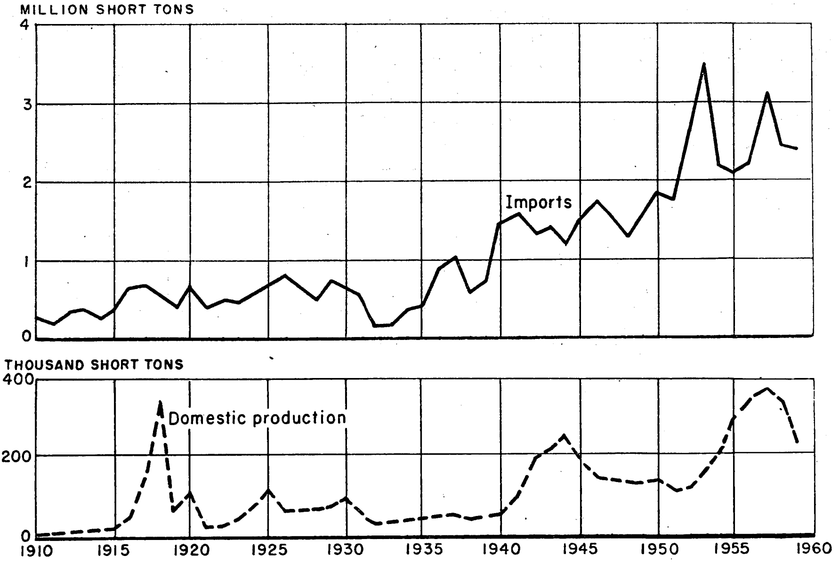

Figure 1.—General imports and domestic production (shipments) of manganese ore, 1910–59.

---

[1] Commodity specialist.
[2] Statistical assistant.

August 5 was the last date for new commitments on the Government's carlot domestic manganese purchase program, and the program was virtually finished by the end of September. As of December 31, 1959, 28,069,900 long-ton units of contained manganese, valued at $71,400,000, had been acquired in the carlot program since it began in July 1952.

A revision, P–30a–R1 of May 18, 1959, of the National Stockpile Purchase Specification for standard ferromanganese required that the alloy be "from slabs not less than 8 inches thick which have been allowed to cool slowly." The following chemical requirements were established:

		Percent by weight
Manganese		74. 00–77. 50
Carbon	maximum	7. 50
Silicon	do	1. 00
Phosphorus	do	. 25
Arsenic	do	. 20
Phosphorus plus arsenic	do	. 35
Sulfur	do	. 05
Iron (by analysis)	minimum	14. 00

Both manganese ore and ferromanganese continued to be important among the strategic materials to be exchanged for surplus U.S. agricultural products in the barter program of Commodity Credit Corp., U.S. Department of Agriculture.

DOMESTIC PRODUCTION

Purchases by the Government of domestic Metallurgical-grade material under the carlot program and under special contracts for Nevada nodules accounted for most of the 1959 domestic production of maanganese ore containing 35 percent or more manganese. Ship-

TABLE 1.—Salient statistics of manganese in the United States, gross weight in short tons

	1950–54 (average)	1955	1956	1957	1958	1959
Manganese ore (35 percent or more Mn):						
Production (shipments):						
Metallurgical ore	130, 107	275, 544	341, 291	364, 227	[1] 327, 309	223, 139
Battery ore	13, 582	11, 711	3, 444	2, 107	(2)	6, 011
Miscellaneous ore	12	----------	----------	----------	----------	24
Total shipments [3]	143, 701	287, 255	344, 735	366, 334	[1] 327, 309	229, 174
Value (thousands)	$9, 637	$21, 651	$26, 990	$29, 363	[1] $23, 637	$17, 903
General imports	2, 387, 593	2, 078, 205	2, 238, 568	3, 105, 172	2, 452, 578	2, 397, 804
Consumption	1, 857, 723	2, 109, 623	2, 264, 159	2, 361, 460	1, 497, 574	1, 603, 429
Manganiferous ore (5 to 35 percent Mn):						
Production (shipments)	1, 013, 266	911, 636	680, 651	865, 127	520, 601	470, 271
Value (thousands)	$4, 998	$5, 128	$3, 984	$5, 413	$3, 532	$3, 146
Ferromanganese:						
Domestic production	779, 183	869, 977	923, 012	963, 814	636, 736	629, 307
Imports for consumption	95, 419	65, 121	160, 203	338, 079	63, 932	90, 062
Exports	1, 102	1, 789	2, 248	7, 395	1, 406	947
Consumption	820, 766	934, 451	945, 210	935, 725	674, 495	756, 440

[1] Revised figure.

[2] Battery ore included in metallurgical.

[3] Shipments are used as the measure of manganese production for compiling U.S. mineral-production value. They are taken at the point where the material is considered to be in marketable form from the consumer's standpoint.

ments under the carlot program from Western States totaled 124,000 short tons, 15 percent more than in 1958. Arkansas, Georgia, Tennessee, and Virginia also contributed to the program.

Arizona, with shipments from more than 80 mines, was the leading manganese-ore-producing State, exceeding Nevada which had held that position for 4 years. Manganese, Inc., with its production of metallurgical nodules containing 45 percent manganese from the oxide ore of the Three Kids deposit, gave Nevada second place. A strike during much of the latter half of the year curtailed operations of The Anaconda Co. at Butte, Mont. Taylor-Knapp Co. and Trout Mining Division, American Machine and Metals, Inc., both in Montana's Philipsburg district, were the Nation's only producers of natural Battery-grade ore or concentrate. The ammonium carbamate leach process was still used by Manganese Chemicals Corp., Riverton, Minn., to produce synthetic battery ore and synthetic miscellaneous ore from low-grade Cuyuna range material.

Commercial shipments of low-grade manganese ores containing 10 to 35 percent manganese were made from Arizona, Georgia, Minnesota, Montana, New Mexico, Tennessee, and Virginia. Minnesota was the only shipper of manganiferous iron ore containing 5 to 10 percent manganese.

CONSUMPTION, USES, AND STOCKS

Despite the steel strike from July 15 to November 6, U.S. consumption of manganese ore increased 7 percent over 1958. Domestic sources supplied less than 1 percent of the manganese ore consumed,

TABLE 2.—Metallurgical manganese ore,[1] ferruginous manganese ore,[2] and manganiferous iron ore,[3] shipped in the United States, by States, gross weight in short tons

State	1958			1959		
	Metallurgical manganese ore	Ferruginous manganese ore	Manganiferous iron ore	Metallurgical manganese ore	Ferruginous manganese ore	Manganiferous iron ore
Arizona	62, 279	1, 455		68, 183	10, 693	
Arkansas	22, 221			17, 742		
California	17, 644			19, 354		
Colorado	210			1, 218		
Georgia	(4)	(4)		1, 547	(4)	
Michigan			112, 536			
Minnesota		50, 289	320, 314		122, 736	306, 366
Montana	[5] 53, 123	(4)		15, 569	2, 415	
Nevada	127, 322			56, 586		
New Mexico	[6] 28, 866	(4)		27, 528	(4)	
Tennessee	5, 935			7, 586	[7] 56	
Utah	1, 043			1, 511		
Virginia	8, 128	56		6, 232	(4 7)	
Washington				83		
Undistributed [8]	538	35, 951			28, 005	
Total	[6] 327, 309	87, 751	432, 850	223, 139	163, 905	306, 366

[1] Containing 35 percent or more manganese (natural).
[2] Containing 10 to 35 percent manganese (natural).
[3] Containing 5 to 10 percent manganese (natural).
[4] Included with "Undistributed."
[5] Includes battery ore.
[6] Revised figure.
[7] All miscellaneous ore.
[8] Includes shipments of metallurgical manganese ore from Missouri in 1958 and tonnages indicated by footnote 4.

TABLE 3.—Manganese and manganiferous ores shipped[1] in the United States in 1959, by States

	Short tons		Value (thousands)
	Gross weight	Manganese content	
Manganese ore:[2]			
Arizona	68,183	28,260	$5,727
Arkansas	17,742	6,714	1,398
California	19,354	8,095	1,663
Colorado	1,218	510	102
Georgia	1,547	622	(3)
Montana	21,604	11,761	1,520
Nevada	56,586	25,588	3,917
New Mexico	27,528	11,219	2,248
Tennessee	7,586	3,028	589
Utah	1,511	624	124
Virginia	6,232	2,596	499
Washington	83	35	(3)
Total	229,174	99,052	17,903
Manganiferous ore:			
Ferruginous manganese ore:[4]			
Arizona	10,693	2,620	234
Minnesota	122,736	14,437	(3)
Montana	2,415	483	34
Tennessee[5]	56	18	1
Georgia, New Mexico and Virginia[5]	28,005	3,391	149
Total	163,905	20,949	(3)
Manganiferous iron ore:[6] Minnesota	306,366	19,671	(3)
Total manganiferous ore	470,271	40,620	3,146

[1] Shipments are used as the measure of manganese production for compiling U.S. mineral-production value. They are taken at the point where the material is considered to be in marketable form from the consumer's standpoint, Besides direct-shipping ore, they include, without duplication, concentrate and nodules made from domestic ores.

[2] Containing 35 percent or more manganese (natural). All metallurgical ore except that shipped from Montana, which includes 6,011 short tons of battery ore containing 3,537 tons of manganese and 24 short tons of miscellaneous ore containing 11 tons of manganese. Does not include Minnesota's production of synthetic battery ore and synthetic miscellaneous ore. Instead, the low-grade Minnesota ore used to make these items is included under ferruginous manganese ore and manganiferous iron ore.

[3] Included in total.

[4] Containing 10 go 35 percent manganese (natural).

[5] All Tennessee and Virginia manganiferous ore was miscellaneous ore.

[6] Containing 5 to 10 percent manganese (natural).

compared with 3 percent in 1958 and 2 percent in 1957. Yearend industrial ore stocks of more than 2.6 million short tons were the greatest on record and represented an increase of 32 percent over 1958.

In the production of steel ingots, consumption of manganese as ferroalloys and direct-charged ore per short ton of open-hearth, bessemer, and electric steel produced was 13.1 pounds, compared with 12.8 pound in 1958. Of the 13.1 pounds, 11.6 pounds was ferromanganese, 1.2 pounds silicomanganese, 0.1 pound spiegeleisen, and 0.2 pound manganese metal.

Electrolytic Manganese and Manganese Metal.—Consumption of manganese metal increased 39 percent over 1958, of which most was electrolytic. Increased use of manganese metal in the production of carbon steel was reported. Foote Mineral Co. and Union Carbide Metals Co. continued to produce electrolytic manganese, and Union Carbide made a small quantity of manganese metal in electric furnaces. Manganese Chemicals Corp. produced manganese metal by a thermic process.

TABLE 4.—Consumption and stocks of manganese ore[1] in the United States, gross weight in short tons

	Quantity consumed		Stocks, Dec. 31, 1959[2] (including bonded warehouses)
	1958	1959	
Manganese alloys and manganese metal:			
Domestic ore	41, 986	3, 841	399
Foreign ore	1, 372, 627	1, 512, 013	2, 636, 201
Total	1, 414, 613	1, 515, 854	2, 636, 600
Steel ingots:			
Domestic ore	6	----------	----------
Foreign ore	585	430	347
Total	591	430	347
Steel castings:			
Domestic ore	----------	----------	----------
Foreign ore	82	225	97
Total	82	225	97
Pig iron:			
Domestic ore	951	222	----------
Foreign ore	4, 090	8, 430	5, 148
Total	5, 041	8, 652	5, 148
Dry cells:			
Domestic ore	2, 157	4, 097	728
Foreign ore	24, 447	24, 637	24, 618
Total	26, 604	28, 734	25, 346
Chemicals and miscellaneous:			
Domestic ore	164	388	94
Foreign ore	50, 479	49, 371	18, 130
Total	50, 643	49, 759	18, 224
Grand total:			
Domestic ore	45, 264	8, 548	1, 221
Foreign ore	1, 452, 310	1, 594, 881	2, 684, 541
Total	1, 497, 574	1, 603, 429	[3] 2, 685, 762

[1] Containing 35 percent or more manganese (natural).
[2] Excluding Government stocks.
[3] Excludes small tonnages of dealers' stocks.

Ferromanganese.—Production of ferromanganese in the United States was 629,000 short tons, compared with 637,000 tons in 1958. The following plants were active producers: The Anaconda Co., Anaconda, Mont.; Bethlehem Steel Co., Johnstown, Pa.; E. J. Lavino & Co., Reusens, Va., and Sheridan, Pa.; Ohio Ferro-Alloys Corp., Philo, Ohio; Pittsburgh Coke & Chemical Co., Neville Island (Pittsburgh), Pa.; Pittsburgh Metallurgical Co., Calvert City, Ky., Niagara Falls, N.Y., and Charleston, S.C.; Tennessee Products & Chemical Corp., Rockwood, Tenn.; Tenn-Tex Alloy & Chemical Corp., Houston, Tex.; Union Carbide Metals Co., Division of Union Carbide Corp., Alloy, W. Va., Ashtabula, Ohio, Marietta, Ohio, Niagara Falls, N.Y., Sheffield, Ala., and Portland, Oreg.; United States Steel Corp., Ensley, Ala., and Duquesne, Pa.; and Vanadium Corp. of America, Cambridge, Ohio, and Niagara Falls, N.Y. The quantity of ferromanganese made in blast furnaces was 1¾ times that made in electric furnaces. Shipments of ferromanganese totaled 710,000 short tons valued at $169 million compared with 608,000 tons valued at $146 million in

TABLE 5.—Consumption, by end uses, and stocks of manganese ferroalloys and metal in the United States, gross weight in short tons

End uses	Ferromanganese		Silicomanganese	Spiegeleisen	Manganese metal[1]	Briquets
	High carbon	Medium and low carbon				
Steel ingots:						
Stainless steel	7,940	2,136	3,106	15	6,955	----------
Other alloy steel	105.969	9,080	21,937	9,433	397	34
Carbon steel	534,344	40,327	57,797	18,388	2,517	----------
Other	937	190	995	19	168	26
Total	649,190	51,733	83,835	27,855	10,037	60
Steel castings:						
Stainless steel	169	293	116	----------	99	1
Other alloy steel	12,131	1,360	3,906	136	72	37
Carbon steel	9,453	1,665	5,435	1,042	4	193
Other	2,564	201	590	288	166	8
Total	24,317	3,519	10,047	1,466	341	239
Steel mill rolls	915	217	527	444	----------	----------
Gray and malleable castings	14,334	4,650	3,477	11,551	1	8,374
Alloys	6,378	803	436	77	2,425	18
Other	205	179	317	----------	32	----------
Grand total	695,339	61,101	98,639	41,393	12,836	8,691
Stocks, Dec. 31, 1959:[2]						
Consumers	102,019	12,117	14,212	14,153	1,851	1,651
Producers	(3)	(3)	(3)	22,348	(3)	----------

[1] Mostly electrolytic.

[2] Including bonded warehouses. Excluding Government stocks.

[3] Producers' stocks of ferromanganese, silicomanganese, and manganese metal total 115,505 short tons.

1958, a 16-percent increase in both quantity and value. Manganese ore consumed in making ferromanganese totaled 1,279,000 tons, almost all of which was from foreign sources.

Silicomanganese.—Production of silicomanganese in the United States was 106,000 short tons, compared with 81,000 tons in 1958. Shipments from furnaces totaled 107,000 tons ($27,930,000), compared with 82,000 tons ($20,638,000) in 1958. The following plants were active producers of silicomanganese during the year: Interlake Iron Corp., Beverly, Ohio; Ohio Ferro-Alloys Corp., Philo, Ohio; Pitts-

TABLE 6.—Ferromanganese imported into and made from domestic and imported ores in the United States

	1958		1959	
	Gross weight (short tons)	Mn content (short tons)	Gross weight (short tons)	Mn content (short tons)
Ferromanganese:[1]				
Made in United States:				
From domestic ore[2]	25,855	20,893	2,501	2,013
From imported ore[2]	610,881	473,868	626,806	484,536
Total domestic production	636,736	494,761	629,307	486,549
Imported	63.932	49,521	90,062	70,232
Total ferromanganese	700,668	544,282	719,369	556,781
Open-hearth, bessemer, and electric-furnace[3] steel produced	85,254,885	--------------	93,446,132	--------------

[1] Number of domestic plants making ferromanganese: 1958, 17; 1959, 21.

[2] Estimated.

[3] Includes crucible.

burgh Metallurgical Co., Calvert City, Ky., and Niagara Falls, N.Y.: Tennessee Products & Chemical Corp., Rockwood, Tenn.; Tenn-Tex Alloy & Chemical Corp., Houston, Tex.; Union Carbide Metals Co., Division of Union Carbide Corp., Alloy, W. Va., Ashtabula, Ohio, Marietta, Ohio, Niagara Falls, N.Y., Sheffield, Ala., and Portland, Oreg.; and Vanadium Corp. of America, Niagara Falls, N.Y. and Graham, W. Va. Consumption of silicomanganese was 13.0 percent that of ferromanganese, compared with 12.9 percent in 1958.

Spiegeleisen.—Spiegeleisen was produced at three plants during the year: New Jersey Zinc Co., Palmerton, Pa.; Pittsburgh Coke & Chemical Co., Neville Island (Pittsburgh), Pa.; and Union Carbide Metals Co., Division of Union Carbide Corp., Marietta, Ohio.

Manganiferous Pig Iron.—Pig-iron furnaces used 1,357,000 short tons of manganese-bearing ores containing (natural) over 5 percent manganese. Of this amount, 699,000 tons was of domestic and 658,000 tons of foreign origin. Of the domestic ore, 641,000 tons contained (natural) 5 to 10 percent manganese, 57,000 tons contained 10 to

TABLE 7.—Ferromanganese produced in the United States and metalliferous materials consumed in its manufacture[1]

Year	Ferromanganese produced			Materials consumed (short tons)			Manganese ore used per ton of ferromanganese[1] made (short tons)
	Short tons	Manganese contained		Manganese ore (35 percent or more Mn, natural)		Iron and manganiferous iron ores	
		Percent	Short tons	Foreign	Domestic		
1950–54 (average)	779,183	76.4	595,025	1,466,853	81,310	13,972	2.0
1955	869,977	77.0	670,165	[1] 1,924,643	[1] 46,936	1,594	[1] 2.0
1956	923,012	77.0	709,895	2,025,678	63,561	283	2.3
1957	963,814	77.2	743,634	2,066,693	36,692	503	2.2
1958	636,736	77.7	494,761	1,228,769	42,061	1,091	2.0
1959	629,307	77.3	486,549	1,275,138	3,829	3,935	2.0

[1] For 1955, includes ore used in manufacture of silicomanganese.

TABLE 8.—Manganese ore used in manufacture of ferromanganese in the United States, by source of ore

	1958		1959	
	Gross weight (short tons)	Mn content, natural (percent)	Gross weight (short tons)	Mn content, natural (percent)
Domestic	42,061	56.8	3,829	57.1
Foreign:				
Africa	384,879	46.3	456,780	46.8
Brazil	247,154	45.4	257,975	46.5
Chile	12,295	45.4	12,457	44.6
Cuba	38,415	38.2	57,377	36.5
India	431,681	44.0	335,243	45.1
Mexico	97,897	45.3	130,841	43.9
Philippines	897	48.4	6,851	41.1
Turkey	2,647	42.5	4,418	39.8
Other	12,904	42.8	13,196	46.2
Total	1,270,830	45.3	1,278,967	45.5

35 percent manganese, and 1,000 tons contained over 35 percent manganese. Of the foreign ore, 650,000 tons contained (natural) 5 to 10 percent manganese and 8,000 tons contained 35 percent or more manganese. All of the foreign manganiferous iron ore came from Canada.

Battery and Miscellaneous Industries.—Manufacturers of dry-cell batteries in 1959 used 29,000 short tons of manganese ore containing more than 35 percent manganese (natural); 4,000 tons was of domestic origin. Chemical plants and miscellaneous industries used 50,000 tons of manganese ore containing 35 percent or more manganese, almost all from foreign sources. Virtually all of the Chemical-grade manganese dioxide ore used, 35,000 tons, was imported.

PRICES

Manganese Ore.—Government prices for domestically mined manganese ore meeting specifications and regulations continued to be calculated on the basis of $2.30 per long dry-ton unit for 48 percent of contained manganese. Commercial prices for spot purchases of Indian manganese ore containing 46 to 48 percent manganese, as quoted by E&MJ Metal and Mineral Markets, opened the year at $0.915 to $0.965, nominal, per long-ton unit of manganese, c.i.f. U.S. ports, import duty extra. These prices decreased in April to $0.87 to $0.90, nominal, and remained at that level until the end of the year for analysis of 10 percent iron, 0.15 percent phosphorus, and 13 percent aluminum plus silicon. Beginning in October, E&MJ Metal and Mineral Markets also listed prices, at the same terms, for South African ore containing 46 to 48 percent manganese, 9 percent iron, 0.05 percent phosphorus, and 13 percent aluminum plus silicon at $0.87 to $0.90, nominal, per long-ton unit of manganese, and for Brazilian ore containing 48 to 50 percent manganese, 5 percent iron, 0.1 percent phosphorus, 7 percent aluminum plus silicon, and 0.2 percent arsenic at $0.91 per long-ton unit of manganese, nominal. The price of crude manganese dioxide, 84 percent MnO_2, c.i.f. U.S. ports, was quoted by the same source at $110 to $120 per long dry ton in bulk until October, with no quotations thereafter. Duty on manganese ore continued to be ¼ cent per pound of contained manganese, except that ore from Cuba and the Philippines continued to be exempt from duty and ore from the U.S.S.R. and certain neighboring countries was dutiable at 1 cent per pound of contained manganese.

Manganese Alloys.—The average value, f.o.b. producers' furnaces, for ferromanganese shipped in 1959 was $238.54 per short ton, compared with $239.51 in 1958. The price of standard ferromanganese, 74 to 76 percent manganese, at eastern furnaces, carlots, was unchanged throughout the year at 12.25 cents per pound of alloy. Spiegeleisen containing 19 to 21 percent manganese sold at the quoted price of $102.50 per long ton, unchanged for the third consecutive year.

Manganese Metal.—As in 1958, the price of electrolytic manganese metal continued to be quoted by E&MJ Metal and Mineral Markets at 34 cents per pound for carlots and 36 cents per pound for ton lots. A premium of 0.75 cent per pound for hydrogen-removed metal also continued unchanged throughout the year.

FOREIGN TRADE[3]

The average grade of imported manganese ore was 47.7 percent manganese, compared with 46.9 percent for 1958, and was the highest grade recorded for general imports since 1947. Of the total ore received in 1959, Brazil supplied 41 percent; India, 16 percent; Ghana, 12 percent; Mexico, 8 percent; and the Union of South Africa, 7 percent. General imports of ore containing more than 10 percent and less than 35 percent manganese totaled 8,194 short tons, of which 7,449 tons came from Mexico, 405 tons from Ghana, and 340 tons from India. Except for omission of the Ghana ore, imports for consumption were identical with general imports.

Imports for consumption of ferromanganese increased 41 percent over 1958. Imports for consumption classified as "manganese silicon (includes silicon manganese)" totaled 12,495 short tons (manganese content). Japan supplied 7,170 tons; Italy, 1,710; Norway, 1,634; Chile, 1,161; Yugoslavia, 325; Belgium-Luxembourg, 223; France, 215; and Canada, 57. Imports for consumption of manganese metal were 32 tons, all from Japan. No imports for consumption of spiegeleisen were reported.

Exports of ferromanganese totaled 947 short tons valued at $388,000, compared with 1,406 tons valued at $464,000 in 1958. Exports classified as "manganese metal and alloys in crude form and scrap" were 1,260 tons ($752,000) in 1959 and 586 tons ($300,000) in 1958. Exports of spiegeleisen in 1959 were 380 tons valued at $38,000. The quantity of manganese ore and concentrate (10 percent or more manganese) exported totaled 5,702 tons valued at $819,000.

WORLD REVIEW

NORTH AMERICA

Cuba.—After being closed late in 1958 by rebel action, Cuba's largest manganese mine, Chàrco Redondo, was intervened by the revolutionary government early in 1959. Its production continued to be adversely affected by technical, marketing, labor, and management problems. Preliminary figures for 1959 show that 35,000 short tons of Chàrco Redondo ore was exported. Remaining Cuban manganese ore exports amounted to 23,000 tons, of which 600 tons was produced in 1957 by Inter-American Industries. The rest was exported by Holston Trading Corp. All shipments went to the United States.[4] New mineral legislation, enacted October 27, 1959, provided for an annual tax of $20 per hectare for mines deemed not under adequate exploitation or $10 for those adequately exploited, plus a 5-percent production levy. If ore is exported, the State's participation becomes 25 percent.[5]

---

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

[4] U.S. Embassy, Habana, Cuba, State Department Dispatches 1441, 205, 857, and 1305: June 25, Aug. 7, and Dec. 14, 1959, and Mar. 15, 1960.

[5] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 1, January 1960, p. 53.

TABLE 9.—Manganese ore (35 percent or more Mn) imported into the United States, by countries

[Bureau of the Census]

Country	General imports [1] (short tons)				Imports for consumption [2]					
					Short tons				Value	
	Gross weight		Mn content		Gross weight		Mn content			
	1958	1959	1958	1959	1958	1959	1958	1959	1958	1959
North America:										
Canada		57		27		57		27		$2,074
Cuba	71,895	50,067	30,224	22,532	71,895	50,067	30,224	22,532	$2,356,637	1,336,620
Mexico	181,832	180,855	83,915	83,388	155,828	176,190	72,031	80,821	6,805,355	6,466,469
Panama	2,001		900		2,001		900		119,741	
Total	255,728	230,979	115,039	105,947	229,724	226,314	103,155	103,380	9,281,733	7,805,163
South America:										
Argentina		15		6		15		6		490
Brazil	661,134	991,385	315,798	477,503	426,051	472,249	201,717	224,597	20,588,179	19,252,473
Chile	17,941	25,446	8,137	11,291	18,584	28,871	8,360	12,968	845,109	1,063,415
Peru	5,312	1,137	2,191	643	5,312	1,137	2,191	643	192,426	51,853
Total	684,387	1,017,983	326,126	489,443	449,947	502,272	212,268	238,214	21,625,714	20,368,231
Europe: Greece	17,932	18,162	8,607	8,774	5,715	10,195	2,757	4,857	267,716	560,349
Asia:										
India	638,374	373,408	291,863	172,758	513,565	419,415	234,410	195,693	18,254,964	14,036,117
Indonesia	3,345		1,503		3,345		1,503		74,400	
Philippines	11,236	18,937	5,417	9,236	9,611	18,937	4,667	9,236	434,049	584,404
Portuguese Asia, n.e.c		6,043		2,780		6,043		2,780		172,490
Thailand	220		116		220		116		18,024	
Turkey	6,057	3,736	2,549	1,665	6,057	3,736	2,549	1,665	173,379	71,618
Total	659,232	402,124	301,448	186,439	532,798	448,131	243,245	209,374	18,954,816	14,864,629

Africa:										
Angola	27,038	28,028	13,602	13,679	43,779	32,827	21,775	16,370	1,689,613	1,252,387
Belgian Congo	150,316	97,874	74,875	47,875	69,723	93,973	34,910	46,583	3,449,023	3,726,357
Ghana	310,839	278,238	154,594	137,370	192,935	269,446	94,569	131,342	10,701,203	14,036,353
Morocco	38,088	79,689	19,211	42,405	23,977	74,229	11,483	39,348	1,384,670	4,914,967
Mozambique	1,098	------	494	------	1,098	------	494	------	40,127	------
Rhodesia and Nyasaland, Federation of	10,022	32,062	4,720	15,322	10,022	31,396	4,720	15,030	380,974	1,168,410
Sudan	------	------	------	------	------	1,793	------	656	------	98,186
Union of South Africa	266,158	177,037	117,079	78,444	207,611	172,493	93,272	75,292	7,038,130	5,306,397
United Arab Republic (Egypt Region)	6,947	17,675	3,255	8,352	4,778	3,274	2,214	1,725	174,560	107,129
Total	810,506	710,603	387,830	343,447	553,923	679,431	263,437	326,346	24,858,300	30,610,186
Oceania:										
Australia	9,131	8,326	4,200	4,163	9,131	4,436	4,200	2,218	470,387	167,213
British Western Pacific Islands	15,662	9,627	7,192	4,621	17,384	7,286	8,038	3,292	797,805	272,023
Total	24,793	17,953	11,392	8,784	26,515	11,722	12,238	5,510	1,268,192	439,236
Grand total [3]	2,452,578	2,397,804	1,150,442	1,142,834	1,798,622	1,878,065	837,100	887,681	76,256,471	74,647,794

---

[1] Comprises ore received in the United States; part went into consumption during the year, and remainder entered bonded warehouses.

[2] Comprises ore received during the year for immediate consumption plus material withdrawn from bonded warehouses; excludes imports for manufacture in bond and export.

[3] In 1959, general imports of ore classified as Battery and Chemical grades totaled 132,055 short tons averaging 53 percent manganese. Of this quantity 61,084 short tons came from Morocco, 41,791 short tons from Ghana, 10,833 short tons from Greece, 6,597 short tons from Cuba, 5,767 short tons from Belgian Congo, 3,117 short tons from Union of South Africa, 2,162 short tons from India, and 704 short tons from Peru. In addition it is believed that virtually all the ore from Greece was Battery and Chemical grade. Imports for consumption of Battery and Chemical grades in 1959 totaled 110,610 short tons valued at $7,781,015 or $70.35 per short ton f.o.b. foreign ports. Of this total Morocco supplied 61,084 short tons ($4,099,845), Ghana 31,179 short tons ($2,950,204), Cuba 6,597 short tons ($281,450), Belgian Congo 5,767 short tons ($231,303), Union of South Africa 3,117 short tons ($115,951), India 2,162 short tons ($74,598), and Peru 704 short tons ($27,664).

TABLE 10.—Ferromanganese imported for consumption in the United States, by countries

[Bureau of the Census]

Country	1958			1959		
	Gross weight (short tons)	Mn content (short tons)	Value	Gross weight (short tons)	Mn content (short tons)	Value
North America:						
Canada	198	153	$46,281	127	101	$40,821
Mexico	813	624	147,688	----------	----------	----------
Total	1,011	777	193,969	127	101	40,821
South America: Chile	1,913	1,513	276,500	1,540	1,233	244,297
Europe:						
Belgium-Luxembourg	4,163	3,182	519,715	6,782	5,297	787,733
France	16,237	12,394	3,135,993	22,288	17,198	3,245,611
Germany, West	----------	----------	----------	4,711	3,594	618,892
Italy	----------	----------	----------	3,031	2,285	412,532
Norway	55	43	9,850	16,137	12,780	2,626,543
Sweden	----------	----------	----------	1,323	1,005	175,911
Yugoslavia	4,403	3,525	738,044	5,997	4,726	877,201
Total	24,858	19,144	4,403,602	60,269	46,885	8,744,423
Asia:						
India	648	483	114,796	5,547	4,143	721,075
Japan	35,502	27,604	6,056,925	22,579	17,870	4,316,563
Total	36,150	28,087	6,171,721	28,126	22,013	5,037,638
Grand total	63,932	49,521	11,045,792	90,062	70,232	14,067,179

TABLE 11.—World production of manganese ore, by countries,[1] in short tons[2]

[Compiled by Pearl J. Thompson and Berenice B. Mitchell]

Country[1]	Percent Mn[3]	1950–54 (average)	1955	1956	1957	1958	1959
North America:							
Cuba	36–50+	226,328	[4] 284,883	[4] 268,810	[4] 160,967	[4] 74,636	[4] 58,806
Mexico	30+	166,289	97,326	[3] 171,000	[3] 220,000	[3] 187,400	[3] 181,900
Panama	44+	----------	----------	----------	2,154	4,489	----------
United States (shipments)	35+	143,700	287,255	344,735	366,334	327,309	229,174
Total	----------	536,317	669,464	784,545	749,455	593,834	469,880
South America:							
Argentina	30–40	4,827	14,145	9,682	10,779	14,628	[3] 14,300
Brazil	38–50	229,764	234,249	342,645	1,011,939	972,413	[4] 1,055,436
Chile	40–50	48,555	47,795	51,878	59,724	42,061	68,498
Peru	40+	2,895	8,446	11,826	16,917	3,242	1,320
Venezuela	38+	----------	----------	10,318	32,930	9,039	----------
Total	----------	286,041	304,635	426,349	1,132,289	1,041,383	1,139,554
Europe:							
Bulgaria	30+	[5] 24,582	69,005	84,657	89,600	[3] 88,200	[3] 88,200
Greece	35+	14,825	27,148	8,695	17,545	22,046	33,070
Hungary	30+	108,670	105,208	[3] 94,000	[3] 132,000	[3] 132,000	[3] 132,000
Italy	30–	39,489	62,684	51,697	51,286	47,810	57,138
Portugal	35+	9,203	4,388	3,508	6,035	5,484	[3] 5,500
Rumania	35	118,575	429,814	259,054	292,402	220,755	[3] 275,600
Spain	30+	30,165	48,375	36,100	45,622	40,267	[3] 49,600
U.S.S.R.[6]	----------	4,657,900	5,228,300	5,443,200	5,674,700	5,915,000	[3] 5,952,500
Yugoslavia	30+	6,821	4,850	[3] 6,000	[3] 4,400	11,060	8,900
Total[1]	----------	5,010,230	5,979,772	5,986,911	6,313,590	6,482,622	[3] 6,600,000

See footnotes at end of table.

TABLE 11.—World production of manganese ore, by countries,[1] in short tons [2]—Continued

Country [1]	Percent Mn [3]	1950–54 (average)	1955	1956	1957	1958	1959
Asia:							
Burma	35+	4,651	342	1,287	506	1,405	605
China [3]	--------	128,100	305,000	580,000	770,000	935,000	1,100,000
India	40+	1,557,447	1,773,566	1,946,126	1,852,701	1,377,602	1,207,029
Indonesia	35–49	14,010	43,061	118,858	59,338	48,490	[3] 49,600
Iran [7]	36–46	6,297	5,484	6,614	2,205	2,200	[3] 2,200
Japan	32–40	196,040	222,350	314,175	318,497	326,269	374,800
Korea, Republic of	30–48	3,176	3,838	2,158	3,533	287	495
Philippines	35–51	22,871	13,131	4,866	33,324	24,590	38,365
Portuguese India	32–50+	106,631	149,523	215,836	257,904	113,809	76,375
Thailand	40+	--------	--------	450	381	1,100	452
Turkey	30–50	67,002	55,228	66,966	62,522	24,920	34,833
Total [3]	--------	2,106,000	2,572,000	3,257,000	3,361,000	2,856,000	2,885,000
Africa:							
Angola	38–48	45,875	34,853	29,647	23,518	38,499	39,314
Bechuanaland	50+	--------	--------	--------	243	14,213	20,507
Belgian Congo	48+	180,231	508,972	363,250	404,572	372,741	425,694
Ghana [8]	48	[4] 788,005	[4] 604,330	[4] 712,154	[4] 718,306	[4] 574,672	[4] 589,853
Morocco:							
Northern zone	50	1,464	1,262	1,795	732	--------	--------
Southern zone	35–50	422,314	453,013	461,470	541,772	452,041	518,711
Rhodesia and Nyasaland. Federation of:							
Northern Rhodesia	30+	[10] 7,839	19,717	40,760	39,703	49,947	63,069
Southern Rhodesia	48+	320	1,330	816	1,785	2,512	2,126
South-West Africa	45+	22,453	41,880	57,262	89,661	103,049	49,442
Sudan	36–44	--------	--------	[4] 7,700	[4] 8,800	[4] 6,600	[4] 440
Union of South Africa	40+	871,537	649,471	768,395	787,878	934,097	1,069,195
United Arab Republic: (Egypt Region) [9]	57	3,154	6,398	5,087	10,315	48,730	[3] 49,600
Total	--------	2,343,192	2,321,226	2,448,336	2,627,285	2,597,101	2,827,951
Oceania:							
Australia	45-48	20,396	53,039	66,510	86,153	66,845	[3] 105,000
Fiji	40+	[4] 3,289	[4] 19,803	[4] 25,067	[4] 38,858	[4] 25,198	[4] 14,566
New Caledonia	45+	10,550	--------	--------	--------	--------	--------
New Zealand	48+	358	179	175	41	116	[3] 110
Papua	--------	23	22	14	--------	--------	--------
Total	--------	34,616	73,043	91,766	125,052	92,159	119,676
World total (estimate) [1]	--------	10,316,000	11,920,000	12,995,000	14,309,000	13,663,000	14,042,000

[1] In addition to the countries listed, Czechoslovakia and Sweden report production of manganese ore approximately 15–17 percent manganese content), but since the manganese content averages less than 30 percent, the output is not included in this table. Czechoslovakia averages annually 220,000 short tons and Sweden approximately 16,500 tons.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included.

[3] Estimate.

[4] Exports.

[5] Average for 1952–54.

[6] Grade unstated. Source: The Industry of the U.S.S.R., Central Statistical Administration, 1958 (Moscow).

[7] Year ending March 20 of year following that stated.

[8] Dry weight.

[9] In addition to high-grade ore shown in the table, Egypt produced the following tonnages of less than 30 percent manganese content: 1950-54 (average), 208,524; 1955, 236,096; 1956, 215,761; 1957, 83,957; 1958, 74,303; and 1959, not available.

[10] Average for 1951–54.

Mexico.—All manganese ore exported in 1959 (85,000 short tons metal content) went to the United States.[6] The hurricane of October 27, 1959, damaged the Autlán-Manzanillo highway to the extent that Cia. Minera Autlán was forced to suspend manganese ore shipments for the rest of the year.[7]

---

[6] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 5, May 1960, p. 19.

[7] U.S. Consulate, Guadalajara, Mexico, State Department Dispatch 45: Jan. 5, 1960.

SOUTH AMERICA

British Guiana.—The manganese ore deposits on the Barima River in northwest British Guiana continued under development by Union Carbide Corp., through Northwest Guiana Mining Co., Ltd. Early in January, Union Carbide Ore Co., Division of Union Carbide Corp., awarded a contract for erecting an ore-dressing and blending plant at Warwick (Newport News), Va., having a capacity of 30,000 tons of ore a month. Plans called for beneficiating the Barima ore in this plant.

Chile.—Exports of manganese ore in 1959 totaled 27,000 short tons, of which 93 percent went to the United States and the remainder to West Germany. Ferromanganese exports totaled 2,900 tons; 38 percent went to the United States and the remainder to Colombia, Peru, Brazil, and Panama. Silicomanganese exports totaled 3,500 tons; 75 percent were shipped to the United States and the remainder to Venezuela, Netherlands, West Germany, Colombia, Peru, and Argentina.[8]

Peru.—Exports in 1958 were 2,200 short tons of contained manganese. Peruvian production (3,200 tons) averaged 42 percent manganese, and Mina Gran Bretana continued to be the principal producer.[9]

Venezuela.—Exports of manganese ore in 1957 totaled 24,000 short tons: 43 percent went to West Germany, 31 percent to France, and 26 percent to the United States. Small-scale mining activity by individuals was reported in 1959.[10]

EUROPE

Bulgaria.—Because of approaching exhaustion of the better manganese ores of the Ignatievo and Rudnick regions, the extraction goals of the Pobeda State Mining Enterprise decreased from 70,000 tons in 1957 to 20,000 tons in 1959. Pobeda has mined the ores since 1953. The Scientific Research Institute for the Chemical Industry successfully investigated beneficiation of the remaining lower grade ores, such as the 28 million tons of the Ignatievo deposit averaging about 17 percent manganese and 0.4 percent phosphorus. As a result, two beneficiating plants were planned; the largest would process 100,000 tons of ore into approximately 25,000 tons of concentrate containing 55 percent manganese or more and virtually no phosphorus.[11]

France.—Of the 606,000 short tons of manganese ore imported in 1958, Morocco supplied 265,000 tons, India 116,000, the U.S.S.R. 105,000, and the Union of South Africa 93,000. Of the Moroccan total, 160,000 tons was sinter.[12] Ferromanganese production in 1958 totaled 262,000 tons; spiegeleisen, 147,000 tons; and silicomanganese, 13,000 tons.[13]

---

[8] U.S. Embassy, Santiago, Chile, State Department Dispatches 1221, 145, 340, and 544: June 8, Aug. 18, Nov. 4, 1959, and Jan. 29, 1960.

[9] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 2, August 1959, p. 28.

[10] Republica de Venezuela Ministerio de Minas e Hidrocarburos, Direccion de Economia, Carta Semanal (Caracas): No. 53, July 4, 1959, pp. 17–21.

[11] Ikonomicheska Misul (Sofia), [Mineral Resources in Varna Okrug]: No. 9, 1959, pp. 49–53.

[12] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 6, December 1959, p. 23.

[13] U.S. Embassy, Paris, France, State Department Dispatch 218: Aug. 6, 1959.

Germany, West.—Consumption of manganese metal containing more than 96 percent manganese was 1,500 short tons in 1958, compared with 1,200 tons in 1957.[14] Imports and exports were 1,200 and 36 tons, respectively, including waste and scrap, in 1958[15] and 600 and 35 tons, respectively, in the first half of 1959.[16]

Sweden.—Manganese ore imports totaled 81,000 short tons in 1958. India supplied 34,000 tons; U.S.S.R., 20,000; Union of South Africa, 8,600; Turkey, 6,600; and Belgian Congo, 3,200. Exports were 560 tons, most of which went to Czechoslovakia. The only significant Swedish source of manganese ore in 1958 was the Langban mine of the Uddeholm Co., north of Filipstad, Varmland County. This ore, apparently containing 10 to 14 percent manganese, was converted into ferromanganese by the Hagfors steel division of the company.[17]

U.S.S.R.—Technologic improvements were credited with increasing manganese production from mines and mills of the Nikopol'-Marganets basin 13 percent in 1959 over 1958.[18] The Seven-Year Plan for this basin in the Ukraine called for doubling manganese ore production, apparently comparing 1965 to 1958.[19] The Seven-Year Plan for the Chiatura district of the Georgian S.S.R. would almost double productive capacity for the district. It was reported that the entire production would then be high-quality concentrate. New mines and mills were planned, including a central flotation plant, a beneficiation plant for carbonate ores, and three plants "to improve the quality of porous manganese ores."[20] Soviet exports of manganese ore in 1958 totaled 918,000 short tons, distributed as follows: Poland, 255,000 tons; East Germany, 165,000; United Kingdom, 127,000; Czechoslovakia, 93,000; France, 90,000; West Germany, 69,000; Norway, 36,000; Japan, 30,000; Sweden, 19,000; Italy, 12,000; Yugoslavia, 11,000; Austria, 10,000; and unaccounted, 1,000. Exports of peroxide manganese ore, presumably of battery grade, totaled 8,200 tons, of which East Germany received 2,900 tons, Czechoslovakia 1,900, Poland 900, Netherlands 700, and Finland 300.[21] Production of ferromanganese and spiegeleisen were, respectively, 619,000 and 67,000 short tons in 1958, 569,000 and 101,000 in 1957, and 518,000 and 78,000 in 1956.[22]

ASIA

China.—Reserves of manganese ore were believed to be between 50 and 100 million tons,[23] with a substantial part averaging 40 to 50 percent manganese. The most important deposits of the better grades of ore are south of the Yangtze River from Fukien Province on the

---

[14] U.S. Embassy, Bonn, West Germany, State Department Dispatch 148: July 28, 1959.

[15] U.S. Consulate General, Duesseldorf, West Germany, State Department Dispatch 262: May 19, 1959.

[16] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 2, February 1960, p. 12.

[17] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 5, November 1959, p. 25.

[18] Trud (Moscow), [Nikopol'-Marganets Basin to Double Ore Production]: Dec. 18, 1959, p. 1.

[19] Gorny Zhurnal (Moscow): No. 2, February 1960, pp. 13–14.

[20] Kommunist Tadzhikistana (Stalinabad), [Manganese Production in Georgian S.S.R. to Expand]: Dec. 16, 1959, p. 1.

[21] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 1, Special Suppl. 58, January 1960, 36 pp.

[22] Central Statistical Administration (Moscow), National Economy of the U.S.S.R., Statistical Yearbook: 1959, pp. 187, 193.

[23] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 3, Special Supp. No. 59, March 1960, p. 29.

east through Kiangsi, Hunan, Kwangtung, Kwangsi, and Kweichow Provinces.

India.—Preliminary data showed 1959 exports of manganese ore to be 1,029,000 short tons, distributed as follows: United States, 440,000 tons; Japan, 224,000; France, 131,000; United Kingdom, 97,000; Netherlands, 54,000; West Germany, 24,000; Belgium, 17,000; Poland, 11,000; Yugoslavia, 8,300; Norway, 3,900; Rumania, 2,700; Italy, 2,300. The State Trading Corp. exported 34 percent of the total. Other preliminary data indicated that 1959 ferromanganese exports totaled 5,700 tons, of which 4,700 tons went to the United States and the remainder to United Kingdom and Rumania, and that exports of manganese dioxide totaled 3,900 tons, of which 2,200 went to United Kingdom, 730 to West Germany, 440 to Japan, 420 to Netherlands, and 110 to Yugoslavia.[24] Manganese ore exports continued to be licensed on a quota basis.[25] A monograph reported on the beneficiation studies that the National Metallurgical Laboratory, Jamshedpur, had conducted for some time on low-grade Indian manganese ores. The ores were broadly classified into four groups: Simple, ferruginous, garnetiferous, and complex.[26] Of a total of 50,000 tons of ferromanganese produced in 1958, the Joda plant of Tata Iron & Steel Co. was credited with 22,000; Ferro Alloys Corp., Garivadi, 14,000; Electro Metallurgical Works, Dandeli, 9,000; Jeypore Sugar Co., Rayagada, 3,000; and Mysore Iron and Steel Works, Bhadravati, 2,000. Exports of ferromanganese in 1958 totaled 12,000 tons and imports, 200 tons.[27] In the latter part of 1959, the newly built electric-furnace plant of Cambatta Ferro-Manganese Private, Ltd., began producing standard ferromanganese at Tumsar, Bombay State.

A basic agreement was signed March 3, 1959, between the Governments of the United States and India for the exchange of 500,000 short tons or more of American food grains, valued at $31,500,000, for an undetermined quantity of manganese, ferromanganese, or other materials to be agreed upon, originating in India or processed from materials of Indian origin. Processing might be done in India, other countries, or the United States. Negotiations on details of the barter continued throughout the year.

Japan.—Production of electrolytic manganese was 2,600 short tons in 1958 and 1,300 tons in the first half of 1959.[28] Annual domestic consumption was estimated to be 350 tons for steelmaking and 150 tons for other purposes. From data prepared by the Japan Ferroalloy Association, manganese metal exports in 1958 totaled 2,000 tons, as follows (1957 exports, in parentheses, totaled 1,600 tons): West Germany, 900 (740); United Kingdom, 750 (480); Sweden, 240 (150); France, 40 (20); United States, 20 (none); and others, 50 (210).[29]

Philippines.—The Philippine Bureau of the Census and Statistics reported that 1958 manganese ore exports totaled 34,000 short tons. The United States took 18,000 tons; Japan, 15,000; and Formosa, 1,000. For the first 9 months of 1959, exports totaled 35,000 tons with

---

[24] U.S. Embassy, New Delhi, India, State Department Dispatch 727: Feb. 19, 1960.

[25] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 1, January 1960, pp. 35–36.

[26] Narayanan, P.I.A., and Subrahmanyan, N.N., Beneficiation of Low Grade Manganese Ores of India: Council of Scientific & Industrial Research (New Delhi), 1959, 183 pp.

[27] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 4, October 1959, p. 16.

[28] U.S. Embassy, Tokyo, Japan, State Department Dispatch 597: Nov. 18, 1959.

[29] Work cited in footnote 25, p. 37. P. 37 is page of report cited.

approximately the same distribution.[30] Production of manganese ore in 1958 was largely dependent upon the procurement of barter permits which offered the best possibility for profitable operation. Production was reported by Bonanza Consolidated Mines, Inc., from its mine in Cagayan de Oro, Misamis Oriental, Mindanao; Ferty Manganese in Bani, Camarines Sur; General Base Metals, Inc.; Jecel Mining Corp.; Luzon Stevedoring Co., Inc., Capas, Tarlac; Palawan Manganese Mines, Inc.; Philippine Base Metals, Inc.; and Zambales Base Metals. Much of the actual mining for the last-named three companies was done by private contractors; approximately 400 tons was so mined for Zambales Base Metals. General Base Metals, the largest producer, used two diamond drills in continuing exploration. Its washing plant delivered a product averaging 40 percent manganese.[31]

Portuguese India.—Of the reported 139,000 short tons of manganese ore exported from Goa in 1958, half was ferruginous manganese ore and half contained over 35 percent manganese.[32] Total exports of the two grades of ore in 1959 were 173,000 tons, of which approximately two-thirds was ferruginous. Distribution of the total was: West Germany, 99,000 tons; Sweden, 29,000; Norway, 10,000; Italy, 9,900; Belgium, 9,400; Netherlands, 6,600; United States, 6,300; and Japan, 2,700.[33]

Turkey.—Exports of manganese ore in 1958 totaled 27,000 short tons, of which the United States received 6,400 tons; Czechoslovakia, 5,200; Sweden, 3,800; Spain, 2,800; and Italy, 2,400. The remainder went to West Germany, United Kingdom, Burma, France, Yugoslavia, Netherlands, and Belgium. Ten operators were reported to have produced manganese ore in 1958.[34]

AFRICA

Angola.—Cia. do Manganese de Angola continued to be the principal producer of manganese ore in 1959, shipping over the Luanda Railroad from deposits in the area between Vila Salazar and Dondo and from previously accumulated stocks. Cia. Mineira do Lobito, principally interested in iron ore mining, continued some activity on its deposits of manganese ore and ferruginous manganese ore along the Benguela Railroad near the Belgian Congo border. Production from these deposits has been small,[35] dating from 1956 or earlier.

Bechuanaland.—Marlime Chrysotile Asbestos Corp., subsidiary of Marble Lime and Associated Industries, continued prospecting and developing its manganese deposits on a 9,000-square-mile Crown grant in the Bakgatla Reserve.[36]

Belgian Congo.—A new deposit of manganese ore was reported at Katonto, approximately 1 mile from the railroad running from Kolwezi to the coast at Lobito, Angola. The deposit was reported to be

---

[30] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 3, March 1960, p. 26.

[31] U.S. Embassy, Manila, Philippine Islands, State Department Dispatch 858: June 9, 1959.

[32] U.S. Embassy, Lisbon, Portugal, State Department Dispatch 40: July 24, 1959.

[33] U.S. Embassy, Lisbon, Portugal, State Department Dispatch 459: May 6, 1960. U.S. Consul, Bombay, India, State Department Dispatch 605: May 9, 1960.

[34] Work cited in footnote 17, pp. 25–27.

[35] U.S. Consul, Luanda, Angola, State Department Dispatch 246: May 2, 1960.

[36] Mining World, vol. 22, No. 2, February 1960, p. 73.

similar to that of Lufupa and Kasekalesa, and hand-sorted material analyzed 50 to 80 percent manganese dioxide.[37] Electric power was made available to the Kisenge mine of Beceka Manganese upon completion of a 175-mile high-tension (110,000-volt) line from Kolwezi.[38] An inclined hoistway, with two skips automatically operating in balance,[39] was under construction for lifting loaded 16-ton trucks from the bottom of the main pit.

Ethiopia.—A manganese ore concession in the Danakil Desert was under exploitation.[40]

Gabon.—At midyear, the International Bank for Reconstruction and Development (World Bank) made a loan equivalent to $35 million to Cie. Minière de l'Ogooue (COMILOG) to help finance equipment and services for a mine; crushing, washing, and screening plant; shops and surface plant; 45-mile cableway; and 180-mile railway. Planned capacity of the cableway was 850,000 tons of manganese ore a year. Total cost of the project was estimated to be $89 million, of which $7 million would be provided by a loan from Caisse Centrale de Cooperation Economique, a French Government agency interested in development of the French Community; the balance was to come from COMILOG'S proprietary organizations.[41] United States Steel Corp. had a 49-percent interest in COMILOG; Cie. des Minerais de Fer Magnetique de Mokta el Hadid, 14 percent; Société Auxiliaire du Manganèse de Franceville (owned equally by Mokta el Hadid, Banque de Paris et des Pays Bas, and Cie. Minière de l'Oubangui-Oriental), 15 percent; and the French Government through Bureau Minier de la France d'Outre Mer, 22 percent.[42] The World Bank loan was for 15 years and was guaranteed by France, the Republic of Gabon, and the Republic of Congo. The site chosen for the first mining had a reserve of 8 million tons of ore averaging 49 percent manganese.[43] Construction of the railroad was begun in the third quarter of the year by the successful bidder, a consortium consisting of Cie. Industrielle des Travaux (Schneider) (France), Utah Construction Co. (U.S.A.), and Taylor Woodrow (Great Britain). The railroad was expected to be completed in 3 to 3½ years.

Ghana.—In 1959, exports of Battery-grade manganese ore were 64,000 short tons; metallurgical ore containing over 30 percent manganese, 513,000 tons; and lower-grade metallurgical ore, 12,000 tons.[44]

Ivory Coast.—Cie. des Minerais de Fer Magnetique de Mokta el Hadid was developing near Grand Lahou its lateritic manganese ore deposit, which was estimated to contain 1.3 million tons of ore. Production from open pits was expected to start in 1960 at a rate of 100,000 tons a year,[44a] with a manganese content of 46 to 48 percent for the washed product. Late in the year, the first of two 45-foot barges was launched at Abidjan to be used in transporting the washed ore to that port.[45]

---

[37] U.S. Consul, Elisabethville, Belgian Congo, State Department Dispatch 91: Feb. 29, 1960.

[38] U.S. Consul, Leopoldville, Belgian Congo, State Department Dispatch 11: July 13, 1959.

[39] Mining World, vol. 21, No. 7, June 1959, p. 28.

[40] U.S. Embassy, Addis Ababa, Ethiopia, State Department Dispatch 291: Apr. 14, 1960.

[41] Foreign Commerce Weekly, vol. 62, No. 2, July 13, 1959, p. 27.

[42] American Metal Market, vol. 66, No. 128, July 2, 1959, p. 8.

[43] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 6, December 1959, pp. 23–24.

[44] U.S. Embassy, Accra, Ghana, State Department Dispatch 584: Apr. 26, 1960.

[44a] Work cited in footnote 43, p. 24.

[45] U.S. Consulate General, Dakar, Senegal, State Department Dispatch 260: Mar. 18, 1960.

Morocco.—Production of Chemical-grade manganese ore in 1959 was 87,000 short tons having an estimated average manganese dioxide content of 85 percent; that of Metallurgical-grade ore was 432,000 tons averaging an estimated 45 percent manganese.[46] All of the 62,000 tons of chemical ore produced in 1958 came from the Imini mine of Société Anonyme Chérifienne d'Études Minières (SACEM), excepting 700 tons from the Arbalou deposit of Société Minarba and 60 tons from the Hamarouet mine of Société des Mines de Bou Arfa.[47] In 1958 the Sidi Marouf sinter plant of SACEM produced 167,000 tons of sinter (56 percent manganese) from 212,000 tons of ore or concentrate; the Bou Arfa plant produced 18,000 tons of sinter (35 percent manganese) from 28,000 tons of fines. Exports of Chemical-grade ore in 1958 totaled 49,000 short tons, compared with 59,000 tons in 1957. Distribution for the 2 years was (1957 in parentheses): United States, 23,000 tons (19,000); France, 13,000 (29,000); Germany, 5,800 (4,600); England, 3,300 (1,600); Belgium and Netherlands, 3,000 (3,900); Norway, 230 (740); Italy, 230 (50); and Poland, 220 (none). Exports of Metallurgical-grade ore in 1958 totaled 145,000 tons, compared with 381,000 tons in 1957, distributed as follows: France, 100,000 tons (279,000); United States, 14,000 (33,000); Norway, 12,000 (19,000); Germany, 6,400 (11,000); Yugoslavia, 6,400 (none); Sweden, 3,300 (none); Italy, 2,200 (13,000); England, 220 (20,000); Spain, 100 (5,700); and Switzerland, 70 (none).[48]

Rhodesia and Nyasaland, Federation of.—Of Northern Rhodesia's 1958 production, 38 percent came from the Kampumba mine (50.0 percent manganese), 23 percent from Mashimba (52.8 percent manganese), 18 percent from Chiwefwe (44.0 percent manganese), 7 percent from Bahati (48.8 percent manganese), 6 percent each from Lubemba (30.7 percent manganese) and Luano (47.0 percent manganese), and 2 percent from Fanie's mine (53.9 percent manganese). The Kampumba mine, lying about 50 miles east of Broken Hill, and the Chiwefwe mine, on the Great North Road, belonged to Gypsum Industries, Ltd., and the output was exported. Mashimba and Bahati mines were operated by Rhodesian Vanadium Corp., a subsidiary of Vanadium Corp. of America. These mines and the independent Fanie's mine, output of which was sold to the Vanadium Corp., are in the Ft. Roseberry district. Broken Hill Development Co., Ltd., operated the Lubemba mine in the Broken Hill district, and Nchanga Consolidated Copper Mines, Ltd., operated the Luano mine near Chingola; the mine output of each company was used in its own metallurgical plant. Exports from Northern Rhodesia in 1958 totaled 36,000 tons, and roughly two-thirds went to the United States as in 1957.[49]

South-West Africa.—Manganese ore mining operations of South African Minerals Corp., Ltd., were concentrated on a development program to establish and block out ore reserves.[50]

---

[46] U.S. Embassy, Rabat, Morocco, State Department Dispatch 476: Apr. 25, 1960.

[47] Work cited in footnote 43, p. 25.

[48] U.S. Consulate General, Casablanca, Morocco, State Department Dispatch 20: Aug. 20, 1959.

[49] U.S. Consulate General, Johannesburg, Union of South Africa, State Department Dispatch 78: Sept. 29, 1959.

[50] U.S. Consulate General, Cape Town, Union of South Africa, State Department Dispatch 88: Apr. 1, 1960.

Union of South Africa.—In 1958 manganese ore production and local sales were, respectively: 40 percent manganese and less, 602,000 and 347,000 short tons; 40 to 45 percent, 205,000 and 121,000 tons; 45 to 48 percent, 88,000 and 580 tons; and over 48 percent, 39,000 and 20 tons. Exports in 1958 totaled 383,000 tons, compared with 459,000 in 1957, distributed as follows (1957 in parentheses): United States, 171,000 (215,000); France, 71,000 (51,000); Germany, 42,000 (53,000); United Kingdom, 29,000 (51,000); Norway, 22,000 (14,000); Belgium, 20,000 (18,000); Italy, 10,000 (10,000); Sweden, 6,500 (15,000); Luxembourg, 5,700 (8,800); Canada, 2,800 (none); Netherlands, 1,600 (2,600); Japan, 300 (14,000); Austria, none (4,000); Denmark, none (1,700); and Switzerland, none (270).[51] In July 1959, South African Manganese, Ltd., began producing ore from its important new mine at Hotazel farm, Kuruman district. During the year, South African Railways began constructing a 40-mile extension of its line to this mine from the present terminus at Shishen, and arrangements were made by South African Manganese to supply electric power to Hotazel and other company mining operations by the end of 1960.[52] On December 1, 1959, Ferrometals, Ltd., formerly a subsidiary of Wire Industries Steel Products & Engineering Co., Ltd., became a wholly owned subsidiary of African Metals Corp. (AMCOR). It was expected that the ferroalloys to be produced by AMCOR in the two electric furnaces of the plant would include ferromanganese and silicomanganese.[53] The first of two 9,000-kv.-a. furnaces at the new Cato Ridge plant of Ferroalloys, Ltd., began producing ferromanganese early in August.[54] Both furnaces were reported in operation by yearend. Associated Manganese Mines of South Africa, Ltd., announced its intention to make Ferroalloys, Ltd., a wholly owned subsidiary by acquiring the remaining stock. An improvement in the supply of railway trucks on the South African Railways became evident in 1958, and the situation was greatly improved in 1959. Harbor facilities were being improved at Port Elizabeth to make it the Union's main port for export of bulk ore by 1962.

United Arab Republic (Egypt Region).—Exports of manganese ore in 1958 totaled 22,000 short tons, of which Netherlands received 7,000 tons, Poland 5,400, Switzerland 2,400, West Germany 2,200, Czechoslovakia 2,100, Yugoslavia 1,100, Spain 1,100, and United States 500.[55] A minerals agreement, including manganese and involving the Five Year Plan Authority, the Federal German Republic, and the Krupp and Demag companies, was signed December 22, 1959.[56]

OCEANIA

Australia.—Tasmanian Electro Metallurgical Co. Pty., Ltd., a newly formed, wholly owned subsidiary of Broken Hill Proprietary Co., Ltd., Australia's only steel producer, planned to build a plant at Bell Bay, northern Tasmania, to produce ferromanganese to be used in

---

[51] Work cited in footnote 43, p. 26.
[52] South African Mining and Engineering Journal (Johannesburg), vol. 70, No. 3486. Dec. 4, 1959, pp. 1501–1502.
[53] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 5, May 1960, p. 13.
[54] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 5, November 1959, p. 9.
[55] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 3, March 1960, pp. 26–28.
[56] Work cited in footnote 55, pp. 38–39.

Broken Hill's steel plants at Port Kembla and New Castle. Plans called for producing other electrometallurgical products later.[57]

Fiji.—In 1958, exports of manganiferous ore containing less than 35 percent manganese were 1,600 short tons.[58] A record shipment of 10,000 tons left Lautoka for Baltimore, Md., January 29, 1959.[59] Early in 1959, three large concerns and numerous small independent producers were producing and exporting manganese ore.

New Hebrides.—In January 1959, Cie. Francaise des Phosphates de l'Oceanie obtained a 25-year mining lease covering a manganese ore deposit at Forari on Efate Island. The ore has a manganese content of about 30 percent. Plans called for surface mining, concentration, and agglomeration to obtain a high-quality Metallurgical-grade shipping product at a ratio of about 2 tons run-of-mine ore to 1 ton of product. Exports were expected to be about 70,000 short tons a year after construction of a wharf at Metensa Bay. The ore is reported to contain titaniferous magnetite, which would be separated magnetically and which was expected to amount to 30,000 to 40,000 tons by the time the deposit is exhausted (20 years). Shipments are anticipated by mid-1962.[60]

TECHNOLOGY

Manganese extractions were over 90 percent in bench-scale tests made by the Federal Bureau of Mines at its College Park (Md.) and Salt Lake City (Utah) Metallurgy Research Centers. The Carosella melt-quench-leach process[61] was applied to Colorado rhodonite and to Aroostook County, Maine, siliceous manganiferous materials. The feed was melted or smelted to produce a manganiferous slag, and any iron went mostly to metal. Quenching with water granulated the slag, making it amorphous and readily soluble in dilute sulfuric or other acids.

The Bureau reported upon the operation of its Boulder City, Nev., dithionate-process pilot plant for leaching low-grade manganese ores. Low-grade ore from the Maggie Canyon deposit, Artillery Mountains, Ariz., and flotation middling and concentrate from the same ore were used as feed materials. The ore, middling, and concentrate assayed 9.6, 15.2, and 32.9 percent manganese, respectively; dithionate-process recoveries were 89, 93, and 96 percent to obtain a manganese hydroxide product containing 55 to 60 percent manganese. Capacity of the plant was approximately 1,440 pounds of product per day. In the process, finely ground manganese oxide ore was agitation-leached with dilute sulfur dioxide gas (13 percent SO_2 by volume) in a solution of calcium dithionate (CaS_2O_6). Excess dithionate was used to convert the manganese to manganese dithionate and precipitate calcium sulfate. After filtration, quicklime was added to precipitate manganese hydroxide, and calcium dithionate was regenerated at the

---

[57] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 4, April 1960, p. 8.
[58] U.S. Consulate, Suva, Fiji, State Department Dispatch 92: Mar. 19, 1959.
[59] U.S. Consulate, Suva, Fiji, State Department Dispatch 78: Feb. 13, 1959.
[60] U.S. Consulate, Suva, Fiji, State Department Dispatch 24: Oct. 24, 1959.
[61] Carosella, M. C., Extraction of Manganese: British Patent 785,307, Oct. 23, 1957; Chem. Abs. vol. 52, No. 5, Mar. 10, 1958, p. 3651f.

same time for recycling. In leaching, approximately 2 pounds of sulfur dioxide was consumed per pound of manganese recovered.[62]

The Bureau of Mines at Boulder City, Nev., also reported 93-percent extraction of manganese as manganese sulfate in laboratory studies of an acid-ferrous sulfate leach of Cuyuna range (Minnesota) manganiferous materials containing less than 10 percent manganese. In the method used, a raw material with its manganese and iron as carbonates was leached with sulfuric acid. In addition to manganese sulfate, acid-ferrous sulfate was formed, which then served as the leach agent for a second type of raw material in which the manganese occurred as oxides. By this means a reduction roast was avoided. Tests with a blend of the two raw materials consumed too much acid to be practical.[63]

From a mathematical analysis of the results obtained in assay and amenability tests of the ores purchased by the Government at the Deming, N. Mex., and Wenden, Ariz., purchase depots under the domestic manganese-purchase program, the following conclusions were reached by the Bureau at Salt Lake City, Utah: The composite ores stockpiled at each depot are siliceous and amenable to concentration by flotation of the manganese oxides without selective flotation of calcite. An estimated manganese recovery of 85 percent can be expected with a flotation concentrate which, after sintering, would assay about 45 percent manganese and 12 to 13 percent silica plus alumina and would meet other specifications for ferrograde material, whether a composite sample was used for each depot or a blend of ore from the two depots. The operation of the two depots was described.[64]

As a part of its work with high-damping manganese-copper alloys, the Bureau of Mines published a background report describing the theory, significance, and methods of measuring damping capacity and the instrumentation used by the Bureau at Rolla, Mo. A descriptive bibliography of 160 references concluded the report.[65]

A core-drill sampling project in Minnesota,[66] also investigations of manganese deposits in Nevada [67] and northeastern Oregon,[68] were reported by the Bureau of Mines.

In 8 of 11 samples of Arkansas manganiferous limestone studied by the Bureau at Rolla, Mo., concentrates were obtained with manganese contents ranging from 41.7 to 49.5 percent. Recoveries ranged from 48.2 to 66.0 percent. Manganese content of the raw material ranged from 3.5 to 7.7 percent. Gangue flotation was combined with

---

[62] Rampacek, Carl, Fuller, H. C., and Clemmer, J. B., Operation of a Dithionate-Process Pilot Plant for Leaching Manganese Ore From Maggie Canyon Deposit, Artillery Mountains Region, Mohave County, Ariz.: Bureau of Mines Rept. of Investigations 5508, 1959, 54 pp.

[63] Dolezal, H., and Fuller, H. C., Acid-Ferrous Sulfate Leaching of Low-Grade Manganese Carbonate and Oxide Ores, Cuyuna Range, Minnesota: Bureau of Mines Rept. of Investigations 5442, 1959, 27 pp.

[64] Agey, W. W., Batty, J. V., Knutson, E. G., and Hanson, G. M., Operations of Manganese-Ore-Purchasing Depots at Deming, N. Mex., and Wenden, Ariz: Bureau of Mines Rept. of Investigations 5462, 1959, 18 pp.

[65] Jensen, J. W., Damping Capacity—Its Measurement and Significance: Bureau of Mines Rept. of Investigations 5441, 1959, 46 pp.

[66] Heising, Leonard F., Marovelli, Robert L., Wasson, Paul A., Cooke, S. R. B., and Pennington, James W., Core-Drill Sampling of Cuyuna-Range Manganiferous Iron Formations, Crow Wing County, Minn.: Bureau of Mines Rept. of Investigations 5450, 1959, 34 pp.

[67] Trengove, Russell R., Reconnaissance of Nevada Manganese Deposits: Bureau of Mines Rept. of Investigations 5446, 1959, 40 pp.

[68] Appling, Richard N., Jr., Manganese Deposits of Northeastern Oregon: Bureau of Mines Rept. of Investigations 5472, 1959, 23 pp.

tabling to produce a concentrate that was then leached with dilute sulfuric acid to remove phosphorus and limestone gangue.[69]

Among the heats of formation, determined or verified by the Bureau at Berkeley, Calif., was that for anhydrous manganous chloride from the elements (−115,190 ± 120 calories per mole at 298.15° K.).[70]

Hydrometallurgical processes, developed by Republic Steel Corp. for recovering manganese from ferruginous low-grade manganese ores in which the manganese occurs in different valences, have been patented. In Republic's fundamental chloridization process,[71] the ore is leached with a calcium chloride solution, saturated with sulfur dioxide, under conditions that prevent access of external oxidizing agents. The manganese goes into solution as manganese chloride, and insoluble sulfites or sulfates of calcium and some metals other than manganese are precipitated. These, together with the gangue, are separated from the manganese-bearing solution by filtration or other means. When a milk of lime slurry is added to the solution, manganese is precipitated as oxides or hydrated oxides. In an improved process, designed to recover more sulfur dioxide for recycling, manganese is leached from the ore with a saturated aqueous solution of sulfur dioxide in the absence of air or oxygen, leaving most of the iron undissolved. This leach may be accomplished with or without application of heat or pressure, depending upon costs. Although not essential to the process, reduction of the higher valence manganese before or during the leach might be advantageous economically. After separating the solids, comprised of gangue, iron, and some undissolved manganese, the remaining sulfurous acid solution of manganese sulfite and manganese sulfate is boiled to remove excess sulfur dioxide for recycling and to precipitate manganese sulfite. Upon calcination, more sulfur dioxide and an oxide of manganese are obtained from this precipitate. The remaining solution is treated with calcium chloride to convert its manganese to the water-soluble chloride, which then can be processed to oxides as before.[72] An alternate process, involving no chloridization and simpler in some respects, begins with a sulfur dioxide saturated solution of manganese sulfite and manganese sulfate. The solution is reacted with calcium bisulfite in the absence of virtually all oxygen and halide ions, whereupon its manganese sulfate is converted to manganese sulfite and a precipitate of calcium sulfate formed. After removal of solids, the solution is heated to drive off excess sulfur dioxide and to precipitate most of the manganese sulfite. Calcining this precipitate yields an oxide of manganese and sulfur dioxide for recycling. The use of reduction, heat, or pressure again presents possible variations of the process, dependent upon comparative costs.[73]

---

[69] Fine, M. M., Ferrograde Concentrates From Arkansas Manganiferous Limestone: Min. Eng., vol. 11, No. 8, August 1959, pp. 810–812.

[70] Koehler, Mary F., and Coughlin, J. P., Heats of Formation of Ferrous Chloride, Ferric Chloride and Manganous Chloride: Jour. Phys. Chem., vol. 63, No. 605, 1959. pp. 605–608.

[71] Daugherty, Charles C., Recovery of Manganese From Ores: U.S. Patent 2,747,965, May 29, 1956.

[72] Daugherty, Charles C., Recovery of Manganese From Ores: U.S. Patent 2,890,103, June 9, 1959.

[73] Daugherty, Charles C., Recovery of Manganese From Ores: U.S. Patent 2,890,104, June 9, 1959.

The Committee on Oceanography, National Academy of Sciences, recommended investigation of the potential mineral resources of the deep sea floors.[74] Manganese is one of the most promising of these resources. Although areal coverage of the manganese deposits is believed to be large, the actual thickness is unknown. Thickness is measured in inches, and the bottom is not reached.

Over 125 million gallons of antiknock gasoline, treated with methylcyclopentadienyl manganese tricarbonyl as a supplement to tetraethyl lead, was reported to have been used by the public with highly satisfactory results. It was being made available in commercial quantities to refiners.[75] Methylcyclopentadienyl manganese tricarbonyl, as well as other suitable cyclopentadienyl manganese compounds, was best made by electrolyzing a manganese compound, preferably a chloride, in an electrolyte containing a cyclopentadiene hydrocarbon and gaseous carbon monoxide in the presence of a transition metal carbonyl.[76]

---

[74] National Academy of Sciences, National Research Council, Oceanography 1960 to 1970—1. Introduction and Summary of Recommendations: 1959, p. 23.

[75] American Metal Market, vol. 66, No. 195, Oct. 6, 1959, p. 6; No. 198, Oct. 9, 1959, p. 10.

[76] Pearson, Tillmon H., Cyclopentadienyl Manganese Compounds: U.S. Patent 2,915,440, Dec. 1, 1959.

Mercury

By J. W. Pennington [1] and Gertrude N. Greenspoon [2]

◆

DOMESTIC mercury production in 1959 declined for the first time since 1950. Output was reduced in every major producing State except Alaska. Increased demands by nearly all principal users caused the consumption of mercury in the United States to rise about 5 percent and to exceed 52,000 flasks for the fifth consecutive year. The average price of $227 a flask was almost the same as in 1958. Imports continued at the 1958 rate of 31,000 flasks.

The only active government program was continued assistance in exploration for mercury. However, 6,000 flasks of mercury was received through barter transactions made in 1958.

Because of reduced output in Italy, Mexico, Spain, and the United States, world production of mercury fell to 232,000 flasks and reversed a 10-year upward trend.

TABLE 1.—Salient mercury statistics, in 76-pound flasks

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Production	11,451	18,955	24,177	34,625	38,067	31,256
Value (thousands)	$2,414	$5,504	$6,284	$8,552	$8,720	$7,110
Number of producing mines	44	98	147	120	101	71
Imports:						
For consumption	64,829	20,354	47,316	42,005	[1] 30,196	30,141
General	65,056	20,948	52,009	45,449	[1] 30,973	30,260
Exports	505	451	1,080	1,919	320	640
Reexports	834	267	2,025	3,275	934	553
Stocks at end of year	29,937	10,028	22,310	25,388	11,274	13,580
Producers	1,157	928	1,210	3,588	674	1,880
Consumers and dealers	28,780	9,100	21,100	21,800	10,600	11,700
Consumption	48,735	57,185	54,143	52,889	52,617	54,895
Average price per flask: New York	$189.58	$290.35	$259.92	$246.98	$229.06	$227.48
World: Production	156,000	185,000	[1] 221,000	[1] 246,000	[1] 251,000	232,000

[1] Revised figure.

LEGISLATION AND GOVERNMENT PROGRAMS

Through the Office of Minerals Exploration (OME), mercury exploration continued to be eligible for assistance, with 50-percent government participation. One contract was executed on June 19, 1959, with Oregon Cinnabar Mines, Inc., for exploration of the Big

---

[1] Assistant chief, Branch of Base Metals.
[2] Statistical assistant.

Muddy prospect, Jefferson County, Oreg. The total amount of the contract was $47,910.

Mercury was not on the U.S. Department of Agriculture's list of materials eligible for acquisition through barter or exchange transactions in 1959. However, 6,000 flasks was received in 1959 from Spain under barter transactions made in 1958.

DOMESTIC PRODUCTION

Annual production of primary mercury in the United States declined for the first time since 1950; output was 18 percent less than in 1958 and the lowest since 1956. All principal mercury-producing States, except Alaska, had lower outputs. The number of producing properties decreased to 71, and the quantities of ore treated and mercury recovered each dropped 16 percent. As in 1958, mercury recovery averaged 8.6 pounds per ton of ore. Output of secondary mercury dropped 8 percent.

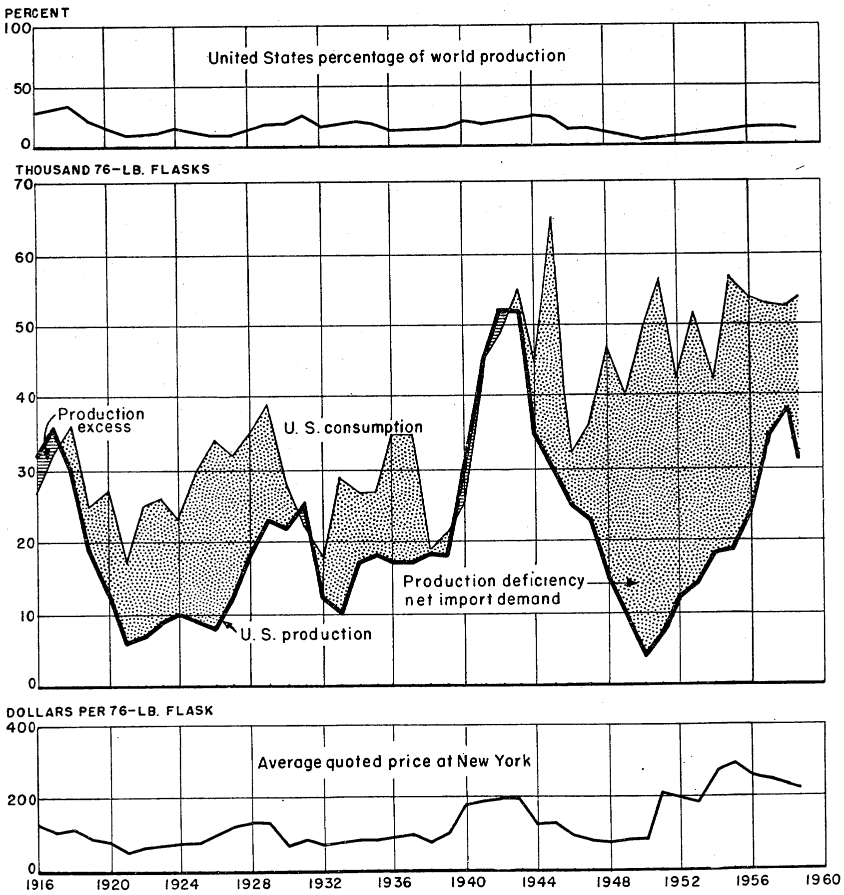

FIGURE 1.—Trends in production, consumption, and price of mercury, 1916–59.

Despite a 24-percent drop in mercury output, California remained the leading mercury-producing State and supplied 55 percent of the U.S. total. The four principal producers—the Abbott, New Idria, Buena Vista, and Mount Jackson (including Great Eastern) properties—operated at reduced rates and accounted for only 81 percent of the State total compared with 86 percent in 1958.

Nevada continued to be the second largest mercury-producing State. Output dropped only 2 percent from the peak of 1958; however, its contribution to the total U.S. output rose from 19 to 23 percent. The Cordero mine was, as usual, the leading producer in the State and ranked second in the United States.

The history, geology, exploration, development, mining methods, processing plant, and auxiliary facilities of the Cordero mine were discussed in detail.[3] Another article described the modification in mining methods developed to overcome the difficult problem of sticky ore at the Cordero mine.[4]

Increased production at the Red Devil mercury mine, Kuskokwim River region, raised Alaska's mercury output 11 percent. Consequently, Alaska supplied 12 percent of total U.S. mercury production and ranked third for the third successive year.

Although mercury production in Idaho dropped 25 percent, the State continued to rank fourth, and supplied 6 percent of the U.S. total. The Hermes mines in Valley County were inactive in the latter part of the year, and output at the Idaho-Almaden mine in Washington County dropped 18 percent from 1958.

A 46-percent decrease resulted in the lowest mercury output in Oregon since 1955. The State's contribution to the total U.S. production fell from 6 percent in 1958 to 4 percent in 1959. Substantially reduced operations at the Bretz mine in Malheur County were chiefly responsible for the decreased output.

TABLE 2.—Mercury produced in the United States, by States

Year and State	Producing mines	76-pound flasks	Value [1]
1956:			
Alaska	2	3,280	$852,538
Arizona and Texas	8	734	190,781
California	71	9,017	2,343,699
Idaho	2	3,394	882,168
Nevada	51	5,859	1,522,871
Oregon	13	1,893	492,029
Total	147	24,177	6,284,086
1957:			
Alaska	2	5,461	1,348,758
Arizona	5	28	6,915
California	57	16,511	4,077,887
Idaho	2	2,260	558,174
Nevada	44	6,313	1,559,185
Oregon	8	3,993	986,191
Texas and Washington	2	59	14,572
Total	120	34,625	8,551,682
1958:			
Alaska	2	3,380	$774,223
Arizona	4	53	12,140
California	48	22,365	5,122,927
Idaho	3	2,625	601,282
Nevada	35	7,336	1,680,384
Oregon	7	2,276	521,341
Texas and Washington	2	32	7,330
Total	101	38,067	8,719,627
1959:			
Alaska	2	3,743	851,458
California	37	17,100	3,889,908
Idaho	2	1,961	446,088
Nevada	20	7,156	1,627,847
Oregon	4	1,224	278,435
Arizona and Texas	6	72	16,379
Total	71	31,256	7,110,115

[1] Value calculated at average price at New York.

---

[3] Gilbert, J. Eldon, and Haas, Verne P., Cordero-Nevada's Largest Hg Mine: Eng. Min. Jour., vol. 160, No. 3, March 1959, pp. 88–90.

[4] Fisk, Elwin L., Slusher Pockets Whip Sticky Ore Problem at Cordero: Eng. Min. Jour., vol. 160, No. 3, March 1959, pp. 91–92.

TABLE 3.—Mercury ore treated and mercury produced in the United States[1]

Year	Ore treated (short tons)	Mercury produced	
		76-pound flasks	Pounds per ton of ore
1955	222,740	18,819	6.4
1956	244,148	24,109	7.5
1957	309,632	34,058	8.4
1958	328,155	37,209	8.6
1959	275,903	31,109	8.6

[1] Excludes mercury produced from placer operations and from cleanup activity at furnaces and other plants.

A total of 71 mercury mines, compared with 101 in 1958, contributed to production; 7 properties, each producing 1,000 flasks or more, supplied 82 percent of the U.S. total. The leading producers were as follows:

State:	*County*	*Mine*
Alaska	Aniak district	Red Devil.
California	Lake	Abbott.
	San Benito	New Idria.
	San Luis Obispo	Buena Vista.
	Sonoma	Mount Jackson (including Great Eastern).
Idaho	Washington	Idaho-Almaden.
Nevada	Humboldt	Cordero.

In addition to the foregoing mines, the following mercury operations produced 100 flasks or more:

State:	*County*	*Mine*
Alaska	Aniak district	Schaefer's Cinnabar.
California	San Benito	San Carlos.
	Santa Barbara	Gibraltar.
	Santa Clara	Guadalupe, New Almaden mine and dumps.
	Trinity	Altoona.
Idaho	Valley	Hermes.
Nevada	Esmeralda	B&B.
	Humboldt	Cahill.
	Nye	Horse Canyon.
Oregon	Douglas	Bonanza.
	Malheur	Bretz.

These 19 miles produced 98 percent of the domestic mercury output.

Production of mercury from secondary sources was 8 percent below 1958. Mercury was reclaimed from dental amalgam, oxide and acetate sludges, and battery scrap.

TABLE 4.—Production of secondary mercury in the United States, in 76-pound flasks

Year:	*Quantity*
1955	10,030
1956	5,850
1957	5,800
1958	5,400
1959	4,950

CONSUMPTION AND USES

Consumption of mercury rose 4 percent to the largest quantity since 1955 and, excepting 1955, was the highest in any peacetime year. The installation of a new chlorine and caustic soda plant using mercury cells at Deer Park, Tex., and expansion of similar plants at Anniston, Ala., and Calvert City, Ky., were partly responsible for the increase in consumption.

The quantity of mercury required to replace losses in the manufacture of chlorine and caustic soda rose for the fifth successive year, and 28 percent more metal was used than in 1958. Consumption of mercury in agriculture, including paper and pulp manufacture (now shown separately in table 5) rose 21 percent; use in pharmaceuticals gained 20 percent; and use as catalysts increased 18 percent. Consumption of mercury in dental preparations rose 5 percent and for manufacturing industrial and control instruments 2 percent. Of the principal uses, only electrical apparatus required less metal than in 1958, and consumption dropped 5 percent to the lowest figure since 1952.

Although mercury used for slime-control compounds in paper and pulp manufacture has been included with the figures for agricultural uses for many years, the estimated quantity consumed for those compounds is now shown separately in table 5. Mercury consumed in mildew-proofing paint, previously included in the data under "Other", also is shown separately. The use of mercury in fulminate and blasting caps ceased in 1956 and is included with "Other" for 1950–56, inclusive, in the table.

TABLE 5.—Mercury consumed in the United States, in 76-pound flasks

Use	1950–54 (average)	1955	1956	1957	1958	1959
Agriculture (includes insecticides, fungicides, and bactericides for industrial purposes)	6,543	7,399	9,930	6,337	6,270	3,202
Amalgamation	180	217	239	244	248	265
Catalysts	1,569	729	871	859	816	965
Dental preparations [1]	1,163	1,177	1,328	1,371	1,741	1,828
Electrical apparatus [1]	10,156	9,268	9,764	9,151	9,335	8,905
Electrolytic preparation of chlorine and caustic soda	1,975	3,108	3,351	4,025	4,547	5,828
General laboratory use	834	976	984	894	968	1,110
Industrial and control instruments [1]	5,737	5,628	6,114	6,028	6,054	6,164
Paint:						
Antifouling	1,596	724	511	568	749	993
Mildew proofing	(2)	(2)	(2)	(2)	(2)	2,521
Paper and pulp manufacture	(3)	(3)	(3)	(3)	(3)	4,360
Pharmaceuticals	2,771	1,578	1,600	1,751	[4] 1,430	1,717
Redistilled [1]	8,198	9,583	9,483	9,703	9,448	9,331
Other	8,013	16,798	9,968	11,958	[4] 11,011	7,706
Total	48,735	57,185	54,143	52,889	52,617	54,895

[1] A breakdown of the "redistilled" classification showed ranges of 53 to 39 percent for instruments, 14 to 5 percent for dental preparations, 44 to 21 percent for electrical apparatus, and 12 to 8 percent for miscellaneous uses in 1950–58, compared with 43 percent for instruments, 10 percent for dental preparations, 37 percent for electrical apparatus, and 10 percent for miscellaneous uses in 1959.

[2] Data not available.

[3] Included with agriculture.

[4] Revised figure.

STOCKS

Consumers' and dealers' stocks of mercury rose 10 percent, despite withdrawals from inventories for installation and expansions of chlorine and caustic soda plants; however, stocks were less than normal for those segments of the industry.

Although stocks held by producers usually comprise only a small part of the total for the industry they were more than double those at the end of 1958.

In addition to the stocks of metal shown in table 6, the national stockpile contained inventories of metal that may not be disclosed.

TABLE 6.—Stocks of mercury producers, consumers, and dealers, in 76-pound flasks

End of year	Producers	Consumers and dealers	Total
1950-54 (average)	1,157	28,780	29,937
1955	928	9,100	10,028
1956	1,210	21,100	22,310
1957	3,588	21,800	25,388
1958	674	10,600	11,274
1959	1,880	11,700	13,580

Mercury withdrawn from stocks for installation and expansion of chlorine and caustic soda plants, mercury-boiler plants, and other nondissipative uses actually constitutes a reserve of metal. In the event that the plants are dismantled or more urgent demands for mercury develop, such mercury could be reclaimed and used. At the end of 1959, the quantity of mercury in use at chlorine and caustic soda plants totaled 94,000 flasks and in boilers nearly 22,000 flasks.

PRICES

The average price for mercury in the United States was almost the same as in 1958 but was the lowest since 1953. The price quotation of \$218–\$222 a flask, established in late December 1958, held through early March 1959, except for a slight increase to \$223 in the upper range in January 1959. An upward trend thereafter brought the price to \$245–\$249 through most of May. The price dropped gradually the last 6 months of 1959, and the year ended with the price at \$212–\$214 a flask.

The average price for the year in London was \$208.61 a flask, 3 percent less than in 1958. At the beginning of the year mercury was quoted at £74 (equivalent to \$207.20); it fluctuated between that price and £79 (\$221.20) until mid-August when it dropped to £71 10s. (\$200.20). In September mercury was quoted at a range of £71 10s.–£72 (\$200.20–\$201.60), and except for a small increase to £72 in late October the year ended with the price in this range.

TABLE 7.—Average monthly prices per 76-pound flask of mercury at New York and London

Month	1957		1958		1959	
	New York[1]	London[2]	New York[1]	London[2]	New York[1]	London[2]
January	$255.00	$236.94	$220.69	$199.74	$218.00	$207.68
February	255.00	236.96	221.86	210.83	218.00	207.89
March	255.00	238.28	231.69	218.19	224.64	209.90
April	255.00	239.85	231.08	218.33	240.55	220.81
May	255.00	248.12	229.23	215.40	245.00	218.48
June	255.00	254.26	228.12	215.05	240.27	215.86
July	254.31	248.81	230.04	217.31	236.13	210.88
August	251.11	240.43	237.77	221.60	229.38	202.56
September	244.75	238.13	238.20	221.46	223.81	201.17
October	231.62	213.06	232.77	220.07	223.33	201.63
November	226.96	197.23	227.05	216.02	216.61	201.62
December	225.00	193.60	220.18	207.48	214.09	200.79
Average	246.98	232.36	229.06	214.98	227.48	208.61

[1] Engineering and Mining Journal, New York.

[2] Mining Journal (London) prices in terms of pounds sterling were converted to American dollars by using average rates of exchange recorded by Federal Reserve Board.

FOREIGN TRADE[5]

Imports.—Imports of mercury for consumption in the United States totaled 30,100 flasks, including 6,000 flasks received through barter from Spain. In addition to the mercury received through barter, 5 flasks of scrap mercury was received from Canada duty free.

The chief suppliers to the United States were Spain (57 percent), Italy (20 percent), Mexico (12 percent), and Chile and Yugoslavia (each 3 percent). Of the principal mercury-producing countries, Italy and Yugoslavia shipped more metal to the United States than in 1958. Small quantities were received from Canada, Bolivia, Chile, Peru, United Kingdom, Philippines, Turkey, Australia, and New Zealand. The metal from Turkey was the first to be received since 1956, and that from Australia and New Zealand the first since data on imports for consumption became available in 1934.

Imports of various mercury compounds, usually insignificant, were more than four times the imports in 1958. Of 40,302 pounds (8,685 in 1958) of mercuric chloride, corrosive sublimate, mercurous chloride (calomel), oxide (red precipitate), and other mercury preparations imported in 1959, 26,187 pounds came from Yugoslavia, 9,468 from the United Kingdom, 4,205 from Spain, 441 from Sweden, and 1 from Israel; 220 pounds of vermilion reds was imported from Italy.

---

[5] Figures on U.S. imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 8.—Mercury imported for consumption in the United States, in 76-pound flasks

[Bureau of the Census]

Country	1950–54 (average)		1955		1956		1957		1958		1959	
	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)
North America:												
Canada	215	$41	114	$37	80	$21	66	$16	50	$7	125	$23
Honduras	2	(1)										
Mexico	7,743	1,227	10,250	2,546	11,536	2,618	5,280	1,023	[2] 8,251	1,506	3,516	646
Total	7,960	1,268	10,364	2,583	11,616	2,639	5,346	1,039	[2] 8,301	1,513	3,641	669
South America:												
Bolivia	4	(1)							9	2	11	2
Chile					25	6			514	102	813	164
Colombia							15	4	80	12		
Peru	1	(1)	95	26	372	89	244	52	[2] 345	61	589	112
Total	5	(1)	95	26	397	95	259	56	[2] 948	177	1,413	278
Europe:												
Denmark	60	4										
Germany, West	50	8										
Italy	24,283	3,596	629	179	16,810	3,934	8,056	1,869	1,133	221	6,146	1,256
Netherlands	215	16			20	5						
Spain	25,090	3,334	5,458	1,302	15,713	3,667	25,276	5,677	[2] 18,494	[2] 3,729	17,111	3,400
Sweden	348	34										
Switzerland	41	5										
United Kingdom	170	11	1	(1)	350	78	2,500	560	(3)	(1)	235	48
Yugoslavia	6,378	946	3,807	1,059	2,350	579	568	132	220	46	954	198
Total	56,635	7,954	9,895	2,540	35,243	8,263	36,400	8,238	[2] 19,847	[2] 3,996	24,446	4,902
Asia:												
India	5	1										
Japan	214	11										
Philippines									1,100	236	400	81
Turkey					60	13					100	36
Total	219	12			60	13			1,100	236	500	117
Africa: Morocco	10	2										
Oceania:												
Australia											126	23
New Zealand											15	3
Total											141	26
Grand total	64,829	[4] 9,236	20,354	5,149	47,316	11,010	42,005	9,333	[2] 30,196	[2] 5,922	30,141	5,992

[1] Less than $1,000. [2] Revised figure. [3] Less than 1 flask. [4] 1954 data known to be not comparable with other years.

TABLE 9.—Mercury imported (general imports)[1] into the United States, in 76-pound flasks

[Bureau of the Census]

Country	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada	215	114	80	66	50	125
Honduras	2					
Mexico	7,991	10,310	12,502	5,991	[2] 8,350	3,631
Total	8,208	10,424	12,582	6,057	[2] 8,400	3,756
South America:						
Bolivia	4				9	11
Chile			125		1,160	400
Colombia				15	80	30
Peru	1	95	372	244	[2] 345	599
Total	5	95	497	259	[2] 1,594	1,040
Europe:						
Denmark	60					
Germany, West	50					
Italy	24,283	579	17,592	9,208	1,015	6,175
Netherlands	195		20			
Spain	25,128	5,524	18,104	25,993	[2] 18,644	17,509
Sweden	348					
Switzerland	41					
United Kingdom	(3)	1	564	2,500	(3)	185
Yugoslavia	6,503	4,325	2,590	1,432	220	954
Total	56,608	10,429	38,870	39,133	[2] 19,879	24,823
Asia:						
Japan	214					
Philippines					1,100	400
Turkey	11		60			100
Total	225		60		1,100	500
Africa: Morocco	10					
Oceania:						
Australia						126
New Zealand						15
Total						141
Grand total	65,056	20,948	52,009	45,449	[2] 30,973	30,260

[1] Data are "general" imports; that is, they include mercury imported for immediate consumption plus material entering the country under bond.
[2] Revised figure.
[3] Less than 1 flask.

Exports.—Exports of mercury, usually small, were double the 1958 quantity. Of the 640 flasks exported (320 in 1958), 382 flasks (41) went to Canada, 68 (19) to Colombia, 46 (none) to Korea, 32 (36) to Saudi Arabia, 20 (39) to Venezuela, 20 (none) to Netherlands Antilles, 19 (39) to Cuba, 15 (less than 1 flask) to Brazil, 11 (none) to Nicaragua, 10 (none) to Haiti, and the remainder in lots of less than 10 flasks each to seven other countries.

TABLE 10.—Mercury exported from the United States

[Bureau of the Census]

Year	76-pound flasks	Value	Year	76-pound flasks	Value
1950–54 (average)	505	$94,171	1957	1,919	$483,892
1955	451	155,433	1958	320	95,003
1956	1,080	284,418	1959	640	92,255

Reexports.—Reexports totaled 553 flasks compared with 934 flasks in 1958. Of the total reexported, 373 (none in 1958) went to Argentina, 105 (293) to Canada, 55 (40) to Taiwan, 16 (150) to Venezuela, and 4 (5) to Cuba.

Tariff.—The duty of 25 cents a pound ($19 a flask) on imports of mercury, in effect since 1922, was continued.

TABLE 11.—Mercury reexported from the United States

[Bureau of the Census]

Year	76-pound flasks	Value	Year	76-pound flasks	Value
1950–54 (average)	834	$127,411	1957	3,275	$763,303
1955	267	77,664	1958	934	198,501
1956	2,025	475,667	1959	553	119,038

WORLD REVIEW

World production of mercury reversed the upward trend of the past 10 years by dropping 8 percent below 1958. Decreases of 27 percent in Mexico, 22 percent in Italy, 18 percent in the United States, and 14 percent in Spain were responsible for the lower output.

TABLE 12.—World production of mercury, by countries,[1] in 76-pound flasks[2]

[Compiled by Augusta W. Jann and Berenice B. Mitchell]

Country[1]	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Mexico	9,390	29,881	19,529	21,068	22,560	16,420
United States	11,451	18,955	24,177	34,625	38,067	31,256
South America:						
Bolivia (exports)	4	---------	---------	---------	10	12
Chile	189	526	575	678	3,343	[3] 4,200
Colombia	---------	36	---------	99	203	[3] 300
Peru	15	148	335	411	1,983	[4] 2,727
Europe:						
Austria	26	16	6	6	---------	[3] 6
Czechoslovakia[5]	725	725	725	725	725	[3] 725
Italy	53,781	53,520	62,309	63,237	58,712	45,833
Spain	44,420	36,231	48,269	54,750	55,382	47,863
U.S.S.R.[3]	[5] 11,900	[5] 12,300	22,000	25,000	25,000	25,000
Yugoslavia	14,471	14,591	13,228	12,328	12,270	13,344
Asia:						
China[3]	5,000	11,500	17,000	17,000	17,000	23,000
Japan	4,582	4,990	8,334	11,872	10,900	16,051
Philippines	---------	635	3,015	3,363	3,321	3,613
Taiwan	9	58	---------	---------	---------	---------
Turkey	52	841	1,079	720	1,486	[3] 1,300
Africa: Tunisia	---------	166	22	---------	39	198
World total (estimate)	156,000	185,000	221,000	246,000	251,000	232,000

[1] Rumania and a few other countries may also produce a negligible amount of mercury, but production data are not available.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Estimate.

[4] Exports.

[5] Estimate according to the 46th Annual issue of Metal Statistics (Metallgesellschaft) except Czechoslovakia 1959.

Chile.—Production of mercury in Chile, which had dropped to less than 1,000 flasks annually after 1944, rose to 4,200 flasks in 1959. Virtually the entire output came from the Los Mantos gold mine near Punataqui operated by Cia. Minera Tamaya. The low-grade ore was concentrated by flotation, mixed with lime, dried in a rotary kiln, and then retorted.

Colombia.—From time to time small quantities of mercury have been produced in Colombia. It was reported[6] that the La Esperanza mine can produce about 400 flasks annually, but output has been adversely affected by labor strikes. Full productive capacity was expected to be reached in 1959.

Italy.—Italy, the world's largest mercury-producing country since 1947, dropped to second place in 1959. Output fell 22 percent below 1958 and was the lowest since 1949. Production was reportedly curtailed because of falling prices and rising inventories.

On May 19, a government announcement suspended, retroactive to February 1, the manufacturing tax of 32,000 lire ($51.20) per flask of metal and 800 lire, ($1.28) per kilogram of mercury in ore that had been instituted on November 24, 1954.[7]

TABLE 13.—Exports of mercury from Italy, by countries of destination, in 76-pound flasks[1] [2]

[Compiled by Bertha M. Duggan and Corra A. Barry]

Country	1958	1959	Country	1958	1959
Argentina	308	29	Netherlands	1,137	1,601
Australia	136	540	Norway	3	252
Brazil	400	6	Poland	1,500	1,018
Canada	600	----------	Switzerland	49	560
Czechoslovakia	789	119	Union of South Africa	41	293
Denmark	----------	3,501	United Kingdom	2,910	10,626
Finland	----------	1,099	United States	949	5,967
France	1,389	2,149	Other countries	206	653
Germany, West	986	6,489			
India	3	238	Total	11,406	35,140

[1] Compiled from Customs Returns of Italy.
[2] This table incorporates some revisions.

Japan.—Mercury was produced from domestic and imported ores and secondary materials. Total output exceeded that in 1958 by 47 percent, and production facilities were being further expanded because of the steady increase in consumption.

TABLE 14.—Exports of mercury from Mexico, by countries of destination, in 76-pound flasks[1]

[Compiled by Bertha M. Duggan and Corra A. Barry]

Country	1958	1959	Country	1958	1959
Canada	816	27	United States	16,606	10,488
France	541	450	Other countries	95	399
Germany	2,979	1,135			
Japan	1,149	6,062	Total	26,160	20,888
United Kingdom	3,974	2,327			

[1] Compiled from Customs Returns of Mexico.

---

[6] Chaplin, Maxwell (second secretary), Annual Minerals Report—Colombia 1958: State Department Dispatch 83, Bogota, Colombia, Aug. 18, 1959, 11 pp.
[7] American Metal Market, Mercury: Vol. 66, No. 96, May 20, 1959, p. 7.

Philippines.—Mercury output in the Philippines rose 9 percent above that of 1958 to 3,600 flasks. As usual, the entire production came from the sole producer—Palawan Quicksilver Mines, Inc. According to the company's annual report, the plant can treat 75,000 tons of ore and recover about 4,200 flasks of mercury annually. The ore reserve was estimated to be about 450,000 tons which, calculated from company data, would average slightly over 4 pounds of mercury a ton.

Spain.—Mercury production in Spain decreased 14 percent but still exceeded Italy's output by 2,000 flasks, and Spain rose to first place among the principal mercury-producing countries. Virtually the entire output came from the Government-owned Almaden mine in Ciudad Real Province.

TABLE 15.—Exports of mercury from Spain, by countries of destination, in 76-pound flasks[1]

[Compiled by Bertha M. Duggan and Corra A. Barry]

Country	1958	1959	Country	1958	1959
Austria	60	1,356	Netherlands	1,026	997
Belgium-Luxembourg	305	300	Portugal	253	138
Brazil	1,058	859	Sweden	288	1,884
Canada	220	851	Switzerland	1,481	530
China	---	385	United Arab Republic (Egypt Region)	450	121
Czechoslovakia	---	2,352	United Kingdom	10,283	6,755
Denmark	1,151	---	United States	20,206	14,018
Finland	100	656	Other countries	263	203
France	6,525	5,130			
Germany	3,237	5,119			
India	3,824	1,365	Total	50,730	43,019

[1] Compiled from Customs Returns of Spain.

Turkey.—Plans were announced to develop the Haliko mercury deposit in Ismir Province, where a reserve of 284,000 tons of 0.44-percent ore has been proved by drilling. Development of a new mercury deposit north of Kastamonu and substantial additions to the known mercury reserve in the Konya area were reported. It was predicted that mercury metal output from the Kadihan area of Konya Province would be possible at a rate of 50 tons per year.

United Kingdom.—Effective January 2, 1959, mercury was removed from the United Kingdom's list of materials embargoed for export to the Soviet bloc and China.

Foreign-trade data for the United Kingdom indicated that 20,700 flasks of mercury was consumed in 1959, and is given below. Imports of metal rose for the second successive year, but the amount of reexports was unchanged from 1958. The new supply of mercury available for consumption rose 47 percent.

	1950-54 (average)	1955	1956	1957	1958	1959
Imports	26,600	12,900	19,600	18,200	19,200	25,700
Reexports	6,620	3,300	4,000	15,300	5,100	5,000
Apparent consumption	19,980	9,600	15,600	2,900	14,100	20,700

Reexports of mercury in 76–pound flasks in 1958 were as follows:

Destination:	*1958*
Australia	654
Belgium	264
Denmark	264
Finland	190
France	300
Germany, West	458
Hong Kong	153
India	1,124
Netherlands	300
Sweden	316
Union of South Africa	521
Other	596
	5,140

TABLE 16.—Exports of mercury from Yugoslavia, by countries of destination, in 76-pound flasks [1] [2]

[Compiled by Bertha M. Duggan and Corra A. Barry]

Country	1958	1959 [3]	Country	1958	1959 [3]
Austria	513	937	United Kingdom	50	450
France	706	1,006	United States	----------	550
Germany, West	2,374	1,430	Other countries	1	----------
Italy	----------	210			
Sweden	70	15	Total	4,114	4,778
Switzerland	400	180			

[1] Compiled from Customs Returns of Yugoslavia.
[2] This table incorporates some revisions.
[3] January through September, inclusive.

TECHNOLOGY

The Federal Bureau of Mines published [8] a comprehensive report on mercury which covered properties, uses, resources, technology, supply and distribution, marketing, and grades and specifications of mercury. The survey was prepared with the cooperation of the U.S. Geological Survey for the Office of Civil and Defense Mobilization.

Basic mercuric sulfate, $H_gSO_4 \cdot 2H_2O$, has been found in several quicksilver deposits in the Western United States and named "Schuetteite" in honor of C. N. Schuette, a specialist on mercury deposits.[9] The mineral is canary yellow and does not darken on exposure to bright light. It has a specific gravity of 8.18.

A new portable instrument, capable of detecting concentration of mercury vapor in the range of 0 to 1.0 milligram per cubic meter, was developed.[10] Rapid spot measurements of toxic mercury concentrations are possible through the use of a chemical-indicator glass tube and aspirator bulb.

---

[8] Pennington, James W., Mercury, A Materials Survey: Bureau of Mines Inf. Cir. 7941, 1959, 92 pp.

[9] Bailey, E. H. Hildebrand, F. A., Christ, C. L., and Fahey, J. J., Schuetteite, A New Supergene Mercury Mineral: Am. Miner, vol. 44, Nos. 9 and 10, September–October 1959, pp. 1026–1038.

[10] Precambrian-Mining in Canada, New Mercury Vapor Detector: Vol. 32, No. 11, November 1959, p. 33.

It was reported that protection from mercury poisoning may be possible soon by taking a tablet orally.[11] In experimental tests, rats were protected from the lethal effects of mercuric chloride by N-acetyl-DL penicillamine or DL-penicillamine. These tests also showed that the N-acetyl compound was less toxic, more effective, and cheaper.

The importance of using pure mercury in instruments to obtain satisfactory performance was emphasized in a report.[12] Also described were methods for checking the purity of mercury and ways of removing the impurities.

A check valve was described in which mercury was used for maintaining gas at a constant pressure in a system.[13] The valve was of simple construction and operated on the principle that the surface tension of mercury prevents the passage of mercury through medium-porosity glass frits.

A method of producing manganese bismuthide (MnBi) was studied [14] in which bismuth and manganese were intimately dispersed in mercury by heating at atmospheric pressure. Subsequent removal of the mercury by distillation left a strongly ferromagnetic residue of MnBi that was identical with that prepared by other methods.

---

[11] Chemical and Engineering News, Tablet Hits Hg Poisoning: Vol. 37, No. 15, Apr. 13, 1959, p. 43.

[12] Lawrence, James B., Purifying Instrument Mercury: ISA Jour., vol. 6, No. 2, February 1959, pp. 47–49.

[13] Smith, Hilton A., Posey, J. C., and Thomas, C. O., Mercury-Glass Check Valves: Rev. Sci. Instr., vol. 30, No. 3, March 1959, p. 202.

[14] Goldman, A., and Post, G. I., Mercury Process for MnBi Production: Jour. Appl. Phys., Supp. to vol. 30, No. 4, April 1959, pp. 2045–2055.

Mica

By Milford L. Skow [1] and Gertrude E. Tucker [2]

⁂

NEW HIGHS were established for tonnage and value of domestic mica sold or used in the United States in 1959; sheet and scrap surpassed 100,000 tons for the first time. Under the stimulus of the Government purchasing program for domestic mica, sales of sheet mica larger than punch and circle were the largest since World War II and had a record value. However, most of this mica went into Government inventories, and industry continued to import most of its requirements of sheet mica. Consumption of block, film, and splittings increased sharply to 10 million pounds, and consumption of scrap mica (indicated by tonnage of ground mica sold) increased 8 percent over 1958.

TABLE 1.—Salient mica statistics

(Quantity and total value in thousands)

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Domestic mica sold or used by producers:						
Sheet mica:						
Pounds	678	642	888	690	[1] 661	706
Value	$1,148	$3, 370	$2, 757	$2, 492	[1] $2, 844	$3, 419
Average per pound	$1. 69	$5. 25	$3. 11	$3. 61	[1] $4. 30	$4. 84
Scrap and flake mica:						
Short tons	74	95	86	92	93	100
Value	$1,828	$2, 058	$1, 850	$2, 109	$2, 065	$2, 645
Average per ton	$24. 65	$21. 57	$21. 43	$22. 82	$22. 12	$26. 47
Ground mica:[2]						
Short tons	74	106	91	96	98	106
Value	$4,228	$6, 558	$6, 228	$6, 073	$5. 560	$5, 626
Consumption of block and film mica:						
Pounds	(3)	4, 093	3, 822	3, 340	2, 856	2, 868
Value	(3)	$5, 607	$5, 708	$4, 651	$3, 632	$4, 449
Consumption of splittings:						
Pounds	10,292	8, 998	8, 662	8, 037	5, 329	7, 223
Value	$8,431	$4, 388	$4, 435	$4, 018	$2, 720	$3, 464
Imports for consumption...short tons	14	16	14	12	10	11
Exports...do	2	3	5	5	5	5
Apparent consumption of sheet mica pounds	17,650	13, 881	12, 711	12, 564	[1] 11, 616	12, 680
World: Production...do	264,000	320, 000	305, 000	320, 000	315, 000	340, 000

[1] Revised figure.
[2] Domestic and some imported scrap mica.
[3] Available data are not comparable with data for succeeding years.

---

[1] Commodity specialist.
[2] Statistical assistant.

LEGISLATION AND GOVERNMENT PROGRAMS

Purchasing and research programs for mica were continued by various Government agencies under authority delegated by the Office of Civil and Defense Mobilization (OCDM).

Defense Materials Service.—Government mica purchases at the three mica-purchasing depots of General Services Administration (GSA) resulted in 280,558 pounds of full-trimmed muscovite block mica (over 0.007 inch thick) in 1959—25 percent more than in 1958 and 19 percent more than the previous record high in 1955. Mica purchased under this program from its beginning in 1952 yielded 1,573,457 pounds of full-trimmed block, 1,033,003 pounds of punch, 188,138 pounds of other sheet, and 12,772,062 pounds of scrap. Ruby mica constituted 79 percent of the total full-trimmed block mica. The quantity of Stained or better qualities of full-trimmed muscovite block obtained from Government purchases of domestic mica in 1959 was 19 percent greater than in 1958 and was equivalent to 14 percent of the total 1959 fabrication of muscovite block and film of these qualities, regardless of grade.

Review of mobilization factors indicated that Government inventories of strategic mica were adequate. Accordingly, on July 1, GSA issued written notices that its long-term contracts with importers for delivery of block and film mica from foreign sources would be terminated effective July 1, 1960.

TABLE 2.—Yield of full-trimmed muscovite ruby and nonruby block mica from domestic purchases by GSA, 1959, by quality, grade, and depot, in pounds

Depot and grade	Ruby				Nonruby			
	Good Stained or better	Stained	Heavy Stained	Total	Good Stained or better	Stained	Heavy Stained	Total
Spruce Pine, N.C.:								
2 and larger	472	1,642	347	2,461	71	211	65	347
3	852	2,042	399	3,293	189	300	99	588
4	2,151	4,090	769	7,010	412	383	110	905
5	8,693	16,237	3,643	28,573	1,903	2,086	576	4,565
5½	6,273	11,274	3,200	20,747	1,025	1,085	358	2,468
6	26,613	53,528	17,865	98,006	5,575	7,998	2,666	16,239
Total	45,054	88,813	26,223	160,090	9,175	12,063	3,874	25,112
Franklin, N.H.:								
2 and larger	22	130	119	271	--------	(1)	(1)	(1)
3	70	217	196	483	(1)	(1)	1	1
4	243	534	598	1,375	1	1	(1)	2
5	1,385	3,362	2,870	7,617	9	11	3	23
5½	1,185	3,111	2,742	7,038	11	15	5	31
6	7,005	17,828	13,671	38,504	75	106	34	215
Total	9,910	25,182	20,196	55,288	96	133	43	272
Custer, S. Dak.:								
2 and larger	7	95	26	128	--------	2	--------	2
3	20	294	184	498	(1)	3	--------	3
4	32	790	391	1,213	1	1	1	3
5	235	5,193	3,622	9,050	3	9	2	14
5½	96	3,092	1,767	4,955	4	7	2	13
6	514	11,835	11,519	23,868	13	27	9	49
Total	904	21,299	17,509	39,712	21	49	14	84
Grand total	55,868	135,294	63,928	255,090	9,292	12,245	3,931	25,468

(1) Less than 1 pound.

TABLE 3.—Yield of byproducts from domestic purchases of ruby and nonruby mica by GSA, 1959, by depots, in pounds

Depot	Ruby			Nonruby		
	Miscellaneous [1]	Punch	Scrap	Miscellaneous [1]	Punch	Scrap
Spruce Pine, N.C.	1,869	28,135	1,252,618	321	3,459	165,018
Franklin, N.H.	1,632	33,217	694,394			1
Custer, S. Dak.	2,488	15,567	320,446	5	25	835
Total	5,989	76,919	2,267,458	326	3,484	165,854

[1] Includes some full-trimmed thins and block of lower than Heavy Stained qualities.

As a result of the improved defense position on natural sheet mica, effort on the industry-Government program authorized by OCDM for research on substitutes for strategic mica was diminished. Contracts with Frankford Arsenal, General Electric Co., and Horizons, Inc., were terminated during the year by GSA. By December 31, contracts for research to develop usable, reconstituted, synthetic-mica sheet were in effect with the Bureau of Mines, National Bureau of Standards (NBS), Sylvania Electric Products, Inc., and Synthetic Mica Co., Division of Mycalex Corp. of America; the contract with NBS for research on properties of natural mica for electron-tube use also remained in effect.

Commodity Credit Corporation.—No more surplus agricultural commodity barter contracts were negotiated for muscovite or phlogopite mica. However, muscovite block, film, and splittings and phlogopite splittings were received under old contracts.

Office of Minerals Exploration (OME).—This office was established in September 1958 by the Secretary of the Interior under authority of Public Law 701, 85th Congress, to give financial assistance in exploration for unknown or undeveloped sources of certain minerals, including strategic mica. By December 31, 1959, four mica-exploration contracts with a total value of $51,934 had been executed by OME. During 1959, OME also terminated the four remaining Defense Minerals Exploration Administration (DMEA) mica contracts. The Government had advanced $2,926 on the latter contracts with a total value of $25,320.

DOMESTIC PRODUCTION

Sheet Mica.—Total sheet mica sold or used by producers was 7 percent greater than in 1958; 83 percent of the increase was the increment larger than punch and circle. Quantity of larger sheet mica sold or used was the highest since World War II, and the value reached a record high. Most of this mica was sold to the Government at above-market prices under the domestic-mica purchasing program. North Carolina continued to be the principal producing State, but its proportion of total sheet mica (72 percent) was considerably smaller than in recent years.

Scrap and Flake Mica.—Demand for scrap and flake mica sold or used by grinders increased for the third consecutive year and reached a

TABLE 4.—Mica sold or used by producers in the United States

Year	Sheet mica						Scrap and flake mica [3]		Total	
	Uncut punch and circle mica		Uncut mica larger than punch and circle [1]		Total sheet mica [2]					
	Pounds	Value	Pounds	Value	Pounds	Value	Short tons	Value	Short tons	Value
1950-54 (average)	566,625	$92,586	111,350	$1,055,616	677,975	$1,148,202	74,160	$1,827,720	74,499	$2,975,922
1955	383,401	41,290	258,712	3,329,107	642,113	3,370,397	95,432	2,058,035	95,754	5,428,432
1956	593,620	53,914	294,251	2,703,159	887,871	2,757,073	86,309	1,849,573	86,753	4,606,646
1957	425,737	34,341	264,315	2,458,121	690,052	2,492,462	92,438	2,109,463	92,783	4,601,925
1958	376,005	31,044	[4] 285,339	[4] 2,813,425	[4] 661,344	[4] 2,844,469	93,347	2,064,632	[4] 93,675	[4] 4,909,101
1959:										
Alabama	----	----	818	7,459	818	7,459	(5)	(5)	(5)	(5)
Arizona	----	----	----	----	----	----	3,069	54,890	3,069	54,890
Colorado	----	----	----	----	----	----	68	1,375	68	1,375
Georgia	7,898	948	10,563	117,926	18,461	118,874	(5)	(5)	(5)	(5)
Maine	430	43	21,930	236,626	22,360	236,669	157	4,380	168	241,049
New Hampshire	1,930	290	117,233	1,132,392	119,163	1,132,682	(5)	(5)	(5)	(5)
New Mexico	----	----	247	1,598	247	1,598	210	6,562	210	8,160
North Carolina	373,271	35,372	132,352	1,719,942	505,623	1,755,314	47,736	1,211,721	47,989	2,967,035
South Carolina	----	----	251	2,820	251	2,820	(5)	(5)	(5)	(5)
South Dakota	----	----	38,775	157,827	38,775	157,827	158	4,916	177	162,743
Virginia	----	----	108	1,212	108	1,212	----	----	(6)	1,212
Undistributed [7]	----	----	589	5,035	589	5,035	48,543	1,361,493	48,612	2,628,363
Total	383,529	36,653	322,866	3,382,837	706,395	3,419,490	99,941	2,645,337	100,293	6,064,827

[1] Includes full-trimmed mica equivalent of hand-cobbed mica, 1952–59.

[2] Includes small quantities of splittings in certain years.

[3] Includes finely divided mica recovered from mica and sericite schist and as a byproduct of feldspar and kaolin beneficiation.

[4] Revised figure. Total sheet mica in New Hampshire revised to 81,472 pounds valued at $646,098 from 80,151 pounds, $637,290.

[5] Included with "Undistributed" to avoid disclosing individual company confidential data.

[6] Less than 1 ton.

[7] Includes Idaho, Massachusetts, Montana, Pennsylvania, Tennessee, Wyoming, and States indicated by footnote 5.

record high in tonnage and value. North Carolina, accounting for almost half the tonnage, was again the principal producer; but Georgia, Alabama, and South Carolina furnished considerable quantities.

Ground Mica.—Although sales of ground mica increased 8 percent in tonnage, compared with 1958, value increased only 1 percent. Total tonnage was 87 percent dry-ground and 13 percent wet-ground mica. Production was reported by 27 grinders in 22 dry-grinding and 8 wet-grinding plants. Jolex Mica Co., Fort Collins, Colo., and Los Compadres Mica Co., Ojo Caliente, N. Mex., reported production of dry-ground mica for the first time. International Minerals & Chemical Corp., did not operate its dry-grinding mill at Pueblo, Colo.

TABLE 5.—Ground mica sold by producers in the United States, by methods of grinding

Year	Dry-ground		Wet-ground		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1950–54 (average)	62, 110	$2, 553, 604	11, 954	$1, 673, 990	74, 064	$4, 227, 594
1955	91, 695	4, 541, 482	14, 490	2, 016, 157	106, 185	6, 557, 639
1956	77, 665	4, 150, 996	13, 605	2, 077, 062	91, 270	6, 228, 058
1957	83, 025	4, 015, 353	13, 307	2, 058, 055	96, 332	6, 073, 408
1958	85, 106	3, 714, 962	12, 423	1, 845, 102	97, 529	5, 560, 064
1959	91, 521	3, 495, 729	14, 059	2, 130, 543	105, 580	5, 626, 272

CONSUMPTION AND USES

Sheet Mica.—Consumption of total sheet mica (block, film, and splittings) in the United States increased 23 percent from 8.2 million pounds in 1958.

Domestic fabricators consumed almost 2.9 million pounds of muscovite block and film mica, slightly more than in 1958. A large part of this, 65 percent, went for electronic uses, principally tubes. The 23 companies fabricating muscovite block and film mica were in nine States. New Jersey, with 5, had the most plants. More than half of the domestically fabricated block and film mica came from 13 companies in three States—New Jersey (5), New York (4), and North Carolina (4).

Consumption of mica splittings rose sharply from the 1958 level with a 36-percent increase in quantity and a 27-percent increase in value. However, this did not reverse the downward trend in use of splittings since the record high was reached in 1951. Muscovite splittings from India continued to constitute the bulk of the consumption (93 percent); the remainder was principally phlogopite from Madagascar. Eleven companies fabricated mica splittings at 12 plants in nine States. More than 40 percent of the splittings were used at 3 plants, 2 in New York and 1 in New Hampshire.

Built-Up Mica.—Fabricators of splittings produced various forms of built-up mica for use principally as electrical insulation. Mica tape continued to be the form in strongest demand (26 percent of the total built-up mica), followed closely by segment plate (25 percent) and molding plate (23 percent).

TABLE 6.—Fabrication of muscovite ruby and nonruby block and film mica and phlogopite block mica, by qualities and end-product uses in the United States, 1959, in pounds

Variety, form, and quality	Electronic uses				Nonelectronic uses			Grand total
	Capacitors	Tubes	Other	Total	Gage glass and diaphragms	Other	Total	
Muscovite:								
Block:								
Good Stained or better	228	8,868	1,855	10,951	4,373	467	4,840	15,791
Stained	7,618	1,353,976	5,319	1,366,913	1,316	32,025	33,341	1,400,254
Lower than Stained [1]	----	367,016	32,078	399,094	----	964,801	964,801	1,363,895
Total	7,846	1,729,860	39,252	1,776,958	5,689	997,293	1,002,982	2,779,940
Film:								
First quality	6,166	----	----	6,166	----	----	----	6,166
Second quality	68,646	----	----	68,646	----	150	150	68,796
Other quality	1,808	----	----	1,808	----	----	----	1,808
Total	76,620	----	----	76,620	----	150	150	76,770
Block and film:								
Good Stained or better [2]	75,040	8,868	1,855	85,763	4,373	617	4,990	90,753
Stained [3]	9,426	1,353,976	5,319	1,368,721	1,316	32,025	33,341	1,402,062
Lower than Stained	----	367,016	32,078	399,094	----	964,801	964,801	1,363,895
Total	84,466	1,729,860	39,252	1,853,578	5,689	997,443	1,003,132	2,856,710
Phlogopite: Block (all qualities)	----	----	1,369	1,369	----	10,280	10,280	11,649

[1] Includes punch mica.
[2] Includes First- and Second-quality film.
[3] Includes other-quality film.

Reconstituted Mica.—This sheet material, which is formed by papermaking procedures from specially delaminated natural mica scrap, substituted for built-up mica in many applications and also was the dielectric material in special capacitors. General Electric Co. at Coshocton, Ohio, and Samica Corp. (subsidiary of Minnesota Mining & Manufacturing Co.) at Rutland, Vt., continued to be the only commercial producers. Total output, substantially greater than in 1958, was the largest since production began in 1952.

Synthetic Mica.—Commercial production of synthetic mica flake, principally for use in glass-bonded mica ceramic materials, was continued by Electronic Mechanics, Inc., Clifton, N.J., and Mycalex Corp. of America, Synthetic Mica Co. Division, West Caldwell, N.J. Electronic Mechanics processed its crude product to recover high-quality crystals of synthetic mica 1 square inch or larger. These were split and punched for commercial use in a special electronic tube.

Other Substitutes for Sheet Mica.—Farnam Manufacturing Co., Inc., Asheville, N.C., continued to manufacture a heat-resistant, electrical-insulation product from finely divided natural mica bonded with water-soluble aluminum phosphate. The material was produced as rigid sheets and various shapes.

Ground Mica.—Increased sales of ground mica to the principal consuming industries reflected greater use of both the wet-ground and dry-ground varieties. Wet-ground mica, used principally in manufacturing paint and rubber, registered a quantity increase of 13 percent over 1958 sales. Dry-ground mica, used chiefly in roofing

TABLE 7.—Fabrication of muscovite ruby and nonruby block and film mica in the United States, 1959, by qualities and grades, in 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	3,455	1,656	1,220	8,183	20	14,534
Stained	13,424	44,234	94,882	1,136,000	83,528	1,372,068
Lower than Stained	104,620	84,974	72,750	347,764	471,287	1,081,395
Total	121,499	130,864	168,852	1,491,947	554,835	2,467,997
Nonruby:						
Good Stained or better	1,217	40	----------	----------	----------	1,257
Stained	381	4,448	1,193	22,024	140	28,186
Lower than Stained	31,060	21,490	8,536	200	221,214	282,500
Total	32,658	25,978	9,729	22,224	221,354	311,943
Film:						
Ruby:						
First quality	1,140	1,574	635	1,692	----------	5,041
Second quality	31,565	23,868	7,097	4,831	----------	67,361
Other quality	----------	----------	----------	----------	1,808	1,808
Total	32,705	25,442	7,732	6,523	1,808	74,210
Nonruby:						
First	----------	200	600	325	----------	1,125
Second	400	350	650	35	----------	1,435
Other	----------	----------	----------	----------	----------	----------
Total	400	550	1,250	360	----------	2,560

[1] Figures for block mica include "all smaller than No. 6" grade and "punch" mica.

TABLE 8.—Consumption and stocks of mica splittings in the United States, by sources

(Thousand pounds and thousand dollars)

	Canadian		Indian		Madagascan		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Consumption:								
1950–54 (average)	[1] 155	[1] $84	9,422	$7,815	715	$532	10,292	$8,431
1955	(2)	(2)	8,204	3,845	[2] 794	[2] 543	8,998	4,388
1956	--------	--------	7,996	3,945	666	490	8,662	4,435
1957	(2)	(2)	7,531	3,617	[2] 506	[2] 401	8,037	4,018
1958	(2)	(2)	4,982	2,437	[2] 347	[2] 283	5,329	2,720
1959	(2)	(2)	6,726	3,098	[2] 497	[2] 366	7,223	3,464
Stocks (Dec. 31):								
1950–54 (average)	[3, 4] 78	[3, 4] 50	7,067	6,660	[4] 441	[4] 393	7,586	7,103
1955	(2)	(2)	6,191	3,623	[2] 401	[2] 302	6,592	3,925
1956	(2)	(2)	5,077	2,814	[2] 374	[2] 304	5,451	3,118
1957	(2)	(2)	4,942	2,594	[2] 325	[2] 267	5,267	2,861
1958	(2)	(2)	3,392	1,801	[2] 316	[2] 258	3,708	2,059
1959	--------	--------	3,057	1,387	347	244	3,404	1,631

[1] Domestic and Mexican included with Canadian, 1950–51.
[2] Canadian included with Madagascan.
[3] Domestic and Mexican included with Canadian, 1950.
[4] Canadian included with Madagascan, 1954.

TABLE 9.—Built-up mica[1] sold or used in the United States, by kinds of product

(Thousand pounds and thousand dollars)

Product	1958		1959	
	Quantity	Value	Quantity	Value
Molding plate	909	$2,224	1,232	$2,785
Segment plate	1,049	2,358	1,390	3,119
Heater plate	601	1,836	799	2,586
Flexible (cold)	361	1,277	519	1,880
Tape[2]	1,259	5,622	1,402	6,720
Other	[3] 261	[3] 1,174	116	898
Total	[3] 4,440	[3] 14,491	5,458	17,988

[1] Consists of alternate layers of binder and irregularly arranged and partly overlapped splittings.
[2] Includes a small quantity of built-up mica for "Other combination materials."
[3] Revised figure.

TABLE 10.—Ground mica sold by producers in the United States, by uses

Use	1958		1959	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Roofing	33,524	$1,033	34,974	$905
Wallpaper	690	96	519	74
Rubber	9,622	750	12,101	869
Paint	20,114	1,791	21,178	1,865
Plastics	2,505	175	3,294	157
Welding rods	2,757	176	1,769	116
Joint cement	12,675	866	14,863	1,017
Well drilling	(1)	(1)	12,508	388
Other uses[2]	15,642	673	4,374	235
Total	97,529	5,560	105,580	5,626

[1] Included with "Other uses."
[2] Includes mica used for molded electric insulation, house insulation, Christmas-tree snow, annealing, well drilling (1958), and other purposes.

materials, joint cement, well-drilling compounds, and paint, increased correspondingly almost 8 percent. The proportion of total ground mica to various end uses was essentially the same as in 1958.

PRICES AND SPECIFICATIONS

Prices offered by mica fabricators for domestic clear sheet mica (roughly trimmed), as reported in E&MJ Metal and Mineral Markets, ranged from 7 to 12 cents a pound for the smallest size (punch) to $4 to $8 a pound for 6- by 8-inch sheets. Stained or electric mica was quoted 10 to 20 percent lower.

The Government continued to purchase domestically produced full-trimmed and half-trimmed muscovite mica at prices established in May 1956. Government prices for hand-cobbed mica have not changed since 1954; however, purchasing procedures have varied.

North Carolina scrap mica was quoted throughout the year at $20 to $30 a short ton, depending on quality. Prices for dry- and wet-ground mica were steady.

Tentative methods of determining the properties commonly specified for built-up mica used for hot molding, commutator insulation, heating plates, and similar insulation were advanced to standard by the American Society for Testing Materials.[3]

TABLE 11.—Prices for domestically produced muscovite mica purchased by the Government, 1959, by grade and quality

	Price per pound				
	Full-trimmed			Half-trimmed	
	Good Stained or better	Stained	Heavy Stained	Stained	Heavy Stained
Block and film mica:					
Ruby:					
No. 3 and larger	$70.00	$31.90	$14.80	$12.00	$8.00
No. 4 and No. 5	40.00	18.25	6.85	5.00	4.00
No. 5½ and No. 6	17.70	7.55	4.00	3.00	2.00
Nonruby:					
No. 3 and larger	70.00	25.55	11.85	9.60	6.40
No. 4 and No. 5	40.00	14.60	5.45	4.00	3.20
No. 5½ and No. 6	17.70	6.55	4.00	2.40	1.60

	Per short ton
Hand-cobbed mica:	
Ruby	$600
Nonruby	540

---

[3] American Society for Testing Materials, Tentative Methods of Testing Pasted Mica Used in Electrical Insulation: D 352–59T, Supplement to Book of ASTM Standards, including tentatives, pt. 9, 1959; index reference to pt. 9, 1958, pp. 1139–1147.

TABLE 12.—Price of dry- and wet-ground mica in the United States, 1959 [1]

[Oil, Paint and Drug Reporter]

	Cents per pound
Dry-ground:	
Paint, 100-mesh	4
Plastic, 100-mesh	4
Roofing, 20- to 80-mesh	3
Wet-ground: [2]	
Biotite	6½
Biotite, less than carlots [3]	7¼
Paint or lacquer	8¼
Wet-ground [2]—Continued	
Paint or lacquer, less than carlots [3]	9
Rubber	8
Rubber, less than carlots [3]	8¾
Wallpaper	8¾
Wallpaper, less than carlots [3]	9
White, extra fine	8¼
White, extra fine, less than carlots [3]	9

[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] Exwarehouse or freight allowed east of the Mississippi River.

FOREIGN TRADE [4]

Imports.—Total imports of mica for consumption increased 11 percent in quantity and 6 percent in value, compared with 1958. Increase in tonnage was divided about equally between scrap mica and uncut sheet and punch. Total imports of manufactured mica were virtually unchanged; however, a 15-percent decrease in value of imported manufactured mica counteracted part of the gain in value from imports of sheet and scrap.

Exports.—Total exports of mica and mica products were 8 percent greater than in 1958. Ground-mica exports increased 9 percent and again constituted most of the total. Exports of unmanufactured mica increased for the sixth consecutive year.

---

[4] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 13.—Mica imported into and exported from the United States

[Bureau of the Census]

Year	Imports for consumption								Exports	
	Uncut sheet and punch		Scrap		Manufactured		Total		All classes	
	Pounds	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1950-54 (average)	2,761,605	[1] $3,589,558	5,079	[1] $78,857	7,619	[1] $13,297,500	14,078	[1] $16,965,915	2,329	$1,099,478
1955	[2] 1,747,106	3,333,721	9,461	121,343	6,156	[1] 7,814,400	16,490	[1] 11,269,464	3,314	1,707,629
1956	1,958,907	[1] 3,747,682	7,218	78,897	5,411	[1] 7,925,802	13,608	[1] 11,752,381	4,896	1,716,731
1957	1,841,840	[1] 3,358,889	5,187	56,888	5,766	[1] 8,031,626	11,874	[1] 11,447,403	5,355	1,550,394
1958	2,181,056	5,091,982	4,064	48,169	5,053	8,800,108	10,208	13,940,259	4,741	1,217,011
1959	3,224,698	7,318,252	4,644	56,825	5,042	7,442,663	11,299	14,817,740	5,102	1,238,780

[1] Data known to be not comparable with other years.
[2] Revised figure.

TABLE 14.—Mica imported for consumption in the United States, by kinds and countries of origin

[Bureau of the Census]

Country	Unmanufactured									
	Waste and scrap, valued not more than 5 cents per pound				Untrimmed phlogopite mica from which no rectangular piece exceeding 1 by 2 inches in size may be cut		Other			
	Phlogopite		Other				Valued not above 15 cents per pound, n.e.s.		Valued above 15 cents per pound	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
1950–54 (average)	745,051	$7,283	9,411,618	[1] $71,574	141,398	$25,389	282,099	$25,075	2,338,108	[1] $3,539,094
1955	270,200	2,822	18,651,490	118,521			139,843	11,034	1,607,263	3,322,687
1956	365,794	3,050	14,070,144	75,847			209,274	16,858	1,749,633	[1] 3,730,824
1957			10,373,171	56,888			220,460	16,424	1,621,380	[1] 3,342,465
1958			8,128,613	48,169			10,317	1,182	2,170,739	5,090,800
1959:										
North America:										
Canada			92,000	1,436						
Jamaica									284	1,151
Mexico									1,127	2,286
South America:										
Argentina									70,825	48,291
Brazil							132,420	7,872	962,154	1,837,339
British Guiana									571	909
Europe:										
Germany, West									1,323	3,614
Italy									7,438	10,164
Spain			29,400	333						
United Kingdom									2,510	14,095
Asia:										
India			8,532,977	48,261					1,902,258	5,097,588
Japan									5,027	13,045
Africa:										
Angola									76,891	145,614
British East Africa									17,820	60,382
Madagascar									30,549	50,447
Mozambique									6,374	13,910
Rhodesia and Nyasaland, Federation of									4,312	5,695
Sudan			22,046	1,000					815	4,350
Union of South Africa			256,634	2,255						
Western Portuguese Africa, n.e.c.			354,941	3,540						
Oceania: Australia									2,000	1,500
Total			9,287,998	56,825			132,420	7,872	3,092,278	7,310,380

See footnote at end of table.

Country	Manufactured—films and splittings							
	Not cut or stamped to dimensions				Cut or stamped to dimensions		Total films and splittings	
	Not above 12/10,000 of an inch in thickness		Over 12/10,000 of an inch in thickness					
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
1950–54 (average)	12,784,638	[1] $8,809,531	1,812,042	[1] $3,277,556	63,021	$90,736	14,659,701	[1] $12,177,823
1955	9,622,464	[1] 2,620,989	2,520,390	3,821,161	51,558	964,543	12,194,412	[1] 7,406,693
1956	7,708,637	2,684,774	2,757,479	3,651,949	62,918	[1] 1,064,288	10,529,034	[1] 7,401,011
1957	9,303,287	[1] 3,871,615	1,936,041	[1] 2,569,468	71,652	[1] 1,050,799	11,310,980	[1] 7,491,882
1958	7,628,263	4,551,191	2,268,139	3,135,871	40,884	646,800	9,937,286	8,333,862
1959:								
North America:								
Jamaica	307	941	1,806	2,476	811	3,604	2,924	7,021
Mexico	4,920	2,720	5,846	6,660	16,011	324,852	26,777	334,232
South America:								
Argentina			6,523	5,796			6,523	5,796
Brazil	185,182	218,094	748,868	754,588	437	2,252	934,487	974,934
British Guiana	99	188					99	188
Europe:								
Belgium-Luxembourg					39	1,058	39	1,058
France	440	1,100					440	1,100
Germany, West	90	109	525	2,163	1,730	36,490	2,345	38,762
Italy			469	1,049	278	5,182	747	6,231
Spain					1,271	13,125	1,271	13,125
United Kingdom	62,844	15,791	21,045	16,207	20,487	401,385	104,376	433,383
Asia:								
India	6,145,065	2,054,464	1,860,694	1,799,738	23,012	121,832	8,028,771	3,976,034
Indonesia			2,800	5,548			2,800	5,548
Japan	1,695	1,392	500	6,721	16,620	352,197	18,815	360,310
Africa:								
Angola	543	1,402	2,187	5,952			2,730	7,354
British East Africa			573	336			573	336
French Somaliland			3,307	1,350			3,307	1,350
Madagascar	657,879	509,862	71,524	34,777			729,403	544,639
Total	7,059,064	2,806,063	2,726,667	2,643,361	80,696	1,261,977	9,866,427	6,711,401

See footnote at end of table.

TABLE 14.—Mica imported for consumption in the United States, by kinds and countries of origin—Continued

Country	Manufactured—cut or stamped to dimensions, shape, or form		Manufactured—other					
			Mica plates and builtup mica		All mica manufactures of which mica is the component material of chief value		Ground or pulverized	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
1950-54 (average)	46,078	$788,534	26,004	[1] $152,433	37,597	$153,538	467,882	$25,172
1955	37,492	[1] 46,896	32,005	[1] 192,449	48,020	168,362	-	-
1956	59,518	[1] 79,273	110,963	[1] 200,130	54,703	[1] 241,248	69,000	4,140
1957	31,904	[1] 44,099	37,866	[1] 85,933	103,924	[1] 406,952	46,000	2,760
1958	2,711	4,328	21,561	24,796	96,456	434,259	48,238	2,863
1959:								
North America:								
Canada	-	-	-	-	40	121	46,000	2,760
Jamaica	-	-	-	-	344	783	-	-
Mexico	697	905	-	-	13,147	40,642	-	-
South America: Brazil	3.417	3,770	-	-	62,341	232,649	-	-
Europe:								
Belgium-Luxembourg	-	-	16,800	16,492	-	-	-	-
France	-	-	-	-	50	148	-	-
Germany, West	-	-	-	-	39	118	-	-
Italy	-	-	-	-	760	7,628	-	-
Netherlands	-	-	-	-	5,780	14,621	-	-
Spain	-	-	-	-	303	1,021	-	-
United Kingdom	246	3,379	13,603	12,573	44,909	370,716	-	-
Asia								
India	950	1,090	-	-	6,271	12,271	49	205
Japan	-	-	-	-	1,342	9,370	-	-
Total	5,310	9,144	30,403	29,065	135,326	690,088	46,049	2,965

[1] Data known to be not comparable with other years.

TABLE 15.—Mica and manufactures of mica exported from the United States

[Bureau of the Census]

Country	Unmanufactured		Manufactured			
			Ground or pulverized		Other	
	Pounds	Value	Pounds	Value	Pounds	Value
1950-54 (average)	338,214	$68,035	4,099,261	$233,216	220,504	$798,227
1955	447,491	35,241	5,808,347	332,293	372,548	1,340,095
1956	546,673	91,991	8,901,497	485,879	343,159	1,138,861
1957	911,006	46,391	9,256,170	520,557	541,432	983,446
1958	1,030,540	90,565	8,198,367	430,820	254,198	695,626
1959:						
North America:						
Bahamas	---	---	20,800	1,080	---	---
Canada	114,125	15,161	3,860,077	185,957	165,140	492,096
Canal Zone	---	---	---	---	50	122
Cuba	60,000	1,560	205,000	12,606	1,525	4,453
Dominican Republic	---	---	22,000	1,760	---	---
Guatemala	---	---	100,000	2,880	---	---
Haiti	2,030	3,250	---	---	---	---
Jamaica	9,558	4,346	---	---	2,824	4,580
Mexico	109,698	52,174	789,200	30,786	4,757	14,163
Netherlands Antilles	---	---	---	---	210	2,670
Panama, Republic of	---	---	6,000	570	---	---
South America:						
Argentina	---	---	20,000	600	2,033	2,198
Brazil	---	---	---	---	393	1,351
Chile	---	---	---	---	1,622	16,505
Colombia	2,286	4,865	116,000	6,691	5,074	12,386
Ecuador	---	---	22,000	1,090	---	---
Peru	---	---	114,300	5,199	60	1,680
Uruguay	550	1,482	---	---	348	4,726
Venezuela	110,360	3,863	656,750	36,742	5	631
Europe:						
Belgium-Luxembourg	60,000	4,440	148,540	12,796	810	1,452
Finland	---	---	---	---	1,632	968
France	720	2,170	423,720	34,424	722	4,008
Germany, West	5,856	8,124	398,872	34,417	930	9,659
Greece	---	---	---	---	6	1,942
Iceland	---	---	---	---	5	536
Italy	250,000	6,530	532,150	30,295	10,838	18,793
Netherlands	---	---	105,000	5,181	2,332	7,442
Norway	---	---	---	---	130	3,178
Spain	4,971	2,833	13,200	1,056	550	3,781
Sweden	---	---	---	---	4,444	14,195
Switzerland	---	---	30,000	2,280	---	---
United Kingdom	4,437	4,040	---	---	961	4,851
Asia:						
India	280	600	1,500	113	---	---
Indonesia	---	---	---	---	458	1,401
Iran	---	---	380,000	14,642	---	---
Israel	---	---	30,000	2,856	8	805
Japan	306,323	8,597	274,000	6,000	---	---
Korea, Republic of	---	---	---	---	377	1,632
Kuwait	---	---	120,000	4,500	---	---
Philippines, Republic of	---	---	16,000	1,280	120	251
Taiwan	2,000	1,590	---	---	310	2,453
Turkey	---	---	50,000	1,500	---	---
Viet Nam	---	---	---	---	1,255	894
Africa:						
Algeria	---	---	---	---	840	1,246
Belgian Congo	---	---	---	---	149	751
Egypt	---	---	40,000	3,500	---	---
Libya	---	---	165,000	5,731	---	---
Somaliland	---	---	25,000	900	---	---
Union of South Africa	29,700	867	230,000	11,993	1,019	4,290
Oceania: Australia	---	---	---	---	4,103	10,774
Total	1,072,894	126,492	8,915,109	459,425	216,040	652,863

WORLD REVIEW

Estimated world production of mica was the highest on record. The 8-percent increase over 1958 was principally increased production of scrap mica in the United States and of sheet and scrap mica in India.

Angola.—Based on 10-month figures, exports of block mica were about 30 percent less than in 1958, but exports of scrap more than doubled. In 1957 and 1958, respectively, exports of block mica were 46,700 pounds valued at $122,000 and 36,500 pounds valued at $115,700; corresponding figures for scrap mica were 613 tons valued at $16,500 and 400 tons valued at $8,400. Almost all exports went to the United States.[5]

Argentina.—Based on incomplete figures, exports of mica were more than double the 96 short tons valued at $32,000 exported in 1958. About 50 percent went to Mexico in 1959, 20 percent to Italy, and 25 percent to the United States.[6]

Brazil.—Circular 164, issued December 26, 1959, by the Director of Internal Revenue was a new schedule of unit values to be placed on mineral products at the mouth of the mine for the purpose of computing taxes. During 1960 the unit value for mica was to be $250 (4,620 cruzieros) per ton.[7]

India.—An all-India convention of mica miners and exporters held at Giridih, Bihar, in August unanimously resolved to form an association vested with powers to formulate and enforce a code of conduct, fix minimum prices, and regulate mica export trade. Membership was to be compulsory for the exporters but optional for the producers[8]

In December the Mica Export Promotion Council announced inauguration of a scheme of preshipment inspection of mica and urged United States importers to support it by insisting on a certificate of preshipment inspection from the Council. The major mica exporters in India were not enthusiastic about the scheme, because they believed it would increase the cost, cause further delays, and be ineffective.[9]

The Council published a brochure in December, which described the Indian mica industry, gave some recent mica export statistics and details of the Council preshipment inspection scheme, and outlined the principal problems of the industry.[10]

Mica exports totaled 24,700 short tons compared with 21,200 tons in 1958. Principal destination was the United States, which received 8,500 tons.[11]

Madagascar.—Exports of mica were expected to be about the same as in 1958, when the total was 925 tons valued at $1,108,000.[12]

---

[5] U.S. Consulate, Luanda, Angola, State Department Dispatch 115: Dec. 7, 1959, encl. 1, p. 1.

[6] U.S. Embassy, Buenos Aires, Argentina, State Department Dispatch 1189: Feb. 10, 1960, p. 5.

[7] U.S. Embassy, Rio de Janeiro, Brazil, State Department Dispatch 764: Jan. 27, 1960, p. 1.

[8] U.S. Consulate, Calcutta, India, State Department Dispatch 122: Aug. 13, 1959, 2 pp.

[9] U.S. Consulate, Calcutta, India, State Department Dispatch 404: Dec. 17, 1959, 2 pp.

[10] Mica Export Promotion Council, Indian Mica—The World's Best: Calcutta, India, Dec. 31, 1959, 51 pp.

[11] U.S. Embassy, New Delhi, India, State Department Dispatch 622: Jan. 22, 1960, encl. 1, p. 1.

[12] U.S. Consulate, Tananarive, Madagascar, State Department Dispatch 37: Oct. 30, 1959, encl. 2, p. 1; encl. 5, p. 1.

TABLE 16.—World production of mica, by countries,[1] in thousand pounds [2]

[Compiled by Liela S. Price and Berenice B. Mitchell]

Country [1]	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada (shipments):						
Block	287	57	79	108	90	738
Splittings	4	----------	2	15	----------	
Ground	1,373	943	1,493	911	1,380	
Scrap	1,390	640	269	247	35	
United States (sold or used by producers):						
Sheet	678	642	888	690	661	706
Scrap	148,320	190,864	172,618	184,876	186,694	199,882
South America:						
Argentina:						
Sheet	1,133	340	322	212	[3] 190	[3] 392
Scrap	26	2	2	2		
Brazil	4,127	3,051	2,926	3,265	2,829	[4] 2,900
Europe:						
Austria	298	----------	----------	----------	134	216
Norway, including scrap	2,143	3,086	3,748	4,630	4,409	[4] 5,500
Spain	24	20	26	24	20	[4] 7
Sweden:						
Block	24	----------	----------	----------	----------	----------
Ground	359	368	392	474	421	[4] 440
Asia:						
Ceylon	7	(5)	----------	----------	----------	----------
India (exports):						
Block	3,205	4,802	6,065	4,392	5,245	6,305
Splittings	18,611	16,479	14,663	16,643	14,314	15,988
Scrap	16,369	25,699	27,282	27,915	22,835	29,242
Taiwan, including scrap	240	----------	29	11	1	(5)
Africa:						
Angola:						
Sheet	40	33	53	46	46	20
Scrap and splittings	287	518	968	844	716	384
Kenya	4	2	----------	----------	15	22
Madagascar (phlogopite):						
Block	509	62	77	139	234	198
Splittings	1,338	534	1,109	2,011	2,153	1,543
Morocco, Southern zone:						
Sheet	9	----------	----------	----------	----------	----------
Scrap	55	----------	----------	----------	----------	----------
Mozambique, including scrap	26	29	26	66	4	7
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia: Sheet	15	4	7	1	2	(5)
Southern Rhodesia:						
Block	183	141	123	71	108	106
Scrap	591	----------	----------	----------	----------	----------
South-West Africa	77	----------	----------	----------	----------	234
Sudan:						
Block	----------	----------	----------	13	225	----------
Scrap	----------	----------	----------		154	----------
Tanganyika (exports):						
Sheet	168	146	128	148	108	117
Ground	33	----------	----------	----------	----------	----------
Scrap	46	613	280	----------	24	190
Union of South Africa:						
Sheet	13	11	1	2	1	(5)
Scrap	4,233	7,818	5,038	4,226	4,254	3,752
Oceania: Australia:						
Block	68	57	29	37	31	[4] 30
Scrap	44	20	----------	40	62	[4] 180
Damourite	1,173	977	1,058	1,455	1,080	[4] 1,100
World total (estimate)[1] [2]	264,000	320,000	305,000	320,000	315,000	340,000

---

[1] Mica is also produced in China, Rumania, and U.S.S.R., but production data are not available; estimates for these countries are included in the total.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Exports.

[4] Estimate

[5] Less than 500 pounds.

Paraguay.—Several mica deposits in pegmatitic bodies in northeast Paraguay, between Concepción and the Río Apa, had been explored, but no detailed reports had been issued. Although scanty evidence was available, mica is probably widely and abundantly distributed in Precambrian rocks in the northern part of the country. Although most of the mica probably is of scrap quality, good sheet mica may exist in some places.[13]

Sudan.—Mica-bearing pegmatites occur in an area west of the Nile about 250 miles north of Khartoum. A. R. Girais & Sons had a mining concession in the area and produced some mica in 1956–58.[14]

Tanganyika.—Exports of sheet mica in 1959 increased slightly and were valued at $146,000. The two cooperative societies operating in the Uluguru Mountains again were responsible for the larger share of mica sold to licensed dealers. The Anglo-American Vulcanized Fibre Co., Ltd., progressed in establishing itself in the Tungwa area to export mica directly to its London, England, factory. The Jumbadimive mine in the Mpwapwa District and the Kabende mines in the Mpanda District closed after many years as important producers.[15]

The pegmatites of the Nyanzwa area were reported to contain commercial deposits of mica.[16]

Union of South Africa.—The Department of Mines forecast that traffic in mica would change little from 1958 when 1,060 tons valued at $27,200 were exported and 950 tons valued at $14,500 were sold locally.[17]

U.S.S.R.—Imports of 1,014,000 pounds of Indian mica valued at $1,600,000 represented a twentyfold increase in quantity over 1957 or 1958, when figures were, respectively, 51,500 pounds valued at $483,000 and 50,000 pounds valued at $445,000. The large increase was in splittings, most of which were imported during the last half of 1959.[18]

TECHNOLOGY

Natural Mica.—Several muscovite occurrences in British Columbia were reported,[19] and deposits of mica in Tanganyika[20] and Madagascar[21] were described. Details of exploration, development, and mining operations for a highly productive mica mine in North Carolina traced the project from discovery, through exploration under DMEA, to production of more than 700,000 pounds of mine-run mica.[22] A general discussion of pegmatite deposits included the

---

[13] Eckel, E. B., Geology and Mineral Resources of Paraguay, A Reconnaissance: Geol. Survey Prof. Paper 327, 1959, p. 89.

[14] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 2, February 1960, p. 12.

[15] Mining Journal (London), Tanganyika's Record Mining Year: Vol. 254, No. 6499, Mar. 11, 1960, pp. 294–295.

[16] Whittingham, T. K., The Geology of the Nyanzwa Area Quarter Degree Sheet 63 NW: Tanganyika Geol. Survey Bull. 29, 1958–59, 27 pp.

[17] U.S. Consulate, Johannesburg, Union of South Africa, State Department Dispatch 52: Aug. 28, 1959, encl. 2, p. 2: encl. 3, p. 2.

[18] Work cited in footnote 10, pp. 33–35, and footnote 11.

[19] Bronlund, E., A Survey of Known Mineral Deposits in the Northern Rocky Mountain Trench: Canadian Min. and Met. Bull. (Montreal), vol. 52, No. 565, May 1959, p. 334.

[20] Sampson, D. N., The Mica Pegmatites: Records Geol. Survey Tanganyika, vol. 4, 1954 (pub. 1956), pp. 21–31; Chem. Abs., vol. 53, No. 10, May 25, 1959, col. 8965d.

[21] Brenon, P., Mica Deposits: Republic Malgache, Serv. Geol., Ann. Rept. 1958, pp. 115–119; Chem. Abs., vol. 53, No. 10, May 25, 1959, col. 8965e.

[22] Amos, D. H., DMEA Project Blossoms Into Best U.S. Mica Mine: Min. World, vol. 21, No. 11, October 1959, pp. 30–34.

problems encountered in evaluation, development, and extraction of valuable minerals.[23]

Treatment of muscovite with molten lithium nitrate lowered the layer charge on the mica and demonstrated that interlamellar expansion depended on attaining a critical value of this charge.[24] Tests of the ion-exchange properties of muscovite were made with potassium chloride of various concentrations and with dodecylamine at different pH values.[25] Prolonged grinding of muscovite resulted in oxidation of any ferrous iron, hydration, and deep structural changes in the mica.[26] Studies on mica structure furnished additional data on muscovite [27] and on a hydromuscovite.[28]

Direct-current resistivities of block mica measured at room temperature were significantly greater for the ruby variety than for the green. Within either variety no correlation was found between resistivity and visual quality.[29]

New devices to be used in fabricating mica on automatic machinery provided a means for feeding mica disks to gaging and processing operations [30] and a mechanism for hydraulically punching and stripping mica disks in high-speed equipment.[31]

A process for the recovery of mica from silt deposits utilized an initial size separation, a flotation with hydrocarbons and frothing agents, and a flotation with cationic reagents.[32] Details of a fluid-energy mill with a means for particle classification were disclosed,[33] and a description of an industrial application of the mill gave general operating information.[34] A laboratory device for recovering mica flakes from mineral samples employed asymmetric vibration of an inclined plate.[35]

Ground mica was used as a constituent of simulated snow,[36] as an ingredient in bituminous protective coatings,[37] as a filler to impart

---

[23] Sinclair, W. E., Economic Problems and Pegmatite Minerals: Min. Magazine (London), vol. 100, No. 1, January 1959, pp. 14–20.

[24] White, J. L., Layer Charge and Interlamellar Expansion in a Muscovite: Clays and Clay Minerals, Nat. Acad. Sci.-Nat. Res. Council, Washington, D.C., Pub. 566, 1958, pp. 289–294.

[25] Seele, G. D., Ion-Exchange Properties of Muscovite: Atomic Energy Comm., NYO–2293, 1958, pp. 21–23.

[26] Tsvetkov, A. I., and Val'yashikhina, E. P. [Hydration and Oxidation of Micas]: Izvest. Akad. Nauk S.S.S.R., Ser. Geol., 1956, No. 5, pp. 74–83; Chem. Abs., vol. 53, No. 22, Nov. 25, 1959, col. 21444d.

[27] Gatineau, L., and Mering, J., Refinements on the Structure of Muscovite: Clay Minerals Bull., vol. 3, 1958, pp. 238–243.

Radoslovich, E. W., Structural Control of Polymorphism in Micas: Nature, vol. 183, No. 4656, Jan. 24, 1959, p. 253.

[28] Threadgold, I. M., A Hydromuscovite, With the $2M_2$ Structure. From Mount Lyell, Tasmania: Am. Mineral., vol. 44, No. 5–6, May–June 1959, pp. 488–494.

[29] Dhar, R. N., Mandal, S. S., and Roy, S. B., Electrical Properties of Indian Mica—DC Resistivity: Central Glass & Ceram. Res. Inst. Bull. (Calcutta), vol. 6, No. 1, January–March 1959, pp. 29–33.

[30] Gannoe, T. E. (assigned to Sylvania Electric Products, Inc.), Mica Feed Apparatus: U.S. Patent 2,885,117, May 5, 1959.

[31] Roeber, H. W. (assigned to Sylvania Electric Products, Inc.), Mica Press Ram With Hydraulically Operated Punch and Stripper Means: U.S. Patent 2,914,981, Dec. 1, 1959.

[32] Fenske, D. H. (assigned to International Minerals & Chemical Corp.), Flotation of Mica From Silt Deposits: U.S. Patent 2,885,078, May 5, 1959.

[33] Croft, G. M. (assigned to Majac, Inc.), Particle Mill System: U.S. Patent 2,909,331, Oct. 20, 1959.

[34] Utley, H. F., Mica Processor Employs Fluid Energy to Grind, Classify to 8 Fine Sizes: Pit and Quarry, vol. 51, No. 12, June 1959, pp. 86–87.

[35] Faul, H., and Davis, G. L., Mineral Separation With Asymmetric Vibrators: Am. Mineral., vol. 44, September–October 1959, pp. 1076–1082.

[36] Hohstine, J. T., Versocki, J. A., and Steckhahn, F. L. (assigned to American Home Products Corp.), Simulated Snow Composition Containing Mineral Filler: U.S. Patent 2,894,928, July 14, 1959.

[37] Lajoie, J. L. (assigned to Patent and Licensing Corp.), Bituminous Coating Compositions and Articles Coated Therewith: U.S. Patent 2,886,459, May 12, 1959.

Pickell, M. W. (assigned to Kerr-McGee Oil Industries, Inc.), Coating Compositions of Asphaltenes and Plasticizer: U.S. Patent 2,909,441, Oct. 20, 1959.

smoothness and body to a flame-resistant fabric,[38] and as a filler in the asphalt-rubber coating material used to make tie pads for railroads.[39]

The platy shape of wet-ground mica increased the moisture resistance of vinyl alkyd paints and improved their protective characteristics in corrosive atmospheres.[40] The sealing properties of wet-ground mica were even more evident in a styrene-butadiene latex paint [41] and in paint films of water-soluble resins. [42] The use of wet-ground mica in paints made with a latex of vinylidene chloride-acrylonitrile copolymer decreased the moisture permeability of the pigmented film and did not react adversely on the stability of the latex.[43] Conclusive results were obtained to show that wet-ground mica decreases burning losses and increases fire retardancy in paints.[44]

Synthetic Mica.—Research on synthetic mica by the Bureau of Mines continued at the Norris Metallurgy Research Laboratory, Norris, Tenn. Principal studies were on factors affecting growth of large single crystals, determination of basic properties of various synthetic micas, and production of synthetic micas. Synthetic fluormicas were found to be harder than most natural micas, and the hardness of both groups was shown to be anisotropic.[45]

The heat of formation, heat capacity, entropy, and other thermodynamic data were determined for fluorphlogopite mica. Calculated minimum heat requirements to form melted fluorphlogopite mica from commonly used ingredients ranged from 765 to 998 B.t.u. per pound.[46]

In the industry-Government program to develop substitutes for strategic natural mica, the search continued for a means of converting flake synthetic mica into a suitable sheet material. The studies were directed mainly to further development of a novel method of delamination, formation of a high-quality synthetic mica paper, bonding of the flakes by recrystallization and other means, basic studies of the surface forces in delamination and reconstitution, and formation of a useful reconstituted sheet from water-swelling fluormicas.

The U.S. Air Materiel Command continued to sponsor synthetic mica research at Synthetic Mica Co., Division of Mycalex Corp. of America, under a contract in effect from May 1958. The objective of the program was to develop a commercially feasible technique for producing large-area, single crystals of fluorphlogopite mica. Some

---

[38] McCluer, J. D. (assigned to Thermoid Co.), Flame and Heat Resistant Asbestos Textile Base Material: U.S. Patent 2,884,343, Apr. 28, 1959.

[39] Green, J. H. (assigned to Texaco, Inc.), Railroad Tie Pads: U.S. Patent 2,892,592, June 30, 1959.

[40] Wet-Ground Mica Association, Inc., Studies on the Influence of Wet-Ground Mica on the Water-Vapor Permeability of Paint Films: Pt. 1, Tech. Bull. 34, January 1958, 4 pp.; pt. 2, Tech. Bull. 35, May 1958, 4 pp.; pt. 4, Tech. Bull. 36, October 1958, 3 pp.; Some Studies on the Water-Vapor Permeability and the Corrosion-Protective Characteristics of Vinyl Alkyd Paints: Tech. Bull. 37, November 1958, 3 pp.

[41] Wet-Ground Mica Association, Inc., Studies on the Influence of Wet-Ground Mica on the Water-Vapor Permeability of Paint Films: Tech. Bull. 35, pt. 3, May 1958, 4 pp.

[42] Wet-Ground Mica Association, Inc., A First Study of the Use of Platy Wet-Ground Mica in Paints Based on Water-Soluble Resins: Tech. Bull. 40, November 1959, 4 pp.

[43] Wet-Ground Mica Association, Inc., Stability and Moisture Resistance of Latex Paints Influenced by Wet-Ground Mica: Tech. Bull. 38, February 1959, 4 pp.

[44] Wet-Ground Mica Association, Inc., Studies on the Use of Platy Wet-Ground Mica in Fire-Retardant Paints: Tech. Bull. 39, June 1959, 8 pp.

[45] Bloss, F. D., Shekarchi, E., and Shell, H. R., Hardness of Synthetic and Natural Micas: Am. Mineral., vol. 44, January–February 1959, pp. 33–48.

[46] Kelley, K. K., Barany, R., King, E. G., and Christensen, A. U., Some Thermodynamic Properties of Fluorphlogopite Mica: Bureau of Mines Rept. of Investigations 5436, 1959, 16 pp.

experiments had been on a laboratory scale; others were larger—200- to 7,000-pound melts.

In other research on synthetic mica a number of hydrous micas were synthesized and their structure, growth characteristics, and stability relations were determined.[47]

In Japan, research on synthetic mica continued with attempts to grow large single crystals in high-alumina clay crucibles,[48] a study of delaminating synthetic mica by chemical agents,[49] and tests of a method for preparing a reconstituted sheet of synthetic mica.[50]

Soviet scientists also were conducting research on synthetic mica. The work was under supervision of the Institute of Crystallography, Academy of Sciences, U.S.S.R.[51] Russian interest in synthetic mica research was shown by a study of the preparation and properties of synthetic mica,[52] and the determination of data on its crystal structure.[53]

Built-Up and Reconstituted Products From Natural and Synthetic Mica.—Evaluation of reconstituted natural mica as a substitute for natural mica in electronic tubes and capacitors continued to be sponsored by the U.S. Army Signal Supply Agency. In one of these contracts, Micamold Electronics Manufacturing Corp., Brooklyn, N.Y., impregnated reconstituted mica with various resins and then evaluated electrical properties of the materials. Mica paper that had been impregnated with resin by the producer but had not been cured was used in fabricating capacitors for testing. Certain types of cased capacitors using resin-impregnated reconstituted mica met specifications.[54]

In the other of these contracts, General Electric Co., Owensboro, Ky., fabricated tube spacers from mica paper bonded with an undisclosed inorganic material and incorporated them in certain types of electronic tubes. These tubes were subjected to shock, vibration, and life tests. The tests indicated that reconstituted mica is a promising substitute for natural mica in some electronic tubes. However, some changes would be required in tube processing, spacer thickness, and hole dimensions.[55]

Delamination of scrap mica in commercial processes for producing

---

[47] Yoder, H. S., Jr., Experimental Studies on Micas: A Synthesis: Ch. in Clays and Clay Minerals, Pergamon Press, New York, N.Y., 1959, pp. 42–60.

[48] Noda, Tokichi, and Sumiyoshi, Yoshihiro [Experiments on Growing Synthetic Mica Crystals. Crystal Growing With Carbon-Granule Resistance Furnace]: Bull. Chem. Soc. Japan, vol. 32, 1959, pp. 54–61: Chem. Abs., vol. 53, No. 21, Nov. 10, 1959, col. 19508e.

Matsushita, Toru (assigned to Tokyo Shibaura Electric Co.), [Synthetic Mica]: Japanese Patent 9290, Oct. 18, 1958; Chem. Abs., vol. 53, No. 5, Mar. 10, 1959, col. 4618a.

[49] Noda, Tokichi, and Others, Hydrothermal Treatment of Fluorphlogopite: Bull. Chem. Soc. Japan, vol. 31, 1958, pp. 508–514; Chem. Abs., vol. 53, No. 8, Apr. 25, 1959, col. 7463e.

[50] Noda, Tokichi (assigned to Tokyo Shibaura Electric Co.), [Artificial Mica Sheets]: Japanese Patent 938, Feb. 15, 1958: Chem. Abs., vol. 53, No. 9, May 10, 1959, col. 8482d.

[51] Kolpakov, E. A., Synthetic Mica [The Dielectric of the Future]: Leninskoye Znamya (Moscow), No. 225, Oct. 23, 1958, p. 3; Sci. Information Rept. (CIA), PB131891 T–18, Mar. 20, 1959, pp. 40–41.

[52] Kapralov, K. V., Koritskii, Yu. V., and Sheftal, N. N., First Experiment on Growing Large Mica Crystals: Growth of Crystals, Repts. 1st Conf. Moscow, 1956 (pub. 1958), pp. 215–218; Yamzin, I. I., and Leizerzon, M. S., The Properties and Uses of Synthetic Mica, pp. 219–226.

[53] Yamzin, I. I., Timofeeva, V. A., Shashkina, T. I., Belova, E. N., and Gliki, N. V. [Structure and Morphological Peculiarities of Fluorine Phlogopite and Taeniolite]: Zapiski Vsesoyuz. Mineral. Obshchestva, vol. 84, 1955, pp. 415–424; Chem. Abs., vol. 53, No. 2, Jan. 25, 1959, col. 999b.

[54] Micamold Electronics Manufacturing Corp., Reconstituted Mica Paper for Capacitors: Quart. Progress Repts. 7–10, Contract No. DA–36(039)–SC–75959, January–December, 1959.

[55] General Electric Company, Receiving Tube Department, Evaluation of Reconstituted Natural Mica for Use in Electron Tubes: Quart. Progress Repts. 6–9, Contract DA–36(039)–SC–75960, January–December 1959.

reconstituted mica begins with a furnacing operation. In addition to the commonly used methods of completing delamination of the resulting partially dehydrated mica, mechanical attrition in an aqueous solution of hydrogen peroxide,[56] quenching and agitation in water containing morpholine,[57] and immersion in an aqueous solution of ammonium carbonate, followed by heating and suspension in water were suggested.[58] The process for making a sheet of integrated mica as covered by U.S. Patent 2,659,412 was modified to enable recovery and use of the extremely fine flakes of mica.[59]

The tensile strength and moisture resistance of mica paper can be improved by treating the mica flakes with potassium silicate prior to sheet formation.[60] Another method of improving these properties is to impregnate sheets of reconstituted mica with one or more chlorosilanes.[61]

Reconstituted mica was used in forming a built-up mica that consisted of alternate layers of mica paper and overlapping mica splittings.[62] Another type of composite built-up mica was formed from doubly oriented polystyrene film, mica splittings, and a thermosetting resin.[63] Impregnants for built-up mica were developed to have rapid and deep penetration and long shelf life at elevated temperatures without thermosetting.[64]

A method was disclosed for making an improved electrical heating element from the sheet material made by bonding ground mica with aluminum phosphate as described in U.S. Patent 2,760,879.[65]

Glass-bonded mica was used in a simplified method of making a mechanically strong, hermetically sealed, electrode structure.[66]

A process for bonding synthetic fluorphlogopite mica with various silicofluorides and alumina produced a ceramic material of purer composition, lower specific gravity, and higher operating temperature than previous glass-bonded micas.[67] A ceramic bond having very desirable properties for use in making abrasive bodies such as grinding wheels was formed from one of a number of fluormicas and a glassy frit.[68]

---

[56] Rotter, H. W. (assigned to Siemens-Schuckertwerke Aktiengeselkschaft), Method for Producing Mica Pulp: U.S. Patent 2,915,477, Dec. 1, 1959.

[57] Irigai, Shinichi, and Miyake, Seizo (assigned to Tokyo Shibaura Electric Co.) [Mica Paper]: Japanese Patent 3016, Apr. 23, 1958; Chem. Abs., vol. 53, No. 5, Mar. 10, 1959, col. 4617i.

[58] Epstein, L. A., Goritskii, Yu. V., Andrianov, K. A., and Kholodovskaya, R. S. [Suspension of Mica]: U.S.S.R. Patent 94,697, Feb. 6, 1959; Chem. Abs., vol. 53, No. 18, Sept. 25, 1959, col. 17375f.

[59] Heyman, M. D., Apparatus and Method for Forming a Sheet of Integrated Mica: U.S. Patent 2,870,819, Jan. 27, 1959.

[60] Gaines, G. L., Jr. (assigned to General Electric Co.), Mica Paper and Method of Preparing It: U.S. Patent 2,914,107, Nov. 24, 1959.

[61] Gaines, G. L., Jr. (assigned to General Electric Co.), Method of Rendering Mica Paper Moisture Resistant and Article Produced Thereby: U.S. Patent 2,914,426, Nov. 24, 1959.

[62] Wolff, G. M., and Richardson, C. D. (assigned to General Electric Co.), Composite Mica Paper, Mica Flake Electrical Insulating Material: U.S. Patent 2,917,570, Dec. 15, 1959.

[63] Foster, N. C., and Philofsky, H. M. (assigned to Westinghouse Electric Corp.), Method of Insulating Electrical Members With Doubly Oriented Polystyrene-Backed Mica Tape: U.S. Patent 2,917,420, Dec. 15, 1959.

[64] Botts, J. C. (assigned to Westinghouse Electric Corp.), Electrical Conductors Insulated With Mica and Completely Reactive Synthetic Copolymer Resinous Compositions: U.S. Patent 2,821,498, Jan. 28, 1958.

[65] Carter, L. J. (assigned to Farnam Manufacturing Co., Inc.), Reconstituted Mica Heating Element: U.S. Patent 2,870,277, Jan. 20, 1959.

[66] Monack. A. J. (assigned to Mycalex Corp. of America), Method of Making an Electrode Structure: U.S. Patent 2,903,826, Sept. 15, 1959.

[67] Hessinger, P. S. (assigned to Mycalex Corp. of America), Cermoplastic and Method of Manufacturing Same: U.S. Patent 2,897,573, Aug. 4, 1959.

[68] Suga, A. M. (assigned to Simonds Abrasive Co.), Abrasive Article: U.S. Patent 2,897,076, July 28, 1959.

Molybdenum

By Wilmer McInnis [1] and Mary J. Burke [2]

⁂

UNITED STATES production of molybdenum contained in concentrate increased about one-fourth in 1959 over 1958 and comprised 72 percent of the estimated world total.

Both domestic and foreign demand for molybdenum were up in 1959, mainly because of increased use in alloy steelmaking.

Except for 1957, exports by domestic firms in 1959 were higher than in any year since 1940, when the Bureau of Mines began to record data on contained molybdenum.

LEGISLATION AND GOVERNMENT PROGRAMS

A program had been announced by the Office of Civil and Defense Mobilization (OCDM) to convert materials in the national stockpile to a more usable form. General Services Administration (GSA)

TABLE 1.—Salient molybdenum statistics

(Thousand pounds of contained molybdenum)

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Concentrate:						
Production	45, 301	61, 781	57, 462	60, 753	41, 069	50, 956
Shipments:						
Total	48, 612	64, 709	57, 126	57, 143	42, 328	51, 603
Value (thousand)[1]	$46, 237	$66, 919	$63, 901	$67, 605	$50, 371	$64, 655
For export	6, 563	12, 046	14, 736	17, 543	11, 649	15, 294
Consumption	29, 668	38, 799	42, 652	38, 954	31, 298	37, 448
Imports for consumption	42	134	---------	27	1	---------
Stocks, end of year [2]	6, 577	2, 730	2, 920	7, 093	5, 643	4, 074
Primary products:[3]						
Production	29, 023	37, 774	41, 208	37, 698	30, 915	36, 294
Shipments:						
To domestic destinations	29, 221	35, 935	39, 082	34, 621	29, 918	38, 393
For export [4]	1, 587	2, 671	3, 738	2, 244	1, 441	3, 265
Total	30, 808	38, 606	42, 820	36, 865	31, 359	41, 658
Consumption	(5)	(5)	33, 497	30, 016	24, 231	32, 350
Stocks [6]	3, 046	3, 156	2, 812	5, 789	8, 081	5, 958
World: Production (Mo in ore and concentrate)	55, 800	75, 000	70, 300	76, 200	[7] 57, 700	70, 300

[1] Largely estimated by Bureau of Mines.
[2] At mines and at plants making molybdenum products.
[3] Comprises ferromolybdenum, molybdic oxide, and molybdenum salts and metal.
[4] Reported by producers to the Bureau of Mines.
[5] Data not available.
[6] Producers' stocks, end of year.
[7] Revised figure.

---

[1] Commodity specialist.
[2] Statistical assistant.

negotiated contracts with domestic firms during 1959 to upgrade stockpiled molybdenite concentrate to molybdic oxide containing 6 million pounds of molybdenum and to ferromolybdenum containing 2.5 million pounds of molybdenum.

Under the Export Control Act of 1949, individual validated licenses were required during 1959 for the export of molybdenum ores, concentrates, and primary products.

DOMESTIC PRODUCTION

Production was derived from molybdenum ores of the Climax deposits in Colorado, porphyry-copper ores from deposits in Arizona, Nevada, New Mexico, and Utah, and tungsten ores from the Pine Creek deposit in California.

Although labor strikes kept molybdenite-recovery units at six copper mills closed during most of the last half of 1959, total domestic production for the year was 24 percent higher than in 1958.

Molybdenum Mines.—Production from the Climax molybdenum mine in Lake County, Colo., was 46 percent higher than in 1958 and comprised more than two-thirds of the total domestic output in 1959. In addition to molybdenite, the Climax ore contained huebnerite, cassiterite, and pyrite, which were recovered as byproducts in a new 32,000-ton-a-day plant that reached full production in April 1958.[3]

The Climax Molybdenum Co. continued development of a shaft for the eventual opening of two mine levels 300 feet and 600 feet, respectively, below the Storke level, and improved the mill tailing-disposal system.

Molybdenum Corporation of America continued extensive diamond drilling and drifting of the Questa molybdenite deposit in Taos County, N. Mex. Exploration conducted through 1959 revealed a large mineralized area, and additional work was planned to determine the extent of the deposit, grade of ore, and most feasible mining method.

Byproduct Sources.—Molybdenum was recovered from copper ores by eight firms and from tungsten ores by one firm. Output of molybdenum from all byproduct sources was 9 percent lower than in 1958. This decrease was due mainly to labor strikes during most of the last half of 1959 at the Arthur, Magna, McGill, and Chino mills of Kennecott Copper Corp., the Morenci mill of Phelps Dodge Corp., and the San Manuel mill of San Manuel Copper Corp. The molybdenite content of the copper ores treated ranged from about 0.01 percent to 0.05 percent, and recovery varied from a low of about 20 percent at some mills to as much as 75 percent at others.

Early in 1959, Duval Sulphur and Potash Co. completed construction of a molybdenite-recovery unit, including furnace and other facilities for converting the concentrate to molybdic oxide, at its copper mill in Pima County, Ariz. First production from the new facility was reported in April 1959. Miami Copper Co. closed its molybdenite-recovery unit on June 30, 1959, except for clean-up operations, when it discontinued underground mining from the Miami copper deposit.

---

[3] Burk, Snell G., New Plant Recovers Tungsten, Tin: Min. World, vol. 21, No. 12, November 1959, pp. 38–43.

CONSUMPTION AND USES

Domestic consumption of molybdenum contained in concentrate increased 20 percent compared with 1958. Consumption during the first half of 1959 totaled 21.9 million pounds, but owing, at least in part, to the steel strike that curtailed production of molybdenum-bearing steels, consumption declined during the last half of the year. Except for quantities used in making lubricant-grade molybdenum disulfide and other direct uses such as additions to steel melts, the molybdenite concentrate was converted to molybdic oxide, the raw material used in producing virtually all other molybdenum products. Approximately 34 percent of the molybdic oxide produced was used in making ferromolybdenum and other molybdenum products; 9 percent was shipped for export to foreign nations; and the rest was shipped to domestic consumers for direct use in making cast iron, steel, and other end products.

Consumption of molybdenum as given in table 3, was estimated to comprise nearly 93 percent of the total new molybdenum used in steelmaking and other applications in 1959. The consumption figures were compiled from reports submitted by more than 700 individual domestic firms that used molybdenum during 1959.

TABLE 2.—Production, shipments, and stocks of molybdenum products in the United States

(Thousand pounds of contained molybdenum)

	Product					
	Molybdic oxide [1]		Metal powder		Ammonium molybdate	
	1958	1959	1958	1959	1958	1959
Received from other producers	2,901	3,080	----------	110	4	47
Gross production during year	28,093	33,816	2,499	2,517	871	1,716
Used to make other products listed here	7,694	11,545	----------	210	669	1,426
Net production	20,399	22,271	2,499	2,307	202	290
Shipments:						
Domestic consumers	20,428	26,156	2,383	2,401	198	220
Export	1,210	3,038	----------	----------	----------	10
Total	21,638	29,194	2,383	2,401	198	230
Producers' stocks, end of year	6,172	2,326	272	287	74	181

	Product				Total	
	Sodium molybdate		Other [2]			
	1958	1959	1958	1959	1958	1959
Received from other producers	1	4	----------	----------	2,906	3,241
Gross production during year	382	361	7,434	11,067	39,279	49,477
Used to make other products listed here	1	2	----------	----------	8,364	13,183
Net production	381	359	7,434	11,067	30,915	36,294
Shipments:						
Domestic consumers	296	374	6,613	9,242	29,918	38,393
Export	----------	----------	231	217	1,441	3,265
Total	296	374	6,844	9,459	31,359	41,658
Producers' stocks, end of year	98	86	1,465	3,078	8,081	5,958

[1] Includes molybdic oxide briquets, molybdic acid, and molybdenum trioxide.

[2] Includes ferromolybdenum, calcium molybdate, phosphomolybdic acid, molybdenum disulfide, and pellets.

The quantity of molybdenum consumed in producing various types of alloy steels comprised 69 percent of the total used, about the same ratio as in 1958. Compared with 1958, molybdenum consumed in steelmaking increased 34 percent, gray and malleable castings 83 percent, steel mill rolls 71 percent, and molybdenum wire, rod, and other shapes 18 percent; the quantity consumed in pigments, other color compounds, and catalysts decreased slightly.

The quantity of molybdenum consumed in making magnetic alloys totaled 202,000 pounds, nickel-base alloys 71,000 pounds, and titanium-base alloys 23,000 pounds. In the manufacture of hard facing, electrical resistance, and other special alloys, a total of 116,000 pounds was used. A new molybdenum-base alloy, containing about 70 percent molybdenum and 30 percent tungsten, and other molybdenum-tungsten and tungsten-molybdenum alloys were produced. A uranium-base fuel alloy containing 10 percent molybdenum was used experimentally in atomic reactors.[4] A new precipitation hardening stainless steel containing 15 percent chromium, 7 percent nickel, 2.25 percent molybdenum, and 1.20 percent aluminum was developed for use in airframe and missile components where temperatures up to about 1,000° F. are encountered.[5] Molybdenum and molybdenum-base alloys were used for making missile components, such as jetavators, liners, and nozzles. It was reported that about 50 percent of the domestic output of metallic molybdenum was purchased by missile builders.[6] Because

TABLE 3.—**Consumption of molybdenum products by end uses in 1959**

(Thousand pounds of contained molybdenum)

End uses	Molybdic oxides [1]	Ferromolybdenum [2]	Molybdenum metal powder	Ammonium molybdate	Sodium molybdate	Other [3]	Total
Steel:							
High speed	1,576	887	20			5	2,488
Hot-work tool	244	53				1	298
Other tool	327	137				2	466
Stainless	1,779	1,761				19	3,559
Other alloy [4]	14,059	1,398				75	15,532
Steel mill rolls	906	122					1,028
Gray and malleable castings	383	2,779	1			19	3,182
Welding rods		233					233
High-temperature alloys	632	244	5			452	1,333
Molybdenum powder:							
Wire, rod and sheet			1,046				1,046
Other			1,160				1,160
Chemicals:							
Pigments (ceramic and paint)	533			6	72		611
Other color compounds	145			6	137	2	290
Catalysts	195			40	1		236
Miscellaneous [5]	61	394	11	14	5	403	888
Total	20,840	8,008	2,243	66	215	978	32,350
Stocks at consumers' plants December 31, 1959	2,783	1,470	86	10	43	195	4,587

[1] Includes technical and purified oxides.
[2] Includes molybdenum silicide and calcium molybdate.
[3] Includes thermite molybdenum and molybdenum pellets, purified molybdenum disulfide, and molybdenite concentrate.
[4] Includes quantities believed used in producing high-speed steels, because some firms failed to specify individual uses.
[5] Includes magnets, other special alloys, friction material, lubricants, pesticides, refractories, packings.

---

[4] Nucleonics. Metallic Fuels: Vol. 18, No. 4, April 1960, p. 82.

[5] Marshall, M. W., and Tanczyn, Harry, pH 15-7 Mo—More Strength at Elevated Temperatures: Metal Prog., vol. 75, No. 3, March 1959, pp. 121–125.

[6] Missiles and Rockets, Half the Nation's Molybdenum: Vol. 5, No. 37, Sept. 7, 1959, p. 9.

of the increasing demand for molybdenum in making components for aircraft and missile and various other applications, some firms expanded or built new facilities. Wah Chang Corp., began building a new plant at Fair Lawn, N.J., at a reported cost of $2 million, for the production and fabrication of tungsten and molybdenum.[7] A new use of metallic molybdenum was in making gold-clad molybdenum-base tabs for silicon transistors and diodes.[8]

The miscellaneous uses given in table 3 include about 9,000 pounds of molybdic oxide used in making ground coat frit and over 1,000 pounds of sodium molybdate used as a trace element in fertilizer.

STOCKS

Industry stocks of molybdenum contained in concentrate declined 28 percent during 1959. Producers of molybdenum products reduced stocks by 26 percent during the year, but the consumers of products increased their stocks by 6 percent.

PRICES

Prices quoted by E&MJ Metal and Mineral Markets for molybdenum were constant during the year. The prices quoted for molybdenum concentrate and primary products, f.o.b. shipping point were: Molybdenite concentrate, 95 percent MoS_2, $1.25 a pound of contained molybdenum, plus cost of container, Climax, Colo.; molybdic trioxide, MoO_3, bags, $1.46, cans $1.47 a pound of contained molybdenum; ferromolybdenum, powdered $1.82, other sizes $1.76 a pound of contained Mo; and carbon reduced molybdenum powder, $3.35 a pound.

FOREIGN TRADE[9]

Imports.—Imports for consumption of molybdenum products included: Ferromolybdenum containing 1,190 pounds of molybdenum valued at $4,993; molybdenum ingots, shots, bars, or scrap, with a gross weight of 67,771 pounds, valued at $31,127; and molybdenum sheets, wire, or other forms not elsewhere provided for, with a gross weight of 43,979 pounds, valued at $351,906.

Exports.—Domestic exports of molybdenum contained in concentrate and molybdic oxide were 58 percent higher than in 1958. The quantity exported during the first half of 1959 was only slightly higher than the quantity exported during the same months of 1958, but, beginning in July, foreign demand increased sharply, resulting in a 115 percent increase during the last half of 1959 compared with the same period in 1958.

Ferromolybdenum valued at $280,495 was exported to 7 countries; molybdenum wire valued at $250,302 went to 13 countries; and molybdenum powder valued at $36,387 was exported to 3 countries—Canada, Chile, and Sweden. Other molybdenum products exported included

---

[7] American Metal Market, Wah Chang Molybdenum Tungsten Plant Near Completion: Vol. 66, No. 235, Dec. 5, 1959, p. 8.

[8] Missiles and Rockets, New Missile Products: Vol. 5, No. 52, Dec. 21, 1959, pp. 29–30.

[9] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

15,172 pounds of molybdenum metal, alloys in crude form, scrap metal valued at $22,027, and 8,921 pounds of molybdenum semifabricated forms valued at $90,815.

Tariff.—Pursuant to concessions granted under various trade agreements to the Tariff Act of 1930, import duties on molybdenum products from all countries, except Soviet Russia and other designated Communist countries and areas, were: Molybdenum ores and concentrates, 30 cents a pound of contained molybdenum; ferromolybdenum, molybdenum metal and powder, calcium molybdate, and other compounds and alloys of molybdenum, 25 cents a pound of contained molybdenum plus 7.5 percent ad valorem; bars, ingots, scrap, and shots, 21 percent ad valorem; and sheets, wire, or other forms of molybdenum or molybdenum carbide, 25.5 percent ad valorem.

TABLE 4.—Molybdenum ore and concentrate (including roasted concentrate) exported from the United States, by countries of destination

[Bureau of the Census]

Country	1957		1958		1959	
	Molybdenum content (pounds)	Value	Molybdenum content (pounds)	Value	Molybdenum content (pounds)	Value
North America:						
Canada	4,567,836	$5,439,899	269,102	$227,375	243,737	$335,712
Jamaica	528	367	----------	----------	----------	----------
Mexico	----------	----------	----------	----------	600	910
Total	4,568,364	5,440,266	269,102	227,375	244,337	336,622
South America:						
Argentina	----------	----------	----------	----------	1,000	1,600
Brazil	1,652	1,148	745	1,455	----------	----------
Total	1,652	1,148	745	1,455	1,000	1,600
Europe:						
Austria	314,722	469,278	709,354	1,028,021	1,597,175	2,291,279
Belgium-Luxembourg	24,100	35,083	12,000	17,640	51,415	79,027
France	3,371,629	4,140,673	3,095,004	3,824,630	2,467,769	3,165,071
Germany, West	5,807,870	7,200,117	3,612,401	4,493,555	6,023,620	7,703,833
Italy	572,070	754,786	503,441	666,217	963,133	1,231,803
Netherlands	162,612	194,190	93,923	157,402	327,137	451,690
Sweden	2,073,864	2,636,519	892,355	1,154,424	1,368,596	1,747,365
Switzerland	----------	----------	1,298	1,799	82,816	106,551
United Kingdom	5,044,886	6,199,113	[1] 2,770,063	[1] 3,385,886	4,074,786	5,288,599
Total	17,371,753	21,629,759	[1] 11,689,839	[1] 14,729,574	16,956,447	22,065,218
Asia:						
Japan	3,514,545	5,342,209	2,693	3,905	1,625,986	2,339,886
Philippines	----------	----------	----------	----------	3,500	5,550
Total	3,514,545	5,342,209	2,693	3,905	1,629,486	2,345,436
Oceania: Australia	9,201	14,715	3,825	3,165	20,000	27,800
Africa: Rhodesia and Nyasaland, Federation of	----------	----------	----------	----------	1,009	1,545
Grand total	25,465,515	32,428,097	[1] 11,966,204	[1] 14,965.474	18,852,279	24,778,221

[1] Revised figure.

TABLE 5.—Molybdenum reported by producers as shipments for export from the United States

(Thousand pounds of contained molybdenum)

	1957	1958	1959
Concentrate (not roasted)	17,543	11,649	15,294
Roasted concentrate (oxide)	1,917	1,210	3,038
All other primary products	327	231	227

TABLE 6.—Molybdenum products exported from the United States, gross weight, in pounds

[Bureau of the Census]

	1957	1958	1959
Ferromolybdenum [1]	383,271	226,246	248,012
Metal and alloys in crude form and scrap	98,513	14,151	15,172
Wire	13,750	11,346	12,395
Powder	28,222	4,841	11,314
Semifabricated forms (mainly rods, sheets, and tubes)	4,289	20,878	8,921

[1] Ferromolybdenum contains about 60–65 percent molybdenum.

WORLD REVIEW

World molybdenum output was from deposits in about 12 countries, but 72 percent of the total was from those in the United States. The Republic of the Philippines became a producer.

NORTH AMERICA

Canada.—The Molybdenite Corporation of Canada, Ltd., the only molybdenum producer in Canada opened two new mining levels at its La Corne mine in Quebec—one at 875 feet and the other at 1,000 feet vertical depth. The blocked-out ore reserve at the end of September 1959 was 241,000 tons, averaging 0.39 percent MoS_2 compared with 206,000 tons on December 31, 1958.[10] During the first 9 months of the year, the firm produced molybdic oxide containing 245,254 pounds of molybdenum.

Climax Molybdenum Co., a division of American Metal Climax, Inc., continued exploration of its Boss Mountain molybdenum deposit in British Columbia. Other molybdenum explorations reported included work at Lindsay Explorations property in McTavish Township, in the Port Arthur area of Ontario, Canol Metal Mines, Ltd., property about 90 miles north of Whitehorse in the Yukon, and the Jonsmith Mines property about 22 miles northwest of Gogama, in northern Ontario.[11] A molybdenite deposit in the Maniwaki, Quebec, area was being developed by Provincial Molybdenum Corp., Ltd. The firm started constructing a beneficiation plant during the last half of 1959.

---

[10] Molybdenite Corporation of Canada, Ltd., Annual Report to Stockholders: Dec. 1, 1959, pp. 2–3.

[11] Northern Miner (Toronto), Lindsay Options Molybdenum Group to Dutch Interests: Vol. 45, No. 21, Aug. 13, 1959, pp. 17, 27. Cut High Grade Molybdenite at Canol Adit: Vol. 45, No. 15, July 2, 1959, pp. 1, 16. Jonsmith Discovers Molybdenum Show on Gogama Ground: Vol. 45, No. 17, July 16, 1959, pp. 1, 16.

TABLE 7.—World production of molybdenum in ores and concentrates, by countries,[1] in thousand pounds [2]

[Compiled by Pearl J. Thompson and Berenice B. Mitchell]

Country [1]	1950–54 (average)	1955	1956	1957	1958	1959
Australia	2	2	(3)	2	4	(3)
Austria	24	18	2	------	------	------
Canada	249	833	842	785	888	851
Chile	3,058	2,817	3,122	2,998	2,972	3,785
China	(4)	(4)	(4)	(4)	[5] 2,200	[5] 3,300
Japan	238	439	534	600	683	793
Korea, Republic of	15	24	31	31	68	49
Mexico	31	55	33	29	57	57
Norway	271	379	366	397	481	[5] 480
Peru	7	------	------	------	(3)	------
Philippines	------	------	------	------	------	97
Portugal	[6] 4	11	11	18	------	------
Sweden	2	------	------	------	------	------
Union of South Africa	------	------	------	13	9	------
U.S.S.R	(4)	(4)	(4)	[5] 9,300	[5] 9,300	[5] 9,900
United States	45,301	61,781	57,462	60,753	41,069	50,956
Yugoslavia	974	948	(4)	------	------	------
World total (estimate) [1]	55,800	75,000	70,300	76,200	57,700	70,300

[1] Molybdenum is also produced in North Korea, Rumania, and Spain, but production is negligible.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in detail.
[3] Less than 500 pounds.
[4] Data not available; estimate by senior author of chapter included in total.
[5] Estimate.
[6] Average for 1953–54.

Greenland.—Exploration of molybdenum occurrences near Mestersvig in northeast Greenland was continued.[12]

SOUTH AMERICA

Chile.—Molybdenum production in Chile was the highest in any year since 1951. All output was recovered as a byproduct of copper. The Braden Copper Co., a subsidiary of Kennecott Copper Corp., was the major producer. The Chile Exploration Co., a subsidiary of The Anaconda Co., produced molybdenite concentrate at its Chuquicamata cencentrator, and the concentrator at its El Salvador mine was near completion at yearend.

Exports of molybdenite concentrate from Chile totaled 3,902 short tons, with an estimated molybdenum content of 4,369,000 pounds. Of the total exports, 39 percent went to the United Kingdom, 25 percent to West Germany, 12 percent to France, 15 percent to the Netherlands, and 9 percent to Sweden.

EUROPE

Italy.—A molybdenite deposit extending over an area of about 3 square miles was discovered in Sardinia by Mazzacurati and Giacomelli, Rome, Italy. The deposit has an average molybdenum content of 0.4 to 0.5 percent, with some parts containing as much as 4 to 6 percent molybdenum.[13] The deposit is between the towns of Ala Sardi and Buddoso, about 31 miles from a port at Olbia.

---

[12] U.S. Embassy, Copenhagen, Denmark, State Department Dispatch 168: Sept. 4, 1959.
[13] U.S. Embassy, Rome, Italy, State Department Dispatch 471: Nov. 16, 1959, pp. 1–2.

ASIA

Japan.—Both production and consumption of molybdenum in Japan were higher than during 1958. Production of ferromolybdenum totaled 23,093 short tons compared with 965 tons in 1958. Consumption of ferromolybdenum was 19,842 short tons compared with 12,600 in 1958. Japanese firms imported about 1,462,000 pounds of molybdenum contained in concentrate compared with only 375,000 pounds in 1958.

Philippines.—The first production of molybdenum in the Philippines was reported in July 1959. The molybdenum was a byproduct of ore from the Sipalay Copper mine.

AFRICA

Sierra Leone.—Two cores from separate holes drilled in the Northern Province of Sierra Leone revealed enough molybdenite associated with galena and other valuable minerals to warrant further exploration.[14]

TECHNOLOGY

Although molybdenum research in 1959 ranged from mineralogical to thermodynamic studies, the major emphasis appears to have been in extractive and physical metallurgy of the metal and its alloys.

Research by the Federal Bureau of Mines included the development of an electrolytic process using fused salt for selectively preparing metallic molybdenum and tungsten directly from scheelite containing molybdenum as an impurity. The process consists essentially of mixing molybdenum-bearing scheelite concentrate with alkali phosphates or borates, heating and electrolyzing under low voltage to collect the molybdenum on the cathode, and then removing the first cathode before increasing the voltage to recover tungsten on the second cathode. A preliminary description of the process was published.[15] Another achievement by Bureau researchers was the development of techniques for centrifugal casting molybdenum.[16] Results of Bureau investigations of the heats of combustion and formation of molybdenum subnitride, MoN were published.[17]

Calcium uranium molybdate, $Ca(UO_2)_3(MoO_4)_3(OH)_2 8H_2O$, a new mineral, was reported to occur as elongated prismatic crystals forming sheaf-like radiating aggregates up to 1.5 millimeters long in the lower part of the oxidation zone of hydrothermal uranium-molybdenum veinlets.[18] The mineral, named umohoite, was reported to have been first discovered in 1953 in the Freedom No. 2 mine at Marysvale, Utah.[19] Other recent mineralogical studies included plant-molybdenum-soil relationships at three known molybdenum deposits in

---

[14] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 6, December 1959, p. 27.

[15] Zadra, J. B., and Gomes, J. M., Electrowinning Tungsten and Associated Molybdenum From Scheelite: Bureau of Mines Rept. of Investigations 5554, 1959, 23 pp.

[16] Calvert, E. D., Ausmus, S. L., O'Hare, S. A., and Roberson, A. H. Molybdenum Casting Development: Bureau of Mines Rept. of Investigations 5555, 1960, 16 pp.

[17] Mah, Alla D., Heats of Combustion and Formation of Molybdenum Subnitride and Chromium Subnitride: Bureau of Mines Rept. of Investigations 5529, 1960, 7 pp.

[18] American Mineralogist: Vol. 44, Nos. 3 and 4, March–April 1959, p. 468.

[19] Hamilton, Peggy-Kay, and Kerr, Paul F., Umohoite From Cameron, Arizona: Am. Mineral., vol. 44, Nos. 11 and 12, November–December, 1959, pp. 1248–1260.

California and the effect of molybdenum on microbiological fixation of nitrogen.[20]

Laboratory methods for the preparation of high-purity molybdenum trichloride and molybdenum tetrachloride were developed by the National Bureau of Standards.[21] Methods and uses of molybdenum chlorides in vapor-phase plating were described.[22]

Commercial operation of a single stage process for producing molybdenum powder was started early in 1959 by Metals and Residues, Inc., at Springfield, N.J. Westinghouse Electric Corp. reportedly developed a continuous powder-metallurgy process for making large molybdenum bars or other shapes that is amenable to automatic, integrated processing.[23] Sylvania Electric Products, Inc., developed techniques for preparing large molybdenum ingots and was reported to have installed a 16-ton isostatic press to produce ingots up to 10 inches in diameter.[24] Another achievement in metallic molybdenum research was the reported laboratory development of techniques for producing high-strength and room-temperature ductile welds.[25] Information on the technology of welding and brazing of molybdenum, as well as considerable other research studies, was published.[26]

Research on molybdenum since 1948 was briefly reviewed and techniques for forging, welding, extrusion, and protective coating the metal were among the various aspects of molybdenum fabrication technology published in considerable detail.[27] A method of forming molybdenum and other metal bodies resistant to oxidation at high temperatures was patented.[28] The patent covers methods for simultaneously depositing boron and silicon on the surface of molybdenum, heated to temperatures exceeding 1,400° C., and maintaining the deposits with the heated body until the boron and silicon react with the surface portions of the molybdenum.

---

[20] Carlisle, Donald, and Cleveland, George B., Plants as a Guide to Mineralization: California Division of Mines Special Rept. 50, 1958, 31 pp.

Chemistry and Industry (London), Biological Nitrogen: No. 6, Feb. 7, 1959, p. 171.

[21] National Bureau of Standards, Technical News Bulletin: Vol. 43, No. 3, March 1959, p. 55.

[22] Schultze, H. W., Vapor-Phase Plating With Molybdenum and Tungsten: Metal Prog., vol. 76, No. 3, September 1959, pp. 74–80.

Raymond, Paul L., Molybdenum Plating Inside of Large Bore Tubes: Jour, Electrochem. Soc., vol. 106, No. 5, May 1959, pp. 444–448.

[23] Chemical and Engineering News: Vol. 37, No. 43, Oct. 26, 1959, p. 54.

[24] American Metal Market, Sylvania Will Expand Tungsten and Moly Output: Vol. 66, No. 157, Aug. 12, 1959, pp. 1–7.

[25] Judge, John F., Finn Finds Feasible Method of Welding Molybdenum for Structures: Missiles and Rockets, vol. 5, No. 44, Oct. 26, 1959, pp. 40–41.

[26] Defense Metals Information Center, Welding and Brazing of Molybdenum: Report 108, Mar. 1, 1959, 44 pp; Some Metallurgical Considerations in Forging Molybdenum, Titanium, and Zirconium: DMIC Memorandum 12, Mar. 25, 1959, pp. 5–16; Physical and Mechanical Properties of Molybdenum and the Mo–0.5 Ti alloy: DMIC Memorandum 14, Apr. 10, 1959, 21 pp; Coatings For Protecting Molybdenum From Oxidation at Elevated Temperature: Report 109, Mar. 6, 1959, 40 pp; Ductile-Brittle Transition in the Refractory Metals: Rept. 114, June 25, 1959, pp. 24–43. Procedures For Electroplating Coatings on Refractory Metals: DMIC Memorandum 35, Oct. 9, 1959, pp. 6–25. A Brief Review of Refractory Metals: DMIC Memorandum 40, Dec. 3, 1959, p. 34.

Giancola, John R., Evaluation of Protective Coatings for Molybdenum Nozzle Guide Vanes: Wright Air Development Center, June 1959, 39 pp.

Alloyed Research Corp., Research on The Production of Ultra Pure Refractory Metals: May 15, 1959, pp. 4–12.

[27] American Society For Metals, Fabrication of Molybdenum: 1959, 221 pp.

[28] Yntema, Leonard F., Beidler, Edward A., and Campbell, Ivor E., Highly Refractive Molybdenum Bodies and Method of Preparing Same: U.S. Patent 2,920,006, Jan. 5, 1960.

Nickel

By Joseph H. Bilbrey, Jr.,[1] and Ethel R. Long [2]

❖

BECAUSE of improved business conditions, the nickel industry made a remarkable recovery in 1959. Consumption of nickel was up 43 percent over 1958. More nickel was used in stainless and other steels, in cast irons, nonferrous alloys, electroplating, magnets, and catalysts. Increased free-world demand for nickel was met in a number of ways. Canadian-nickel production, which comprises about 75 percent of free-world supply, increased by 34 percent to 186,341 short tons, within 1 percent of the record high 1957 production. Despite uncertainties arising from the political situation, the U.S. Government plant at Nicaro, Cuba, produced 19,658 tons of nickel—almost as much as in 1958. New Caledonia increased its output of matte and ferronickel to 13,000 tons of contained nickel—one-third over that of 1958. Japan produced 14,320 tons of nickel—double the output in 1958. The U.S. Government by mutual agreement terminated some of its nickel contracts. Thus nickel could be delivered to industry instead of the U.S. Government Stockpile. The Government supplied nickel oxide sinter and electrolytic cathodes to contractors in settlement of the price differential in premium-price nickel contracts. The International Nickel Company of Canada project at Thompson, Manitoba neared completion; it was to begin operating in 1961 and was expected to produce 37,500 tons of nickel a year. Completion by the Freeport Nickel Co. of its Moa Bay nickel plant in Cuba was hampered by actions taken by the Cuban Government. This plant had been scheduled to start production in mid-1959 with an output of 25,000 tons of nickel a year.

TABLE 1.—Salient statistics of nickel, in short tons

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Mine production	---------	4,411	7,392	12,900	13,490	[2] 13,362
Plant production:						
Primary [1]	747	3,807	6,722	10,070	11,740	11,606
Secondary	8,367	11,540	14,860	12,037	7,411	9,438
Imports	111,800	142,000	143,000	140,000	90,000	111,500
Exports, gross weight	8,924	20,601	44,526	13,415	14,032	13,073
Consumption	97,697	110,100	127,578	122,466	[3] 79,017	112,661
Stocks December 31, consumers [4]	8,049	9,001	12,672	25,282	[3] 13,339	14,125
Price, cents per pound	40–64½	64½	64½–74	74	74	74
Canada:						
Production	141,419	174,928	178,515	187,958	[3] 139,559	186,341
Exports	139,216	173,880	176,837	178,656	154,220	171,925
World: Production	200,000	[3] 264,000	[3] 285,000	[3] 315,000	[3] 249,000	312,000

[1] Comprises metal from domestic ore and nickel recovered as a byproduct of copper refining.
[2] Preliminary figure.
[3] Revised figure.
[4] Does not include scrap.

---

[1] Commodity specialist, assisted technically by Isaac E. Weber.

[2] Statistical clerk.

LEGISLATION AND GOVERNMENT PROGRAMS

The Government did not make any new contracts to purchase nickel in 1959. General Services Administration (GSA) announced in August 1959 that the premium-price nickel contract (DMP-80) with The International Nickel Company of Canada, Ltd. (Inco), was canceled. This allowed the 24 million pounds of nickel yet undelivered on the contract to be sold to private industry. In consideration of the cancellation GSA was to pay Inco the difference between the contract price and market price in cash or nickel oxide sinter. Some sinter was delivered under the agreement, but at the request of Inco cathode nickel was substituted for some of the sinter. Inco and GSA further agreed to cancel without charge to the Government, Stockpiling Contract 3423 under which about 1,950,000 pounds of nickel remained to be delivered at market price.

Later, with demand for nickel increasing, GSA working with Inco was able to reduce deliveries of cathode nickel to the Government by 19 million pounds under the premium-price Falconbridge contract (DMP-60). This nickel was to be delivered to Inco at contract price. The premium applicable to this quantity was to be settled by the payment of cash, delivery of nickel oxide sinter, or delivery of nickel cathodes to Inco by GSA. As of December 31, 1959, Defense Production Act stock of nickel was about 153 million pounds.

DOMESTIC PRODUCTION

Primary Nickel.—Domestic mine output of nickel contained in ore was 13,362 tons—about the same as in 1958. The Hanna Nickel Smelting Co. continued to produce ferronickel from ore mined at its nearby Riddle (Oreg.) deposit. It used 823,835 dry short tons of ore, averaging 1.5 percent nickel, to produce 22,631 tons of ferronickel containing 10,397 tons of nickel. Output of ferronickel was 5 percent lower than in 1958.

The National Lead Co. continued to recover a pyrite concentrate containing nickel and cobalt from lead ore found in southern Missouri. Its refinery at Fredericktown, Mo., produced 20 percent more nickel than in 1958.

Refineries at Carteret and Perth Amboy, N.J., Laurel Hill, N.Y., El Paso, Tex., and Tacoma, Wash., recovered 493 tons of nickel as a byproduct of copper refining in the form of nickel sulfate. Shipments from refiners contained 523 tons of nickel.

Refined nickel salts (mainly sulfate), containing 3,420 tons of nickel, were produced in the United States in addition to the nickel sulfate recovered as a byproduct of copper. Total refined salts production was 3,913 tons (nickel content), and shipments of salts to consumers contained 3,940 tons of nickel.

TABLE 2.—**Nickel produced in the United States, nickel content in short tons**

	1950–54 (average)	1955	1956	1957	1958	1959
Primary:						
Byproduct of copper refining	706	451	623	502	502	493
Domestic ore	(1)	3,356	6,099	9,568	11,238	11,113
Secondary	8,367	11,540	14,860	12,037	7,411	9,438

[1] 11 tons produced in 1953, 192 tons in 1954.

Secondary Nickel.[3]—Recovery of nickel from nonferrous scrap in the United States in 1959 totaled 9,400 short tons—an increase of 27 percent from the 7,400 tons recovered in 1958. Increase was reflected in recovery of secondary nickel in all products except ferrous and high temperature alloys, which decreased 49 tons.

Recovery of nickel from ferrous nickel-base scrap is not included in the secondary nickel tables. Ferrous nickel-base alloys consist of those in which the metal of highest percentage is nickel, but which contain so much iron, chromium, cobalt, or other constituents of ferrous alloys that they must be classed as ferrous alloys, although they are also nickel-base. Examples are inconel and nichrome. Both nonferrous and ferrous nickel-base alloys may be used as alloying ingredients in ferrous alloys, but ferrous nickel-base alloys cannot be used to make nonferrous alloys.

Consumption of nonferrous nickel-base scrap increased 78 percent to 13,900 tons, compared with 7,800 tons in 1958. This gain was largely responsible for increased secondary nickel recovery. Noted also was a considerable increase in consumption of nickel-bearing copper-base scrap.

TABLE 3.—**Nickel recovered from nonferrous scrap processed in the United States, by kind of scrap and form of recovery, in short tons**

Kind of scrap	1958	1959	Form of recovery	1958	1959
New scrap:			As metal	1,211	1,379
Nickel-base	1,807	2,370	In nickel-base alloys	1,455	2,356
Copper-base	1,253	1,498	In copper-base alloys	2,457	2,750
Aluminum-base	263	360	In aluminum-base alloys	369	509
Total	3,323	4,228	In ferrous and high-temperature alloys[1]	1,085	1,036
Old scrap:			In chemical compounds	834	1,408
Nickel-base	3,607	4,692	Total	7,411	9,438
Copper-base	360	363			
Aluminum-base	121	155			
Total	4,088	5,210			
Grand total	7,411	9,438			

[1] Includes only nonferrous nickel scrap added to ferrous and high-temperature alloys.

---

[3] Prepared by A. J. McDermid, commodity specialist.

CONSUMPTION AND USES

Nickel consumption in 1959 was 43 percent higher than in 1958. This impressive increase was achieved in spite of the steel strike in the latter half of 1959, when 25 percent less nickel was used than in the first 6 months.

In 1959, 29 percent of the nickel consumed was used in stainless steels, with 40 percent more nickel required for manufacturing these steels than in 1958.

Sixteen percent nickel consumption was used in other steels and 23 percent in nonferrous alloys. Quantities were 26 and 42 percent higher, respectively, than in 1958. Nickel used in high-temperature and electrical-resistance alloys increased 41 percent over 1958. The larger demand for nickel in the electroplating industry (84 percent over 1958) was due partly to increased nickel thickness specifications for the base layer in automobile chromium plating, duplex nickel plating, and greater uses for domestic applicances. Nickel used in manufacturing magnets and catalysts increased 62 and 47 percent, respectively, over 1958.

TABLE 4.—Stocks and consumption of new and old nickel scrap in the United States in 1959, gross weight in short tons

Class of consumer and type of scrap	Stocks, beginning of year	Receipts	Consumption			Stocks, end of year
			New	Old	Total	
Smelters and refiners:						
Unalloyed nickel	170	1,149	694	402	1,096	223
Monel metal	369	1,570	315	1,278	1,593	346
Nickel silver	[1] 576	[1] 3,166	[1] 527	[1] 2,531	[1] 3,058	[1] 684
Miscellaneous nickel alloys	4	5,768	3	5,758	5,761	11
Nickel residues	123	97	30	15	45	175
Total	666	8,584	1,042	7,453	8,495	755
Foundries and plants of other manufacturers:						
Unalloyed nickel	258	3,830	2,404	741	3,145	943
Monel metal	83	676	192	434	626	133
Nickel silver	[1] 2,468	[1] 5,450	[1] 7,778	[1] 107	[1] 7,885	[1] 33
Miscellaneous nickel alloys	27	264	---------	253	253	38
Nickel residues	650	1,689	684	697	1,381	958
Total	1,018	6,459	3,280	2,125	5,405	2,072
Grand total:						
Unalloyed nickel	428	4,979	3,098	1,143	4,241	1,166
Monel metal	452	2,246	507	1,712	2,219	479
Nickel silver	[1] 3,044	[1] 8,616	[1] 8,305	[1] 2,638	[1] 10,943	[1] 717
Miscellaneous nickel alloys	31	6,032	3	6,011	6,014	49
Nickel residues	773	1,786	714	712	1,426	1,133
Total	1,684	15,043	4,322	9,578	13,900	2,827

[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, in short tons

Form	1950–54 (average)	1955	1956	1957	1958	1959
Metal	71,690	83,357	96,403	94,765	61,768	87,751
Oxide powder and oxide sinter	15,052	18,785	20,742	17,049	[1] 13,007	20,710
Matte	9,522	6,219	8,875	9,047	3,309	2,899
Salts [2]	1,433	1,739	1,558	1,605	933	1,301
Total	97,697	110,100	127,578	122,466	[1] 79,017	112.661

[1] Revised figure.
[2] Figures estimated to be 60 percent of total in 1958–59.

TABLE 6.—Nickel (exclusive of scrap) consumed in the United States, by uses, in short tons

Use	1950–54 (average)	1955	1956	1957	1958	1959
Ferrous:						
Stainless steels	22,544	26,520	32,883	26,986	23,039	32,249
Other steels	16,955	18,977	17,413	15,882	14,510	18,342
Cast irons	4,113	5,431	5,819	5,534	3,851	4,857
Nonferrous [1]	30,990	29,361	35,840	33,449	18,048	25,606
High-temperature and electrical resistance alloys	7,190	8,669	11,373	9,837	7,435	10,518
Electroplating:						
Anodes [2]	10,893	14,627	15,952	23,354	7,693	14,644
Solutions [3]	892	1,357	1,074	1,131	734	883
Catalysts	1,365	1,525	2,001	2,113	1,165	1,712
Ceramics	279	417	425	358	[4] 354	373
Magnets	739	882	933	902	636	1,028
Other	1,737	2,334	3,865	2,920	1,552	2,449
Total	97,697	110,100	127,578	122,466	[4] 79,017	112,661

[1] Comprises copper-nickel alloys, nickel silver, brass, bronze, beryllium alloys, magnesium and aluminum alloys, monel, inconel, and malleable nickel.
[2] Figures represent quantity of nickel used for production of anodes, plus cathodes used as anodes in plating operations.
[3] Figures estimated to be 60 percent of total in 1958–59.
[4] Revised figure.

TABLE 7.—Nickel (exclusive of scrap) in consumers' stocks in the United States, by forms, in short tons

Form	1950–54 (average)	1955	1956	1957	1958	1959
Metal	5,753	6,904	9,684	21,082	10,608	9,567
Oxide powder and oxide sinter	1,384	1,447	1,976	3,037	[1] 2,464	4,334
Matte	529	181	424	787	3	24
Salts	383	469	588	376	264	200
Total	8,049	9,001	12,672	25,282	[1] 13,339	14,125

[1] Revised figure.

PRICES

During 1959, domestic prices of all major forms of nickel remained unchanged. Electrolytic nickel sold at 74 cents per pound, duty included, f.o.b. Port Colborne, Ontario; nickel oxide sinter sold at 69.6 cents per pound, nickel content, packaged f.o.b. port of entry; Cuban nickel oxide remained at 69 cents per pound, nickel content, f.o.b. Philadelphia; nickel sulfate was quoted at 28 cents per pound, in bags, carlot delivered.

FOREIGN TRADE [4]

The United States imported 111,500 tons of nickel—an increase of 24 percent over 1958. Canada provided 80 percent and Cuba 16 percent of the imports. The Huntington (W. Va.) plant of International Nickel Company, Inc., processed 2,895 tons of nickel from Canadian matte and slurry.

The duty of 1¼ cents a pound on refined nickel was unchanged; and nickel ore, oxide powder and sinter, matte, slurry, and residues entered duty-free.

Nickel products exported from the United States were mainly nickel and nickel-alloy metals in ingots, bars, rods, sheets, plates, strips, scrap, and other crude forms. Canada (4,187 tons), United Kingdom (2,840 tons), and West Germany (2,126 tons) were the chief foreign markets for 1959.

On October 29, 1959, the Bureau of Foreign Commerce announced less-restrictive export controls for certain destinations on nickel scrap.

TABLE 8.—Nickel products imported for consumption in the United States, in short tons

[Bureau of the Census]

	1950–54 (average)	1955	1956	1957	1958	1959
Ore and matte	13,427	9,088	12,820	13,177	4,574	4,071
Metal (pigs, ingots, shot, cathodes, etc.)[1]	81,504	109,404	106,534	99,787	62,793	82,924
Oxide powder and oxide sinter	23,362	32,896	[2] 32,955	[2] 37,080	29,622	[3] 30,062
Slurry [4]	(5)	(5)	37	211	260	453
Refinery residues [6]	372	89	1,946	---------	211	---------
Scrap [1]	654	464	1,078	410	271	619
Total: Gross weight	119,319	151,941	155,370	150,665	97,731	118,129
Nickel content (estimated)	109,000	142,000	143,000	140,000	90,000	111,500

[1] Separation of metal from scrap on basis of unpublished tabulations.

[2] Figures for 1956 include, but for 1957 exclude, 1,524 tons received from Cuba in December 1956 but not included in figures of Bureau of Census until 1957.

[3] Adjusted by Bureau of Mines.

[4] Nickel-containing material in powders, slurry, or any form, derived from ore by chemical, physical, or any other means, and requiring further processing for the recovery therefrom of nickel or other metals.

[5] Not provided for in import schedule before July 1, 1956.

[6] Reported to Bureau of Mines by importers.

---

[4] Figures on U.S. imports and exports (unless otherwise indicated) compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 9.—New nickel products imported for consumption in the United States, by countries, in short tons

[Bureau of the Census]

Country	Metal		Oxide powder and oxide sinter				Slurry, etc.[1]			
	1958	1959	1958		1959		1958		1959	
	Gross weight	Gross weight	Gross weight	Nickel content	Gross weight	Nickel content	Gross weight	Nickel content	Gross weight	Nickel content
North America:										
Canada	61,254	79,736	7,177	5,392	9,416	7,057	260	68	453	[2] 115
Canal Zone	--------	2	--------	--------	--------	--------	--------	--------	--------	--------
Cuba	--------	--------	22,445	19,650	[2] 20,646	[2] 18,348	--------	--------	--------	--------
Total	61,254	79,738	29,622	25,042	[2] 30,062	[2] 25,405	260	68	453	[2] 115
Europe:										
Austria	--------	4	--------	--------	--------	--------	--------	--------	--------	--------
France	3	(3)	--------	--------	--------	--------	--------	--------	--------	--------
Netherlands	--------	(3)	--------	--------	--------	--------	--------	--------	--------	--------
Norway	1,441	2,848	--------	--------	--------	--------	--------	--------	--------	--------
Portugal	--------	5	--------	--------	--------	--------	--------	--------	--------	--------
Sweden	50	--------	--------	--------	--------	--------	--------	--------	--------	--------
United Kingdom	26	329	--------	--------	--------	--------	(3)	(3)	--------	--------
Total	1,520	3,186	--------	--------	--------	--------	(3)	(3)	--------	--------
Asia: Japan	19	--------	--------	--------	--------	--------	--------	--------	--------	--------
Total, all sources	62,793	82,924	29,622	25,042	[2] 30,062	[2] 25,405	260	68	453	[2] 115

Country	Ore and matte				Refinery residues [4]			
	1958		1959		1958		1959	
	Gross weight	Nickel content	Gross weight	Nickel content	Gross weight	Nickel content	Gross weight	Nickel content
North America:								
Canada	4,574	3,129	4,071	2,780	211	62	----------	----------

---

[1] Nickel-containing material in powder, slurry, or any form, derived from ore by chemical, physical, or any other means, and requiring further processing for the recovery therefrom of nickel or other metals.

[2] Adjusted by Bureau of Mines.

[3] Less than 1 ton.

[4] Reported to Bureau of Mines by importers.

TABLE 10.—Nickel products exported from the United States, by classes

[Bureau of the Census]

Class	1957		1958		1959	
	Short tons	Value	Short tons	Value	Short tons	Value
Ore, concentrate, and matte	--------	------------	10	$1,485	--------	------------
Nickel and nickel-alloy metals in ingots, bars, rods, and other crude forms	11,940	$11,965,309	11,957	13,721,729	5,707	$9,678,331
Nickel and nickel-alloy metal sheets, plates, and strips	816	2,124,371	863	2,320,857		
Nickel and nickel-alloy metal scrap	(1)	(1)	(1)	(1)	6,111	2,289,042
Nickel and nickel-alloy semifabricated forms, not elsewhere classified	508	1,796,505	563	2,491,121	519	2,313,625
Nickel-chrome electric resistance wire, except insulated	151	631,625	154	678,426	139	597,559
Nickel catalysts	(2)	(2)	485	1,022,945	597	1,161,911
	--------	16,517,810	--------	20,236,563	--------	16,040,468

---

[1] Before Jan. 1, 1959, scrap included with nickel and nickel-alloy metals in ingots, bars, rods, and other crude forms.

[2] Not separately classified.

WORLD REVIEW

World output of nickel increased 25 percent, almost equal to the 1957 peak. The free-world output of 249,000 tons was 32 percent higher than in 1958.

TABLE 11.—World production of nickel, by countries,[1] in short tons of contained nickel [2]

[Compiled by Augusta W. Jann and Berenice B. Mitchell]

Country [1]	1950-54 (average)	1955	1956	1957	1958	1959
North America:						
Canada [3]	141,419	174,928	178,515	187,958	139,559	186,341
Cuba (content of oxide)	7,463	15,138	16,062	22,245	19,782	19,658
United States:						
Byproduct of copper refining	706	451	623	502	502	493
Recovered nickel in domestic ore refined	[4] 102	3,356	6,099	9,568	11,238	11,113
Total	149,690	193,873	201,299	220,273	171,081	217,605
South America:						
Brazil (content of ferronickel)	[5] 20	57	70	[5] 90	[5] 80	[5] 80
Venezuela (content of ore)	--------	1	12	35	42	29
Total	[5] 20	58	82	125	122	109
Europe:						
Albania (content of nickeliferrous ore)	--------	--------	--------	--------	[5] 1,000	[5] 1,100
Finland (content of nickel sulfate)	[5] 93	133	164	89	125	[6] 416
Greece (content of nickeliferrous ore)	--------	--------	386	565	265	--------
Poland (content of ore) [7]	[8] 915	970	1,321	1,400	1,488	[5] 1,500
U.S.S.R.[5] [9] (content of ore)	37,800	48,000	52,000	55,000	58,000	60,000
Total [5]	38,800	49,100	53,900	57,100	60,900	63,000
Asia:						
Burma (content of speiss)	180	72	127	74	367	109
Africa:						
Morocco: Southern zone (content of cobalt ore)	99	167	142	94	204	266
Rhodesia and Nyasaland, Federation of:						
Southern Rhodesia (content of ore)	3	4	45	73	4	--------
Union of South Africa (content of matte and refined nickel)	1,526	2,598	3,624	4,562	[5] 3,800	[5] 2,900
Total	1,628	2,769	3,811	4,729	4,008	3,166
Oceania: New Caledonia (recoverable) [10]	9,411	18,000	25,569	32,359	12,345	[5] 28,000
World total (estimate) [1]	200,000	264,000	285,000	315,000	249,000	312,000

[1] Nickel is also produced in Bolivia and Iran, but production data are not available; estimates for these countries are not included in the world total.
[2] This table incorporates some revisions.
[3] Comprises refined nickel and nickel in oxide produced and recoverable nickel in matte exported.
[4] Average for 1953-54.
[5] Estimate.
[6] Includes 324 short tons of nickel contained in nickel concentrates.
[7] According to the United Nations Statistical Yearbook, except for 1959 estimate.
[8] One year only, as 1954 was first year of commercial production.
[9] According to the 46th annual issue of Metal Statistics (Metallgesellschaft), except 1959.
[10] Comprises nickel content of matte and ferronickel produced in New Caledonia and estimate of recoverable nickel in ore exported. Mine production (nickel content of ore) was as follows: 1950-54 (average) 11,547 tons; 1955, 27,200 tons; 1956, 32,500 tons; 1957, 47,700 tons; 1958, 15,600 tons; and 1959, estimated 36,500 tons.

NORTH AMERICA

Canada.—Production of nickel in Canada during 1959 was 186,341 tons—an increase of nearly 34 percent over 1958.

The International Nickel Company of Canada, Ltd., (Inco) operated at capacity except in January when influence of the 1958 strike, which ended in December, slowed production. Nickel delivered to consumers increased 54 percent from 102,900 short tons to 158,520 tons. The Creighton, Frood-Stobie, Garson, Levack, and Murray mines in the Sudbury district were operated; and work on the Levack concentrator was completed. Ore mined by Inco increased 62 percent from 9,457,000 tons to 15,316,000 tons.

Inco's proved ore reserves, other than Manitoba ore, were 264,864,000 tons as of December 31, 1959. Development at the Crean Hill mine was recommenced, and work proceeded at the Victor mine.

The new Inco project at Thompson, Manitoba, proceeds on schedule. Preparatory mining, milling, and smelting operations should begin the second half of 1960. Starting in 1961, 37,500 tons of nickel is to be produced yearly. Facilities will include a concentrator, smelter and refinery. Nickel sulfide anodes are to be used by the refinery instead of the usual metal anodes, and impure sulfur and selenium will be produced as byproducts of the electrolysis. A hydroelectric plant of 210,000 hp. capacity is being built at Kelsey, 53 miles from Thompson. Inco's investment will be about $115 million; the total cost of the project, $175 million.

Inco carried out development in the Thompson and God's Lake areas in Manitoba; it also examined nickel occurrences and explored ore possibilities in the Saskatchewan and Northwest Territories of Canada, and in Africa, Australia, New Caledonia, and the United States.[5]

Falconbridge Nickel Mines Ltd., delivered 29,207 tons of nickel, an increase of 20 percent from 1958 and the 10th, consecutive, annual record. Output the latter part of 1959 was at the rate of 30,000 tons a year. Ore receipts from the Norduna mine were 141,000 tons—an increase of 119 percent. In 1959 Falconbridge milled 2,005,000 tons of ore—an increase of 17 percent from 1958. Ore reserves totaled 46,182,450 tons, averaging 1.45 percent nickel. The diamond-drilling program was actively continued at the Strathcona property, and exploration was made in Manitoba, Ontario, and Quebec.[6]

A comprehensive account of the Falconbridge nickel undertaking was published.[7]

Sherritt Gordon Mines Ltd., mined and milled 988,500 tons of ore from its Lynn Lake (Manitoba) property—an 11 percent increase over 1958. A record 12,406 tons of nickel was produced at its refinery at Fort Saskatchewan, Alberta, from Lynn Lake; and 12 percent more concentrates were purchased than in 1958. December 1959 nickel production was computed at the rate of 15,000 tons a year.

Ore reserve at the end of 1959 was 14 million tons, with a 0.96 percent nickel content.[8]

The Northwest Territories produced an estimated 1,665 tons of nickel in 1959, 14 percent less than in 1958. The mine of North Rankin Nickel Mines Ltd., was the only producing unit. Concentrate containing about 12.75 percent nickel and 3 percent copper was shipped to the Sherritt Gordon refinery.

---

[5] International Nickel Company of Canada Ltd., Annual Report: 1959, pp. 9–11.

[6] Falconbridge Nickel Mines Ltd., Thirty-first Annual Report: 1959, pp. 6–8.

[7] Canadian Mining Journal, The Falconbridge Story: Vol. 80, No. 6, June 1959, pp. 105–230.

[8] Sherritt Gordon Mines Ltd., Annual Report: 1959, pp. 3–5.

North Rankin planned to explore the mine and promising holdings within a 60-mile area. Through the Arctic Exploration Syndicate an area of 1,000 sq. miles on the western shore of Hudson Bay was being explored.[9]

Nickel Mining & Smelting Corp. carried out deep drilling on the Gordon Lake nickel property, 55 miles northwest of Kenora and 25 miles from Minaki. (N.W. Ontario), confirming earlier estimates of 1.5 to 3.5 million tons of ore with an approximate grade of 1.4 percent nickel, and 0.6 percent copper, and platinum-group metals of undetermined values.[10]

Giant Nickel Mines, Ltd., acquired the assets of Western Nickel, Ltd., at Choate, British Columbia, and began operating in June 1959, averaging 1,000 tons of ore a day. The concentrate had a grade of 14 percent nickel and 4.5 percent copper; shipments were made to the Sherritt Gordon refinery. Ore reserves in Brunswick and Pride of Emory were estimated at 1,072,000 tons, averaging 1.18 percent nickel and 0.30 percent copper.[11] Sumitomo Shoji Kaisha, Ltd., made a 3-year contract with Giant Nickel for the purchase of its total nickel concentrate. Deliveries were to begin January 1960, when the Giant contract with Sherritt Gordon was completed.[12]

St. Stephen Nickel Mines, Ltd., started sinking a 300-foot shaft on its Charlotte County Brunswick property 65 miles west of St. John. Drilling has shown 1 million tons of nickel-copper material in the Rogers Zone and 250,000 tons in the Hall-Carroll Zone.[13] Metallurgical studies are underway, and concentration tests will be conducted to obtain nickel and copper concentrates.[14]

The Fatima Mining Co. completed sinking a 790-foot shaft on its property in Bartlett and Gieke township, 20 miles south of Timmins, northern Ontario.[15]

New Manitoba Mining & Smelting Co. will establish an integrated operation to handle output from its nickel-copper mine in the Bird River area, 100 miles northeast of Winnipeg. A 50-ton-a-day sulfuric acid plant will roast concentrates received from the mine and recover the sulfur gases. The roasted concentrate will be leached, and copper and nickel precipitated and sold as oxides.[16]

A new discovery was reported by Genrico Nickel Mines on its Tow Lake property 30 miles east of Lynn Lake, northern Manitoba. Nickel-copper mineralization, 4 miles long and as much as 100 feet wide, was confirmed from samples showing up to 0.66 percent nickel and 3.2 percent copper.[17]

Cuba.—In 1959 the U.S. Government-owned plant at Nicaro produced 1,819 tons of oxide powder (averaging 77.68 percent nickel plus

---

[9] Northern Miner, vol. 45, May 7, 1959, pp. 1–4.

[10] Northern Miner (Toronto), Nickel Mining Continues Drilling: No. 40, Dec. 24, 1959, p. 13; Estimate Tonnage at Nickel Mining, Continue Deep Work: No. 41, Dec. 31, 1959, p. 4.

[11] Northern Miner (Toronto), Giant Nickel Loses No Time in Getting Into Operation: Vol. 45, No. 17, July 16, 1959, pp. 1–7.

[12] Canadian Mining Journal, Giant Nickel Mines Signs Japanese Contract: Vol. 80, October 1959, p. 149.

[13] Mining World, vol. 21, October 1959, p. 76.

[14] Northern Miner (Toronto), St. Stephen Nickel Now Shaft Mining: Vol. 45, Nov. 12, 1959, p. 24.

[15] Northern Miner (Toronto), Fatima Mining Co., Completed Sinking on Nickel Property: Vol. 45, Dec. 24, 1959, p. 15.

[16] Mining World, vol. 21, December 1959, p. 59.

[17] Mining Magazine (London), vol. 100, No. 3, March 1959, p. 163.

cobalt) and 20,271 tons of oxide sinter (averaging 90 percent nickel plus cobalt), totaling 19,658 tons of contained nickel plus cobalt. To produce this required 1,965,500 tons of ore. Production at Nicaro in 1958 was 19,783 tons of contained nickel plus cobalt.

In Cuba, Law No. 617, which took effect on October 27, 1959, required reregistration of all mining claims at a cost of $100 each and payment of an annual tax of $10 per hectare on exploited claims and $20 per hectare on unexploited claims. Owners of concessions were taxed 5 percent of the value of minerals extracted, and a duty of 25 percent was placed on minerals exported, based on the highest average world quotation. Failure to reregister or to pay the tax results in the loss of the concession. Under this law the Department of Mines and Petroleum became part of the Ministry of Agriculture, and the latter was empowered to exploit any canceled mining concessions.

Exports of nickel oxides from the Nicaro plant stopped pending clarification of Law No. 617. The Cuban Government granted a stay of 90 days from December 15, 1959, to permit exports of nickel under conditions existing before the law was put into effect.

In November 1959 the Freeport Nickel Co. produced at its Moa Bay (Cuba) plant nickel-cobalt sulfide concentrate, which was successfully test run at its Port Nickel (La.) refinery. However, by the end of the year the new taxes to be paid under Cuban Mineral Law No. 617 made future operation of the plant uncertain. Approximately $61.5 million had been spent in Cuba on this project.[18] An article describing the nickel-cobalt process was published.[19]

A report issued by the House Committee on Government Operations recommended that the Government dispose of its nickel plant at Nicaro, Cuba, as quickly as possible; however, it pointed out that any acceptable offer must assure a reasonable return to the taxpayer. It also recommended that the U.S. Government obtain an adequate ore reserve at fair cost and with reasonable royalties to provide a 20-year supply for the plant.[20] After the committee issued its report GSA requested proposals by December 1, 1959, from parties interested in buying the Nicaro nickel plant.[21] Private industry made three responses, and the Cuban Government expressed an interest in acquiring the plant.[22] It remained unsold at the end of 1959.

Dominican Republic.—Explored deposits of the Minera y Beneficiadora Falconbridge Dominicana C. por A., the majority-owned subsidiary of Falconbridge Nickel Mines Ltd., were estimated to contain 50 million tons of lateritic ore with a grade of 1.55 percent nickel. Based on work by the Falconbridge metallurgical laboratory at Richvale, Toronto, a pilot plant is being designed to operate in the Dominican Republic.[23]

Puerto Rico.—Methods and results of investigations by the Federal Bureau of Mines on seven deposits of nickel-cobalt-iron-bearing laterite and weathered serpentine near the west coast of Puerto Rico, east and south of Mayaguez, were described. Work was done in co-

---

[18] Freeport Sulphur Co., Annual Report, 1959, p. 7.

[19] Lee, J. A., New Nickel Process on Stream: Chem. Eng., Sept. 7, 1959, pp. 145–152.

[20] Committee on Government Operations, Disposal Problems of Government-Owned Nickel Plant at Nicaro, Cuba: H. Rept. 684 (9th Rept.), 1959.

[21] General Services Administration News Release 1113, Sept. 15, 1959.

[22] General Services Administration News Release 1154, Dec. 2, 1959.

[23] Falconbridge Nickel Mines Ltd., Annual Report, 1959, p. 9.

operation with the Commonwealth of Puerto Rico Economic Development Association.[24]

SOUTH AMERICA

Brazil.—Morro do Niquel, S.A., was formed with a capital of 240 million cruzeiros to mine a nickel deposit in the State of Minas Gerais. Société le Nickel, Banque de L'Indochine, and Credit Foncier du Bresil held interests in the new company. Le Nickel will undertake the engineering of the ferronickel plant to be built.[25]

On December 29, 1959, Diario Official, Brazil, announced that the unit value placed on garnierite, peridotite, and nickel-bearing serpentine ores at the mine was 390.00 cruzeiros. The federal production tax was fixed at 3 percent of the unit value and the state tax at 5 percent.[26]

EUROPE

Finland.—Outokumpu Oy, the Finnish Government copper mining corporation will begin exploitation of the Kotalahti nickel-copper mine in early 1960 planning to have a first year's output of 300,000 tons of ore. This would make Finland self-sufficient in nickel and yield a surplus for export.

The mine is in Savo, on main highway No. 5, about 25 miles from Kuopio and 22 miles from Varkaus.[27]

Norway.—Falconbridge Nikkelverk of Kristiansand, South Norway, a subsidiary of Falconbridge Nickel Mines, Ltd., Canada, raised its annual capacity of nickel to about 28,000 tons.[28]

ASIA

Philippines.—B. M. Gozon, Director of Mines, discussed the laterite reserves of the Surigao Mineral Reservation; technical feasibility of production processes for iron, nickel, and cobalt; and features of the present Nickel Law.[29]

Japan.—Imports of nickel ore soared for 1959 and were 797,700 short tons as compared with 224,350 tons for 1958.[30] The greater part of the ore was imported from New Caledonia; however, the Mitsui Bussan Co. concluded a long-term contract for the importation of ore from Celebes Island at the rate of 1,000 tons a month from May 1959.[31] Japan produced 5,760 short tons of pure nickel in 1959 as compared with 3,987 tons in 1958; nickel contained in ferronickel produced was 8,560 short tons as against 3,200 tons in 1958.[32]

Jumpei Ando reported that production of nickel matte from garnierite (nickel magnesium silicate) and phosphate rock was begun

---

[24] Heidenreich, W. L., and Reynolds, B. M., Nickel-Cobalt-Iron Bearing Deposits in Puerto Rico: Bureau of Mines Rept. of Investigations 5532, 1959, 68 pp.

[25] American Metal Market, French to Work Nickel Deposits in Brazil: Dec. 23, 1959, p. 7.

[26] State Department Dispatch 807, Jan. 27, 1960.

[27] U.S. Consulate, Helsinki, Finland, State Department Dispatch 139, Aug. 25, 1959.

[28] Mining Journal (London), vol. 253, July 24, 1959, p. 85.

[29] Mining Newsletter (Philippines), A Review of the Philippine Steel-Nickel Project: November–December 1959, pp. 93–96, 98–125, 127–129.

[30] Japan Metal Bulletin, Feb. 4, 1960, p. 2.

[31] Japan Metal Bulletin, Apr. 30, 1959.

[32] Letter to Bureau of Mines, Japan Mining Association, 1960.

recently in Japan. This modified process produces calcium magnesium phosphate fertilizer as a byproduct instead of the usual slag.[33]

AFRICA

The Shimura Kako Chemical Processing Co. of Japan and Anglovaal Ltd., a South African company, are now coowners of the Trojan Nickel Mine Ltd. at Bindura, Southern Rhodesia. They have agreed to build a nickel-smelting plant at Bindura at a cost of £2 million; entire output of the nickel matte is to be exported to Japan.[34]

OCEANIA

New Caledonia.—Société le Nickel has completed its new ferronickel plant at Pointe Doniambo. Nickel ore is dehydrated in rotary kilns at 1,300°F. and fed to one of four electric furnaces, using Soderberg electrodes. Each furnace can produce 300 tons a month of nickel as ferronickel, which is subsequently refined. The refined ferronickel is cast into 40- to 60-pound ingots, containing 25 percent nickel plus cobalt and less than 0.04 percent each of sulfur, chromium, silicon, carbon, and phosphoros. Le Nickel, with the new installation, has a capacity of 26,000 tons of nickel a year.

TABLE 12.—Production of nickel matte and ferronickel by Société le Nickel, in short tons

[New Caledonia Mining Service] [1]

Product	1958	1959
Matte:		
Gross weight	9,697	9,954
Nickel content	7,202	7,655
Ferronickel:		
Gross weight	10,153	21,406
Nickel content	2,525	5,424

[1] As reported by Foreign Service Despatch No. 95, April 25, 1960.

TABLE 13.—Nickel ore and nickel products exported from New Caledonia, in short tons

[New Caledonia Mining Service] [1]

Product	1958	1959
Ore:		
Gross weight	189,596	871,529
Nickel content	4,550	[2] 20,786
Matte:		
Gross weight	9,513	8,942
Nickel content	7,060	[2] 6,877
Ferronickel:		
Gross weight	10,524	19,804
Nickel content	2,609	[2] 5,025

[1] As reported by Foreign Service Despatch, No. 95, April 25, 1960.
[2] Estimated.

---

[33] Ando, J., Simultaneous Production of Nickel Matte and Calcium Magnesium Phosphate: Ind. Eng. Chem., vol. 51, No. 10, October 1959, pp. 1267–1270.

[34] Mining Journal (London), Rhodesian Nickel Plant: Vol. 253, Oct. 9, 1959, p. 344.

TECHNOLOGY

The Federal Bureau of Mines research program included development of processes for separating nickel from cobalt, production of high-purity nickel from laterite ores, recovery of nickel from high-temperature alloy scrap and reconstituting this scrap for reuse, and research on recovery of nickel and associated metal values from nickel ores of the Pacific Northwest and Alaska. Research reports published by the Bureau of Mines included basic studies on Nicaro (Cuba) nickel ores,[35] electrolytic method for separating nickel and cobalt,[36] conversion of Nicaro nickel oxide to nickel metal,[37] and codeposition of tin-nickel plate.[38]

A new 70:30 copper-nickel alloy was introduced for high-temperature-feed water heaters and heat exchangers.[39]

Invention of very high strength, 25-percent nickel steels with yield strength over 250,000 p.s.i., 6- to 10-percent elongation, and a reduction in area greater than 20 percent was reported by the International Nickel Company, Inc. The alloys contain 2- to 6-percent titanium and/or aluminum. They are most usable in aircraft and missiles, pressure vessels, and wear-resistant precision bearings.[40] The Haynes Stellite Co., Division of Union Carbide Corp., has developed a new nickel-base alloy to be used as a container material for molten fluoride salts.[41]

The Superior Tube Co. has introduced a new nickel-base cathode alloy (X–3012) with improved properties.[42] Much interest was shown in the nickel-coating field. A duplex-type nickel plate was recommended for zinc-base die castings to improve corrosion resistance.[43] A study has been issued on electroless nickel plating.[44] Improved nickel-cadmium alkaline batteries contain plates made of carbonyl nickel powder sintered on a foundation of nickel wire mesh, making a rugged, durable, long-life battery with large effective-plate area suitable for starting engines.[45] Sonotone Corp., a major producer of the sintered plate and nickel-cadmium battery, and American Motors Corp. announced a joint research program to study possibility of developing a modern version of the electric car.[46]

---

[35] Fisher, R. B., and Dressel, W. M., The Nicaro (Cuba) Ores, Basic Studies, Including Differential Thermal Analysis in Controlled Atmospheres: Bureau of Mines Rept. of Investigations 5496, 1959, 54 pp.

[36] Ferrante, M. J., and Butler, M. O., An Electrolytic Method for Separating Nickel and Cobalt: Bureau of Mines Rept. of Investigations 5543, 1959, 23 pp.

[37] Mahan, W. M., Melcher, N. B., Riott, J. P., and Ostrowski, E. J., Conversion of Nicaro Nickel Oxide to Nickel Metal: Bureau of Mines Rept. of Investigations 5465, 1959, 36 pp.

[38] Campbell, T. T., and Abel, R., Codeposition of Tin-Nickel Plate From Organic and Mixed Aqueous-Organic Solvents: Bureau of Mines Rept. of Investigations 5482, 1959, 11 pp.

[39] Materials in Design Engineering, Copper-Nickel Alloy: November 1959, pp. 177–180.

[40] American Metal Market, New Family of Ultra High Strength Nickel-Steels Developed by Inco: Nov. 21, 1959, p. 8.

[41] Foundry, Resists High Temperature: Vol. 87, July 1959, p. 129.

[42] Materials in Design Engineering, Nickel Cathode Alloy Gives Long Tube Life: Vol. 50, December 1959, pp. 150, 152.

[43] Iron-Age, Duplex-Type Nickel Plate Protects Zinc Die Castings: Vol. 183, June 11, 1959, pp. 132–133.

[44] American Society of Testing Materials, Symposium on Electroless Nickel Plating, Philadelphia, Pa., 1959, p. 70.

[45] American Metal Market, Nickel Cadmium to Replace Lead Cells in Fruit Cars: Vol. 46, Apr. 3, 1959, p. 6.

[46] American Metal Market, Nickel Cadmium Battery Points to Economic Feasibility of Electric Auto: Vol. 46, Oct. 28, 1959, p. 7.

A number of patents were issued on the recovery of nickel from ores,[47] separation of nickel from cobalt,[48] electro and electroless plating of nickel,[49] coating with nickel by decomposition of nickel carbonyl,[50] various alloys,[51] nickel catalysts,[52] manufacture of metal strip from metal power,[53] magnetic nickel-base material,[54] tungsten-tantalum-nickel cathodes,[55] and making foam material from nickel powder.[56]

---

[47] Roy, T. K. (assigned to Chemical Construction Corp.), Cobalt and Nickel Recovery Using Carbon Dioxide Leach: U.S. Patent 2,867,503, Jan. 6, 1959.

Schaufelberger, F. A. (assigned to American Cyanamid Co.), Beneficiation of Laterite Ores: Canadian Patent 568,706, Jan. 6, 1959.

Morrow, J. G. (assigned to Freeport Sulphur Co.), Recovery of Cobalt and Nickel From Ores: U.S. Patent 2,872,306, Feb. 3, 1959.

Bare, C. B., and Clauser, R. L. (assigned to Bethlehem Steel Co.), Nickel and Cobalt Recovery From Ammoniacal Solutions: U.S. Patent 2,879,137, Mar. 24, 1959.

Queneau, P. E., and Illis, A. (assigned to International Nickel Co. of Canada, Ltd.), Recovery of Cobalt and High-Purity Nickel From Laterite Ores: Canadian Patent 575,076, Apr. 29, 1959.

Nossen, E. S., Process for Nitric Acid Leaching of Low Grade Ores, e.g., Laterites: Canadian Patent 576,372, May 26, 1959.

Donaldson, J. W., and Davis, Jr., H. F. (assigned to Quebec Metallurgical Industries, Ltd.) Treating Nickel Ore Concentrates Containing Also Cobalt: Canadian Patent 579,219, July 7, 1959.

Bailey, R. P. (assigned to Quebec Metallurgical Industries, Ltd.), Method for Extracting Nickel From Laterite Ores: U.S. Patent 2,899,300, Aug. 11, 1959.

Forward, F. A., and Mackiw, V. M. (assigned to Sherritt Gordon Mines, Ltd.), Method of Extracting Non-Ferrous Metals From Metal Bearing Material: Canadian Patent 584,305, Sept. 29, 1959.

Dean, J. G. (assigned to the United States of America as represented by the Administrator, of the General Services Administration), Nickel Ore Reduction Process Using Asphalt Additive: U.S. Patent, 2,913,331, Nov. 17, 1959.

[48] Merre, M. de. (assigned to Société Générale Metallurgique de Hoboken), Separation of Nickel From Cobalt: Canadian Patent 568,643, Jan. 6, 1959.

Evans, D. J. I., and Tao-I-Chiang, P. (assigned to Sherritt Gordon Mines, Ltd.), Production of Metal From Solutions Containing Copper, Cobalt and/or Nickel: Canadian Patent 579,633, July 14, 1959.

Hyde, R. W., and Feick III, G. (assigned to Freeport Sulphur Co.), Separate Recovery of Nickel and Cobalt From Mixed Compounds Containing the Same: U.S. Patent 2,902,345, Sept. 1, 1959.

Merre, M. de. (assigned to Société Générale Metallurgique de Hoboken), Separation of Nickel From Cobalt: Canadian Patent 585,158, Oct. 13, 1959.

Goldstein, E. M. (assigned to the United States of America as represented by the Administrator, General Services Administration), Process for Separating Cobalt and Nickel From Ammoniacal Solutions: U.S. Patent, 2,910,354, Oct. 27, 1959.

Dean, J. G. (assigned to the United States of America as represented by the Administrator, General Services Administration), Process for Separating Cobalt and Nickel From Ammoniacal Solutions: U.S. Patents 2,913,334; 2,913,335; 2,913,336, Nov. 17. 1959.

Lyle, A. G., Brubaker, P. E., and Beyer, A. J. (assigned to American Cyanamid Co.), Separation of Nickel and Cobalt: U.S. Patent 2,915,388, Dec. 1, 1959.

Dean, J. G. (assigned to the United States of America as represented by the Administrator, General Services Administration), Process for Separating Cobalt and Nickel From Ammoniacal Solutions: U.S. Patent 2,915,389, Dec. 1, 1959.

Mackiw, V. N., Kunda, V., Benoit, R. L. (assigned to Sherritt Gordon Mines Ltd.), Method for Separating Metal Values From Nickel and Cobalt in Ammoniacal Solutions: Canadian Patent 586,406, Nov. 3, 1959.

[49] Eisenberg, P. H. (assigned to Sylvania Electric Products, Inc.), Electroless Plating of Non-Conductors: U.S. Patent 2,872,312, Feb. 3, 1959.

Metheny, D. E. (assigned to General American Transportation Corp.), Processes of Continuous Chemical Nickel Plating: U.S. Patent, 2,872,353, Feb. 3, 1959.

Lee, W. G. (assigned to General American Transportation Corp.), Processes of Continuous Chemical Nickel Plating: U.S. Patent 2,872,354, Feb. 3, 1959.

Metheny, D. E., and Browar, E. (assigned to General American Transportation Corp.), Methods of Chemical Nickel Plating: U.S. Patent 2,874,073, Feb. 17, 1959.

Kardos, O., and Neumann, R. P. (assigned to Hanson-Van Winkle-Munning Co.), Electroplating Duplex Nickel Coatings: U.S. Patent 2,879,211, Mar. 24, 1959.

Gray, A. G. (assigned to the United States of America as represented by the United States Atomic Energy Commission), Method of Applying Nickel Coatings on Uranium: U.S. Patent 2,894,884, July 14, 1959.

Puls, L. V., and Vincent, W. R. (assigned to General Motors Corp.), Chemical Reduction Nickel Plating Bath: U.S. Patent 2,916,401, Dec. 8, 1959.

Nack, H. R. (assigned to Commonwealth Engineering Co. of Ohio), Catalytic Nickel Plating: U.S. Patent, 2,872,342, Feb. 3, 1959.

[50] Hoover, T. B. (assigned to the United States of America as represented by the United States Atomic Energy Commission), Process of Coating With Nickel by the Decomposition of Nickel Carbonyl: U.S. Patent 2,881,094, Apr. 7, 1959.

[51] Mott, N. S. (assigned to Cooper Alloy Corp.), Precipitation Hardenable, Corrosion Resistant, Chromium-Nickel Stainless Steel Alloy: U.S. Patent 2,868,638, Jan. 13, 1959.

Dyrkacz, W. W., Aggen, G., and Reynolds, E. E. (assigned to Allegheny Ludlum Steel Corp.), Austenitic Alloys: U.S. Patent 2,873,187, Feb. 10, 1959.

Cape, A. T. (assigned to Coast Metals, Inc.), Low Melting Point Nickel-Iron Alloys: U.S. Patent 2,880,086, Mar. 31, 1959.

Furman, W. F., and Harrison, H. T. (assigned to Duraloy Co.), Nickel Alloy: U.S. Patent 2,892,703, June 30, 1959.

Evans, R. M., and Pattee, H. E. (assigned to Trane Co.), High-Temperature Nickel Base Brazing Alloys: U.S. Patent 2,894,835, July 14, 1959.

Cape, A. T., and Foerster, C. V. (assigned to Coast Metals, Inc.), Nickel-Silicon-Boron Alloys: U.S. Patent 2,899,302, Aug. 11, 1959.

Evans, R. M., and Pattee, H. E. (assigned to Trane Co.), Nickel Base Brazing Alloys for High-Temperature Applications: U.S. Patent 2,900,253, Aug. 18, 1959.

McGurty, J. A., and Funston, E. S. (assigned to the United States of America as represented by the United States Atomic Energy Commission), Nickel-Chromium-Germanium Alloys for Stainless Steel Brazing: U.S. Patent 2,901,347, Aug. 25, 1959.

Grala, E. M., and Maxwell, W. A. (assigned to the United States of America as represented by the Secretary of the Navy), Cast Nickel Alloy of High Aluminum Content: U.S. Patent 2,910,356, Oct. 27, 1959.

Bieber, C. G., and Ziegler, G. N. (assigned to The International Nickel Company, Inc.), Cast Nickel Base Alloy for High Temperature Service: U.S. Patent 2,912,323, Nov. 10, 1959.

[52] Feller, M., and Field, E. (assigned to Standard Oil Co.), Catalytic Process: U.S. Patent, 2,880,200, Mar. 31, 1959.

Sargent, D. E. (assigned to General Electric Co.), Catalysts: U.S. Patent 2,892,801, June 30, 1959.

[53] Evans, H. (assigned to the International Nickel Co., Inc.), Manufacture of Metal Strip From Metal Powder: U.S. Patent 2,889,224, June 2, 1959.

[54] Howe, G. H. (assigned to General Electric Co.), Magnetic Nickel Base Material and Method of Making: U.S. Patent 2,891,883, June 23, 1959.

[55] Hoff, R. L. (assigned to Superior Tube Co.), Tungsten-Tantalum-Nickel Cathodes: U.S. Patent, 2,899,301, Aug. 11, 1959.

[56] Grandey, M. F. (assigned to General Electric Co.), Method of Making Foam Material From Nickel Powder: U.S. Patent 2,917,384, Dec. 15, 1959.

Nitrogen Compounds

By E. Robert Ruhlman [1] and Betty Ann Brett [2]

⁂

THE 1959 capacity of the atmospheric nitrogen industry in the United States totaled more than 5.3 million short tons, compared with 4.9 million in 1958. The 1959 output was about 86 percent of the year-opening capacity.

The increased use of ammonium nitrate for field-compounded explosives and the development of improved handling, mixing, and loading techniques for this material were two of the major advancements in the mining industry in the 1950's. Increased utilization was again reported in 1959.

TABLE 1.—Salient statistics of the nitrogen compounds industry, in thousand short tons [1]

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Production of anhydrous ammonia, nitrogen equivalent	1,909	2,896	2,985	3,285	3,347	3,862
Imports of nitrogen compounds, gross weight	1,744	1,605	1,494	1,480	1,374	1,509
Exports of nitrogen compounds, gross weight	385	828	1,038	1,218	704	747
Consumption of nitrogen compounds, nitrogen equivalent, for years ended June 30	1,962	2,731	2,756	3,015	3,252	3,417
World: Production of nitrogen compounds, nitrogen equivalent, for years ended June 30	5,951	8,051	8,893	9,533	10,464	11,462

[1] This table incorporates some revisions.

DOMESTIC PRODUCTION

Anhydrous ammonia production continued its upward trend and reached a new high, 15 percent above the record established in 1958. Armour and Company purchased the anhydrous ammonia plant of the Mississippi River Fuel Co., near Festus, Mo. A new company, Armour Agricultural Chemical Co., with headquarters in Atlanta, Ga., was formed to operate the Armour fertilizer, nitrogen, and phosphate divisions. The ammonia plant of Best Fertilizers Co., Lathrop, Calif., operated above its rated capacity of 117 tons per day. The 150-ton-per-day anhydrous ammonia plant of Coastal Chemical Corp., at Pascagoula, Miss., was completed. Plans were announced by Coastal Chemical to construct a wet-process phosphoric acid plant nearby. Collier Carbon and Chemical Corp. was enlarging its ammonia plant

---

[1] Commodity specialist.
[2] Statistical clerk.

at Brea, Calif. Cooperative Farm Chemicals completed the expansion of its anhydrous ammonia plant at Lawrence, Kans., increasing capacity to 300 tons per day. This company, owned by Consumers Cooperative and Central Farmers Cooperative, was also constructing a nitric acid plant. Low Chemical Co. was expanding its ammonia facilities at Freeport, Tex.

TABLE 2.—Major nitrogen compounds produced in the United States, in short tons [1]

Commodity	1950–54 (average)	1955	1956	1957	1958	1959 [2]
Ammonia (NH_3):						
Synthetic plants [3]	2,083,804	3,251,599	3,378,362	3,732,562	3,878,778	4,509,317
Coking plants	237,287	269,607	251,292	261,527	190,576	186,706
Total anhydrous ammonia	2,321,091	3,521,206	3,629,654	3,994,089	4,069,354	4,696,023
Total N equivalent	1,908,981	2,896,016	2,985,209	3,284,938	3,346,840	3,862,244
Principal ammonium compounds:						
Aqua ammonia, 100-percent NH_3:						
Synthetic plants [3]	36,759	39,341	36,723	40,683	50,933	(4)
Coking plants	22,255	16,621	17,681	17,341	14,902	14,710
Total aqua ammonia	59,014	55,962	54,404	58,024	65,835	(4)
Ammonium sulfate, 100-percent $(NH_4)_2SO_4$:						
Synthetic plants [3]	818,531	1,172,779	1,095,782	1,042,494	1,090,956	1,099,437
Coking plants	860,129	981,326	882,700	908,903	640,418	620,264
Total ammonium sulfate	1,678,660	2,154,105	1,978,482	1,951,397	1,731,374	1,719,701
Ammonium nitrate, 100-percent NH_4NO_3 solution [3]	1,494,323	2,082,446	2,182,558	2,586,007	3,581,312	2,864,901
Ammonium chloride, 100-percent NH_4Cl, gray and white [3]	30,774	30,192	29,712	23,472	22,257	(4)
Ammoniating solutions, 100-percent N [3]	[5] 301,968	468,595	490,320	551,518	624,221	821,912
Diammonium phosphate, NH_3 content	(4)	(4)	6,067	9,689	10,581	12,093

[1] This table incorporates some revisions.
[2] Preliminary figures.
[3] Data from Bureau of the Census Current Industrial Reports.
[4] Data not available.
[5] Average for 1951–54 only.

Grace Chemical Division, W. R. Grace & Co., planned expansion of its ammonia plant near Woodstock, Tenn. Increased ammonia requirements from its adjoining urea facilities and the growing market for ammonia necessitated the increase. Olin Mathieson Chemical Corp. completed expansion of its anhydrous ammonia plant at Lake Charles, La. Southern Nitrogen Co., Inc., was installing equipment to increase ammonia capacity about 25 percent. Construction of urea and ammonium nitrate-limestone facilities was also underway. After 2 years of investigation an argon-recovery unit was installed at the Vicksburg (Miss.) ammonia plant of Spencer Chemical Co. Southwestern Nitrochemical Co. began constructing an anhydrous ammonia plant at Chandler, Ariz., late in 1959. This company is owned jointly by Southwestern Agrochemical Corp. and First Mississippi Corp. Valley Nitrogen Producers Cooperative 150-ton-per-day anhydrous ammonia plant was completed. This plant, near Helm, Calif., will also have facilities for producing ammonium sulfate, wet-process phosphoric acid, and complete fertilizers.

The Sunolin Chemical Co., jointly owned by Sun Oil Co. and Olin Mathieson Chemical Corp., began constructing a urea plant at North Claymont, Del. The 73,000-ton-per-year plant was scheduled for completion in 1960.

The new plant of Ketons Chemical Co., at Ketona, Ala., began producing prilled ammonium nitrate and ammonium nitrate mixtures. Ammonium nitrate plants were being built by California Spray-Chemical Corp., at Kennewick, Wash., and by the Florida Nitrogen Co., at Tampa, Fla. The latter company is a wholly owned subsidiary of Southern Nitrogen Co., of Savannah, Ga.

A truck containing dynamite and an ammonium nitrate fuel oil mixture exploded in Roseburg, Oreg., as a result of a fire in an adjoining building.[3] The locked vehicle was unattended when the explosion occurred.

The ammonium perchlorate plant of Pacific Engineering and Production Co., at Henderson, Nev., began operating early in 1959, and plans were announced to expand its capacity to 5 million pounds per year. Another ammonium perchlorate plant, jointly owned by Hooker Chemical Corp. and Foote Mineral Co., was scheduled for completion at the end of 1959. Pensalt Chemicals Corp., formerly Pennsylvania Salt Manufacturing Co., was expanding its ammonium perchlorate plant at Portland, Oreg. Air Reduction Co. completed new liquid-nitrogen plants at Kansas City, Kans., and Denver, Colo., and was constructing a third plant at Richmond, Calif. Linde Co., a division of Union Carbide Corp., completed a liquid-nitrogen plant at Pittsburg, Calif., and was constructing another at Huntsville, Ala.

CONSUMPTION AND USES

Agriculture continued to be the leading consumer of nitrogen compounds. Over 2.6 million tons of contained nitrogen was consumed by agriculture in the year ended June 30, 1959—16 percent above 1957–58. The principal nitrogen materials, in order of importance as fertilizer in 1958–59, were: (1) Anhydrous ammonia, (2) ammonium nitrate, (3) nitrogen solutions, (4) ammonium sulfate, and (5) aqua ammonia.

The use of ammonium nitrate in field-compounded explosives continued to increase and was more than 25 percent above 1958, totaling about 313,000 short tons.

PRICES

Prices of anhydrous ammonia, ammonium nitrate, and agricultural-grade urea were lower at the end of 1959 than at the beginning. Prices of Chilean nitrate, synthetic sodium nitrate, and ammonium nitrate-dolomite were higher. Prices of ammonium sulfate, cyanamide, and industrial urea remained the same.

---

[3] Farm Chemicals, The Roseburg Disaster: Vol. 122, No. 9, September 1959, p. 39.

TABLE 3.—Prices of major nitrogen compounds in 1959, per short ton

[Oil, Paint and Drug Reporter of the dates listed]

Commodity	Jan. 5, 1959	Dec. 28, 1959	Effective date of change
Chilean nitrate, port, warehouse, bulk	$40.50	[1] $44.00	July 20
Sodium nitrate, synthetic, domestic, c.l. works crude, bulk	40.50	44.00	July 20
Ammonium sulfate, coke ovens, bulk	32.00	32.00	
Cyanamide, fertilizer-mixing grade, 21 percent N, granular, Niagara Falls, Ontario, bagged	57.00	57.00	
Ammonium nitrate, fertilizer grade 33.5 percent N:			
Canadian, eastern, c.l., shipping point, bags	68.00	[2] 67.00	Dec. 7
Western, domestic, works, bags	68.00	[3] 67.00	Dec. 14
Anhydrous ammonia, fertilizer, tanks, works	88.00	[4] 86.00	Oct. 5
Ammonium nitrate-dolomite compound, 20.5 percent N, Hopewell, Va., bags	44.50	[5] 48.00	July 20
Urea:			
Industrial, 46-percent N, bags, c.l., ton lots, delivered Eastern	125.00	125.00	
Agricultural, 45 percent N, bags, c.l., 30-ton minimum, delivered Eastern	110.00	103.00	Feb. 2

[1] Quoted at $41.50 per ton from Jan. 26 to July 20.
[2] Quoted at $63-$66 per ton from Aug. 3 to Dec. 7.
[3] Quoted at $63-$66 per ton from Aug. 3 to Dec. 14.
[4] Quoted at $84 per ton from Aug. 3 to Oct. 5.
[5] Quoted at $45.50 per ton from Jan. 26 to July 20.

TABLE 4.—Major nitrogen compounds imported for consumption and exported from the United States, in short tons

[Bureau of the Census]

	1958	1959
Imports:		
Industrial chemicals: Anhydrous ammonia		53
Fertilizer materials:		
Ammonium nitrate mixtures: Containing 20 percent or more nitrogen	335,281	341,037
Ammonium phosphates	158,722	215,707
Ammonium sulfate	186,881	217,473
Calcium cyanamide	57,334	58,400
Calcium nitrate	88,446	68,849
Nitrogenous materials, n.e.s.:		
Organic	16,491	22,950
Inorganic and synthetic, n.e.s	11,624	22,440
Potassium nitrate, crude	546	473
Potassium-soda nitrate mixtures, crude	23,508	36,438
Sodium nitrate	446,100	461,765
Urea, n.e.s	48,706	[1] 63,734
Exports:		
Industrial chemicals:		
Ammonia, anhydrous, and chemical-grade aqua (ammonia content)	30,109	24,411
Ammonium nitrate	8,288	6,783
Fertilizer materials:		
Ammonium nitrate	82,133	81,934
Ammonium phosphates and other nitrogeneous phosphatic-type fertilizer materials	49,542	69,071
Ammonium sulfate	386,838	399,675
Anhydrous ammonia and aqua (ammonia content)	36,520	59,606
Nitrogenous chemical materials, n.e.c	39,775	39,399
Urea	68,120	64,574
Sodium nitrate	3,167	1,571

[1] Revised by Bureau of Mines.

FOREIGN TRADE [4]

Imports of major nitrogen compounds were 10-percent higher than in 1958. Higher shipments were recorded in nearly all compounds.

Exports were 6 percent more than in 1958, resulting from increased tonnages of anhydrous and aqua ammonia, ammonium phosphates, and ammonium sulfate.

WORLD REVIEW

NORTH AMERICA

Canada.—The urea plant of Cyanamid of Canada, Ltd., at Hamilton Bay, Ontario, the first urea plant in Canada, began operating late in 1959 at its rated capacity of 66,000 tons per year.[5] Consolidated Mining & Smelting Co., Ltd., announced plans to construct a 36,000-ton-per-year urea plant next to its fertilizer plant at Calgary, Alberta.[6] Scheduled completion was set for 1960. Sogemines, Ltd., was building an ammonia and ammonium nitrate plant at Maitland, Ontario.[7]

TABLE 5.—Revised estimates of world production and consumption of nitrogen, years ended June 30, 1956–60, in thousand short tons [1]

[Aikman (London), Ltd.]

Year	Estimated production		Estimated consumption	
	For agriculture	For industry	In agriculture	In industry
1955–56	7,521	1,372	6,952	1,372
1956–57	8,023	1,510	7,691	1,510
1957–58	8,800	1,664	8,568	1,664
1958–59	9,665	1,797	9,179	1,797
1959–60	10,298	1,890	9,639	1,890

[1] Exclusive of U.S.S.R.

Cuba.—The 110,000-ton-per-year nitrogen plant of Cuban Nitrogen Co., being built at Matanzas, was scheduled for completion in 1961.[8] Ammonium nitrate, ammonium sulfate, nitric acid, and urea were among the planned products.

Mexico.—Ammonia plants were being constructed at Nogales by Petroleos [9] and at Monclova by Fertilizantes de Monclova.[10]

---

[4] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

[5] Chemical and Engineering News, Cyanamid's Canadian Urea Plant Rolls: Vol. 37, No. 46, Nov. 16, 1959, pp. 22–23.

[6] Precambrian (Winnipeg), vol. 32, No. 3, March 1959, p. 34.

[7] Chemical Week, New Entry in Nitrogen: Vol. 85, No. 3, July 18, 1959, p. 27.

[8] Chemical Trade Journal and Chemical Engineer (London), Nitrogen Fixation in Cuba: Vol. 145, No. 3778, Oct. 30, 1959, p. 808.

[9] Chemical Week, Ammonia: Vol. 84, No. 26, June 27, 1959, p. 30.

[10] Chemical Trade Journal and Chemical Engineer (London), French Interests in Mexican Ammonia: Vol. 144, No. 3760, June 26, 1959, p. 1434.

TABLE 6.—World production and consumption of fertilizer nitrogen compounds, years ended June 30, 1957–59, by principal countries, in thousand short tons of contained nitrogen

[Converted and rounded from United Nations Food and Agriculture Organization]

Country	Production			Consumption		
	1956–57	1957–58	1958–59 [1]	1956–57	1957–58	1958–59 [1]
Australia	25	27	28	32	36	37
Austria	148	173	(2)	42	46	49
Belgium	256	287	(2)	97	87	105
Brazil	6	6	11	36	36	36
Canada	212	215	231	41	41	41
Ceylon	-----	-----	-----	29	29	29
Chile	284	284	284	39	39	40
Denmark	-----	-----	-----	106	108	108
Egypt	35	35	36	173	173	174
Finland	23	24	(2)	48	45	46
France	473	539	(2)	444	533	573
Germany:						
East	331	342	(2)	265	265	265
West	987	1,168	(2)	581	635	661
Greece	7	10	(2)	60	74	77
India	89	90	90	182	203	283
Indonesia	-----	-----	-----	28	28	28
Israel	11	14	14	13	15	16
Italy	404	468	(2)	301	301	331
Japan	860	974	1,120	650	701	729
Korea (South)	-----	-----	-----	175	161	161
Mexico	14	14	14	159	152	140
Netherlands	363	419	(2)	214	230	237
Norway	236	240	(2)	50	51	51
Peru	48	30	31	52	40	40
Philippines	9	9	9	14	14	20
Portugal	23	15	(2)	62	63	73
Spain	51	60	(2)	189	228	237
Sweden	36	40	(2)	99	96	104
Switzerland	12	13	(2)	12	13	14
Taiwan (Formosa)	20	26	75	92	230	130
Union of South Africa	15	19	24	26	32	37
United Kingdom	368	386	(2)	341	343	371
United States	2,270	2,370	2,607	2,065	2,168	2,385
Yugoslavia	6	6	(2)	56	105	121
World total [3]	7,986	8,720	(2)	7,595	8,000	8,560

[1] Preliminary figures.
[2] Forecasts for 1958–59 not available for Europe.
[3] Exclusive of U.S.S.R.; includes quantities for minor producing and consuming countries not listed above.

SOUTH AMERICA

Chile.—Production of Chilean nitrate totaled 1.39 million short tons in 1959—1 percent below the previous year.[11] Anglo-Lautaro Nitrate Co., Cía, Salitrera de Tarapacá y Antofagosta (COSATAN), and the independent Shanks plants supplied 78, 13, and 9 percent, respectively, of the total output. During 1959 La Granja and Humberstone (owned by COSATAN), both Shanks plants, were closed.

The $20 million modernization and expansion program of Anglo-Lautaro was on schedule. New ship-loading equipment was being installed at Tocopilla.

Prices of sodium nitrate and potassium nitrate at the end of 1959 were $33.12 and $42.20, respectively, per short ton, f.a.s. Chilean port.

Colombia.—Construction of the Barrancabermeja nitrogen plant was delayed due to lack of funds.[12] Completion was rescheduled for 1961. The plant will produce ammonia, ammonium nitrate, and urea.

---

[11] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 5, May 1960, pp. 22–23.
[12] Nitrogen (London), Colombia: No. 2, September 1959, p. 43; No. 4, December 1959, p. 39.

TABLE 7.—Exports of nitrate from Chile, 1959, by countries of destination, in thousand short tons

Country of destination	Thousand short tons	Country of destination	Thousand short tons
Argentina	35	Netherlands	28
Belgium	9	Peru	11
Brazil	73	Spain	170
China	11	Sweden	29
Denmark	13	United Kingdom	12
Egypt	55	United States	541
France	55	Other countries	142
India	30	Total	1,261
Italy	33		
Japan	14		

Peru.—Guano production in 1958 totaled 300,000 tons containing about 33,000 tons of nitrogen equivalent.[13] The Peruvian guano industry supplies less than 20 percent of the nitrogen required by agriculture.[14] Fertilizantes Sinteticos S.A. began operating its Fauser–Montecatini ammonia plant at Callao early in 1959.[15] This plant also produced nitric acid, ammonium nitrate, and ammonium sulfate. A second nitrogenous fertilizer plant was planned at Chimbote to produce urea and ammonium sulfate.[16]

EUROPE

Belgium.—The Société Carbochimique S.A. was constructing facilities at its Tertre plant to produce 70 tons per day of fertilizer-grade and 25 tons per day of technical-grade urea.[17]

Czechoslovakia.—Nitrogenous fertilizer production totaled 119,000 short tons in 1958.[18] Additional facilities for making fertilizer nitrogen were being built at Sala nad Vahom, Slovakia, and at Ostrava Kraj.[19]

Finland.—Tippi Oy announced plans to expand the annual capacity of its Oula plant to 48,000 tons of equivalent nitrogen.[20] In 1958, output was 35,000 tons. Fuel oil was the source of hydrogen.

Germany, East.—The nitrogen plant of VEB Leuna-Werk Walter Ulbricht, near Magdeburg, was being expanded to bring annual capacity to more than 400,000 short tons of nitrogen.[21] The plant supplied about 90 percent of East German nitrogen requirements. Its major product was ammonium sulfate; nitric acid, ammonium nitrate, and urea were also produced. Plans to double the capacity of the 20,000-ton-per-year nitrogenous fertilizer plant of Stickstoffwerk Piesteritz were announced.

Germany, West.—Union Rheinische Braunkohlen Kraftstoff A.G. was constructing a 25,000-ton-per-year urea plant near Cologne.[22] A

---

[13] Fertiliser and Feeding Stuffs Journal (London), Fertilisers in Peru: Vol. 51, No. 5, Oct. 7, 1959, p. 218.

[14] Quiggin, A. H., The Guano Story: Fertiliser & Feeding Stuffs Jour. (London), vol. 50, No. 12, June 17, 1959, pp. 550, 552, 554.

[15] Farm Chemicals, Peru's First Synthetic Ammonia Plant Goes on Stream: Vol. 122, No. 6, June 1959, p. 66.

[16] Nitrogen (London), Peru—Second Synthetic Nitrogen Plant: No. 2, May 1959, p. 45.

[17] Chemical Trade Journal and Chemical Engineer (London), New Urea Plant for Belgium: Vol. 145, No. 3770, Sept. 4, 1959, p. 303.

[18] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 1, July 1959, p. 40.

[19] Hospodarske Noviny (Prague), Sept. 7, 1958, p. 117.

[20] Nitrogen (London), Finland—Oula Plant to be Extended: No. 3, September 1959, p. 44.

[21] Nitrogen (London), East Germany: No. 2, May 1959, p. 43.

[22] Commercial Fertilizer, West Germany: Vol. 98, No. 5, May 1959, p. 25.

byproduct ammonium sulfate plant was being built adjacent to the Kattwyk coking plant on the Hohe Schaar peninsula.[23]

Hungary.—Nitrogenous fertilizer produced in 1958 by the Pét Nitrogen Works, at Varpalota, and the Borsod Chemical Combine, at Kazincbarcika, totaled more than 125,000 tons and contained 26,000 tons of nitrogen.[24] A third plant being constructed at Tiszapalkonya to produce ammonium nitrate (48,000 tons equivalent N per year) was to be completed in 1961. This plant will use natural gas from Rumania.

Ireland.—Construction of the proposed nitrogenous fertilizer plant, reported in the 1958 Nitrogen Compounds chapter, was postponed indefinitely.[25]

Italy.—The nitrogenous fertilizer plant of Azienda Nazionale Idrogenazione Combustibili, a government-owned company, began operating early in 1959.[26] This plant, situated near Ravenna, used the Casale process to make ammonia. Hydrogen was obtained from natural gas and nitrogen from the air-fractionation plant. Rated capacity was 165,000 tons of equivalent nitrogen. Ammonium sulfate and prilled ammonium nitrate were the major products.

Netherlands.—The nitrogenous fertilizer plant under construction at Ijmuiden by the Koninklijke Nederlandsche Hoogovens en Staalfabrieken N.V. was scheduled to begin production in 1960.[27] Natural gas from western Netherlands was to be the hydrogen source.

Norway.—Ammonia output at the Notodden and Glomfjord Salpeterfabrikken plants of Norsk Hydro was reduced because of power shortages.[28] The company announced plans to construct an ammonia and ammonium sulfate plant at Mo.[29]

Poland.—Nitrogenous fertilizer output totaled 250,000 tons of contained nitrogen in 1958 and 282,000 tons in 1959.[30] The 1960 goal was 300,000 tons. Ammonia was produced from water gas at the Tarnow and Kedzierzyn nitrogen plants.[31]

Portugal.—Expansion of the ammonium sulfate plant of Amoniáco Português S.A.R.L., at Estarreja, was completed, and output was near the rated capacity of 70,000 tons per year.[32] The ammonia plant of Sociedade Portugesa de Petroquimica was being built, and plans were announced to expand the capacity to 170 tons per day.[33]

---

[23] Chemical Age (London), New Hamburg Coal-Chemicals Plant: Vol. 82, No. 2100, Oct. 10, 1959, p. 492.

[24] Nitrogen (London), Expansion of the Nitrogen Industry in Hungary: No. 2, May 1959, p. 37.

[25] Chemical Age (London), Erie Drops Plan To Build Fertiliser Factory: Vol. 82, No. 2102, Oct. 24, 1959, p. 580.

[26] Chemical and Engineering News, Petrochemicals Multiply in Italy: Vol. 37, No. 1, Jan. 5, 1959, pp. 86–89.

[27] Fertiliser and Feeding Stuffs Journal (London), Gas for Fertiliser in Holland: Vol. 51, No. 6, Oct. 21, 1959, p. 259.

[28] Chemical Age (London), Drought Halts Norsk Hydro's Ammonia Production: Vol. 82, No. 2101, Oct. 17, 1959, p. 542.

[29] Chemical Age (London), Ammonia From Norwegian Waste Gases: Vol. 82, No. 2098, Sept. 26, 1959, p. 412.

[30] Przeglad Techniczny (Warsaw), Production Fertilizers: No. 45, Nov. 11, 1959, p. 3; Trybuna Ludu (Warsaw), Feb. 9, 1960.

[31] Chemik (Warsaw), Technical and Economic Data on Some Chemicals: October 1958, p. 334.
Nitrogen (London), Poland—Rapid Expansion: No. 4, December 1959, pp. 38–39.

[32] Chemical Trade Journal and Chemical Engineer (London), Nitrogen Fertilisers in Portugal: Vol. 145, No. 3767, Aug. 14, 1959, p. 128.
Bureau of Mines, Mineral Trade Notes: Vol. 48, No. 3, March 1959, pp. 38–39.

[33] Chemical Age (London), Bigger Production From Portuguese Ammonia Plant: Vol. 81, No. 2082, June 6, 1959, p. 939.

Rumania.—Plans for a chemical plant at Tirgu Mures included facilities to produce ammonium nitrate fertilizer.[34]

Spain.—The 100,000-ton-per-year nitrogenous fertilizer plant of Empresa Nacional Calvo Sotelo, at Puente de Garcia Rodriguez in Galicia, began production during the latter part of 1959.[35] Other nitrogen plants were planned by Refineria de Petroleos de Escombreras S.A. and by Abanos Sevilla S.A.[36]

United Kingdom.—The ammonia plant of Shell Chemical Co., Ltd., at Stanford-le-Hope, began operating in May.[37] One-fifth of the plant's 75,000-ton-per-year output was to be used to make an ammonium nitrate-chalk fertilizer. Nitrogen from air and hydrogen from fuel oil were combined to form ammonia by the Fauser-Montecatini process. The 400-ton-per-day ammonium nitrate plant of Fisons, Ltd., began operating in mid-1959, using ammonia from the adjacent Shell plant.[38]

Yugoslavia.—An ammonium nitrate-limestone plant was being built at Pancevo.[39] This plant will have an annual capacity of 360,000 tons of 20.5-percent nitrogen material. Methane will be the source of hydrogen. The anhydrous ammonia plant being built at Lukavac, Bosnia, by Italian and Yugoslav companies, will use coke-oven gases to produce 100 tons per day of anhydrous ammonia.[40] Nitric acid and nitrochalk also will be produced. Another nitrogenous fertilizer plant was planned at Sisak to utilize waste refinery gas.[41]

ASIA

China.—Expansion of the nitrogenous fertilizer industry continued.[42] Plants were planned, being constructed, or expanded at Nanking, Chengtu, Kiangsi, Honan, Maanshan, Kwangtung, Hwainan, Mechuen-hsien, Shantung, and Tientsin.

Imports of nitrogenous fertilizers in 1959 contained about 350,000 tons of nitrogen equivalent.[43]

India.—The Neyveli Lignite Corporation Private, Ltd., contracted with the Montecatini and Ansaldo companies of Italy to construct a urea plant at Neyveli with an annual capacity of 160,000 tons.[44] The

---

[34] Chemical Age (London), Rumanian Fertiliser Plant to Use Natural Gas: Vol. 82, No. 2099, Oct. 3, 1959, p. 449.

[35] Chemical Age (London), Nitrogen Fertilizer Plants for Spain: Vol. 82, No. 2102, Oct. 24, 1959, p. 580.

[36] Fertiliser and Feeding Stuffs Journal (London), Spain's Fertiliser Expansion: Vol. 51, No. 5, Oct. 7, 1959, p. 222.

[37] Chemical Trade Journal and Chemical Engineer (London), Synthetic Ammonia From Fuel Oil: Vol. 144, No. 3757, June 5, 1959, pp. 1273–1274.
Fertiliser and Feeding Stuffs Journal (London), Shell Fertiliser Plant: Vol. 50, No. 11, June 3, 1959, pp. 487–490, 492.

[38] Chemical Age (London), Fisons New Ammonium Nitrate Plant: Vol. 81, No. 2083, June 13, 1959, pp. 975–976.

[39] Chemical Age (London), Yugoslavia Plans Five Fertilizer Factories Based on Local Materials: Vol. 82, No. 2099, Oct. 3, 1959, p. 449.

[40] Farm Chemicals, $8.5 Million Fertilizer Plant for Yugoslavia: Vol. 122, No. 4, April 1959, p. 48.

[41] Oil, Paint and Drug Reporter, Yugoslavia Would Multiply Fertilizer Output by 2: Vol. 175, No. 25, June 15, 1959, pp. 5, 35.

[42] Chemical Age (London), Poland to Supply Nitrogen Plant to China: Vol. 81, No. 2067, Feb. 21, 1959, p. 329.
Commercial Fertilizer, China: Vol. 99, No. 3, September 1959, p. 32.
Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 1, July 1959, pp. 38–40.

[43] Agricultural Chemicals, International Market Round-Up: Vol. 15, No. 2, February 1960, p. 9.

[44] Chemical Age (London), World's Largest Urea Plant?: Vol. 82, No. 2104, Nov. 7, 1959, p. 651.
Chemical Trade Journal and Chemical Engineer (London), Urea in India: Vol. 145, No. 3780, Nov. 13, 1959, p. 920.

plant was to use the Fauser-Montecatini recycling process and was scheduled for completion in 1963.

A nitrogenous fertilizer plant adjoining the steel works at Rourkela was scheduled for completion in 1962.[45] Friedrich Uhde G.m.b.H. of Germany was constructing a 460-ton-per-day ammonia plant.

The 23,000-ton-per-year urea facilities and the 132,000-ton-per-year ammonium sulfate nitrate facilities at the Sindri nitrogenous fertilizer factory were completed. These plants increased total fertilizer capacity by 66 percent.[46]

The plant being constructed at Nanagal, East Punjab, was scheduled to produce 70,000 tons of nitrolimestone and 350,000 tons of ammonium sulfate per year, beginning in 1960.[47]

Indonesia.—An ammonia-urea plant, scheduled to be built near Palembang, was to use natural gas from the nearby refinery of Standard Vacuum Oil Co.[48] The plant, with an annual capacity of 100,000 tons of granular fertilizer-urea, was to use the Casale process for ammonia and the Pechiney-Grace recycle process for urea.

Iraq.—Plans were announced to build a nitrogenous fertilizer plant with an annual ammonia capacity of 60,000 tons. Ammonium nitrate and ammonium sulfate were also to be produced.[49] Equipment and technical assistance were to be provided by the U.S.S.R.

Israel.—The nitric acid plant of Fertilizers & Chemicals, Ltd., began operations, and the company announced plans to expand ammonia facilities and construct an ammonium nitrate plant.[50] These additions would enable the company to double its nitrogenous fertilizer output.

Japan.—Urea production capacity was 720,000 tons per year at the beginning of 1959. Production decreased during the year as a result of stocks build-up.[51]

Korea, South.—The 85,000-ton-per-year urea plant at Chung-Ju began operating in October 1959.[52] The $40-million plant, expected to supply about one-third of South Korea's fertilizer requirements, comprised a power plant, ammonia plant, urea plant, and accessory facilities. The South Korean Government was considering import restrictions to encourage the use of domestic fertilizer.

Pakistan.—Natural gas was to be the raw material for the nitrogenous fertilizer plants being constructed at Fenchuganj in East

---

[45] Chemical Age (London), German Firm Wins Indian Ammonia Plant Contract: Vol. 81, No. 2069, Mar. 7, 1959, p. 407.

[46] Fertiliser and Feeding Stuffs Journal (London), Sindri's Expansion: Vol. 51, No. 7, Nov. 4. 1959, p. 340.

Chemical Age (London), Progress in India's Chemical Industry: Vol. 81, No. 2077, May 2, 1959, pp. 739–740.

[47] Oil, Paint and Drug Reporter, India Fertilizer Installation To Be Finished in Mid-'60: Vol. 175, No. 20, May 11, 1959, p. 4.

[48] Chemical Age (London), Sumatran Urea Plant Plans: Vol. 81, No. 2082, June 6, 1959, p. 940.

Commercial Fertilizer, Indonesia: Vol. 99, No. 2, August 1959, p. 26.

[49] Chemical Week, Red Plants for Iraq: Vol. 84, No. 15, Apr. 11, 1959, p. 24.

[50] Chemical Week, Fertilizers/Israel: Vol. 84, No. 15, Apr. 11, 1959, p. 25.

Chemistry and Industry (London), New Nitric Acid and Phosphate Plants in Israel: No. 4, Jan. 24, 1959, p. 131.

[51] Nitrogen (London), Urea—Japan: No. 2, May 1959, pp. 8–9.

Chemical Age (London), Japan Exports Less Fertilizer: Vol. 82, No. 2091, Aug. 8, 1959, p. 115.

[52] Agricultural Chemicals, Korea's First Fertilizer Plant Is Opened at Chung-Ju: Vol. 14, No. 11, November 1959, p. 96.

Pakistan and at Multan in West Pakistan by the Pakistan Industrial Development Corp.[53] The Multan plant, scheduled for completion in 1960, was to produce 59,000 tons of urea and 103,000 of ammonium sulfate annually. The Fenchuganj plant was scheduled to begin producing 103,000 tons of urea per year in 1961.

Taiwan.—A new urea plant at Nankang, near Taipei, began producing in mid-year with a rated annual capacity of 84,000 tons.

AFRICA

Egypt.—Société Egyptienne d'Engrais et d'Industries Chimiques, S.A.E., announced plans to expand the ammonia facilities at its Suez plant.[54] The increased ammonia output was to be used to make ammonium sulfate. Calcium nitrate would continue to be the major product.

Union of South Africa.—The 325-ton-per-day urea plant being constructed by African Explosives and Chemical Industries, Ltd., at Modderfontein, was scheduled to begin operating early in 1960.[55]

OCEANIA

Australia.—The Australian Government continued to operate the Mulwala ammonia plant and placed the Albion plant in reserve status. The ammonia plants at Ballarat and Villawood were sold to private industry. All four plants were constructed during World War II.[56]

TECHNOLOGY

Processes for producing ammonia,[57] calcium cyanamide,[58] urea,[59] and diammonium nitrate [60] were published.

The Stamicarbon, Chemico, and Pechiney processes for producing urea and improved techniques for its manufacture were discussed.[61]

---

[53] Chemical Age (London), Pakistan's New Fertiliser Plant: Vol. 81, 2063, Jan. 24, 1959, p. 183.

Nitrogen (London), Pakistan—Urea Plants To Be Built: No. 1, February 1959, pp. 42–43.

[54] Fertiliser and Feeding Stuffs Journal (London), Egypt's Fertiliser Expansion: Vol. 50, No. 5, Mar. 11, 1959, p. 224.

Foreign Commerce Weekly, Egypt Fertilizer Firm To Buy U.S. Equipment: Vol. 61, No. 7, Feb. 16, 1959, p. 29.

[55] Nitrogen (London), Urea at Modderfontein: No. 2, May 1959, pp. 25–27.

[56] Chemical Age (London), Australia's Government-Owned Synthetic Ammonia Plants. Vol. 82, No. 2107, Nov. 28, 1959, p. 776.

[57] Chemical Age (London), Process Details of New U.S. 305-Ton-Per-Day Ammonia Synthesis Plant: Vol. 81, No. 2071, Mar. 21, 1959, p. 504.

[58] Chemical Age (London), New Process for Calcium Cyanamide: Vol. 81, No. 7071, Mar. 21, 1959, p. 503.

[59] Chemical Week, Steel-Urea By-Product Swap Pays Both: Vol. 85, No. 22, Nov. 28, 1959, pp. 117–118.

[60] Pearson, C. K., Production of Di-Ammonium Phosphate: Iron and Steel Eng., vol. 36, No. 20, October 1959, pp. 122–125.

[61] Chemical Age (London), Chromium-Nickel Steel Helps Improve Quality of Urea Manufacture: Vol. 81, No. 2081, May 30, 1959, p. 902.

King, J. A., Urea Sets Pace for World Fertilizers: Chem. Eng., vol. 66, No. 20, Oct. 5, 1959, pp. 58, 60, 62.

Nitrogen (London), Urea at Modderfontein—The Stamicarbon Process: No. 2, May 1959, pp. 25–27; The Chemico Urea Process, pp. 31–34; The Pechiney Urea Process, pp. 34–36.

Oil, Paint and Drug Reporter, Nitrogenates—Urea: Section 2, Chemical Forecast 1964, vol. 176, No. 14, Sept. 28, 1959, pp. 10–12.

The Tennessee Valley Authority demonstrated production of 12–12–12 fertilizer in the continuous ammoniator, production of high-nitrogen fertilizers, and the nitrogen loss problem at Muscle Shoals, Ala., June 9–11, 1959.[62]

Several articles on ammoniation and granulation were published.[63]

Improved catalyst recovery techniques were reported to increase the yield of nitric acid from ammonia oxidation plants.[64]

A new technique to measure the quality of water-insoluble nitrogen in urea-form fertilizer was developed.[65] A recently developed gamma ray spectrometer was reported to measure nitrogen content of solid materials.[66]

New techniques to determine the content of nitrogen and other dissolved gas in steel were reported.[67] The source of nitrogen and its effect on steel were discussed.[68]

A new ammonium perchlorate plant was using a new process that eliminated the use of platinum anodes.[69]

Improved techniques in using ammonium nitrate field-compounded explosives in open-pit[70] and underground mines[71] were reported.

---

[62] Agricultural Chemicals, TVA Demonstration Attracts 400: Vol. 14, No. 7, July 1959, pp. 24–26, 91–92; No. 8, August 1959, pp. 32–34, 87, 89.

[63] Perrine, Elmer, Granulation of a 3–2–2 Ratio Fertilizer: Agr. Chem., vol. 14, No. 5, May 1959, pp. 35–36.

Marburger, G. C., Ammoniating Solutions: Agr. Chem., vol. 14, No. 8, August 1959, pp. 37–40, 97, 99.

Reynolds, J. E., Jr., Formulating Granulated Mixed Fertilizers With Nitrogen Solutions: Agr. Chem., vol. 14, No. 4, April 1959, pp. 47–48.

Tucker, H. H., Effects of Urea on Ammonium Nitrate–Ammonia–Water Solutions: Agr. Chem., vol. 14, No. 4, April 1959, pp. 50, 124.

[64] Chemical Week, Nitric Acid: Vol. 84, No. 26, June 27, 1959, p. 92.

[65] Clark, K. G., Yee, J. Y., Lundstrom, F. O., and Lamont, T. G., A Modified Activity Index Procedure for Determining the Quality of the Water-Insoluble Nitrogen in Mixed Fertilizers Containing Urea-Formaldehyde Compounds: Jour. Assoc. Official Agr. Chem., vol. 42, No. 3, August 1959, pp. 592–597.

[66] Chemical and Engineering News, Nitrometer Debuts: Vol. 37, No. 16, Apr. 20, 1959, p. 82.

[67] Mang, Egon, Analyzing Gases in Steel: Foundry, vol. 87, No. 10, October 1959, pp. 178, 180–181.

[68] Iron and Coal Trades Review (London), Nitrogen Content of Electric Steel: Vol. 178, No. 4740, Mar. 27, 1959, pp. 733–735.

Speith, K. G., and von Ende, Hans, Nitrogen in Steels: Jour. Metals, vol. 11, No. 5, May 1959, pp. 333–338.

[69] Chemical Week, vol. 84, No. 17, Apr. 25, 1959, p. 65.

[70] Cook, M. A., Ammonium Nitrate Explosives: Min. Cong. Jour., vol. 45, No. 10, October 1959, pp. 57–62, 107.

Hearon, H. H., Drilling and Blasting at the Jackpile Mine: Explosives Eng., vol. 37, No. 2, March–April 1959, pp. 39–45.

Houck, C. J., A–N Prills Are Soaked With Molasses to Improve Blasting at Weed Heights: Min. World, vol. 21, No. 9, August 1959, pp. 38–39.

Knudson, J. R., Firing Fertilizer for Fragmentation: Presented at AIME Ann. Meeting, San Francisco, Calif., Feb. 15–19, 1959.

Patterson, L. J., Blasting Limestone in Michigan: Min. Cong. Jour., vol. 45, No. 5, May 1959, pp. 55, 57–58.

Quilici, Frank, Blasting Copper Ore in Nevada: Min. Cong. Jour., vol. 45, No. 5, May 1959, pp. 54, 56–57.

Riley, G. G., and Westwater, R., Blasting With Ammonium Nitrate-Fuel Mixtures: Mine & Quarry Eng., vol. 25, No. 5, May 1959, pp. 211–217.

Snow, L. E., Blasting With Commercial Grade Ammonium Nitrate at the Utah Copper Pit of the Kennecott Copper Corp.: Presented at AIME Ann. Meeting, San Francisco, Calif., Feb. 15–19, 1959.

[71] Hoberstorfer, G. G., Ammonium Nitrate Blasting in Underground Mines at Boliden, Sweden: Canadian Min. Jour., vol. 80, No. 10, October 1959, pp. 96–101.

Mitterer, A. V., and Scott, S. A., Ammonium Nitrate Blasting in Potash Mining: Presented at AIME Ann. Meeting, San Francisco, Calif., Feb. 15–19, 1959.

Process modifications permitted the use of ammonium nitrate field-compounded explosives in wet vertical holes[72] and in horizontal holes.[73] A slurry of ammonium nitrate, TNT, and water was reported to be superior to an ammonium nitrate mixed with fuel oil in rock fragmentation and resistance to water.[74] Proceedings of the fourth annual symposium on mining research, at Rolla, Mo., contained several articles on ammonium nitrate explosives technology.[75] The fifth annual symposium on mining research, held at Rolla in November, was devoted to various aspects of the use of field-compounded ammonium nitrate explosives.

---

[72] Withey, M. F., Coulson, Frank, and Bell, R. W., Blasting Wet Holes With Ammonium Nitrate: Min. Cong. Jour., vol. 45, No. 8, August 1959, pp. 40–42, 63.

[73] Mining World, Nitrate With New Jetloader: Vol. 21, No. 7, June 1959, p. 69.

Mining Magazine (London), Loading Nitrate Into Blast Holes: Vol. 100, No. 4, April 1959, p. 220.

[74] Farnam, H. E., Jr., Developments in Ammonium Nitrate Blasting by the Iron Ore Company of Canada: Skillings' Min. Rev., vol. 48, No. 4, Apr. 25, 1959, pp. 4–5.

Mining Journal (London), A New Tool for Blasting: Vol. 253, No. 6472, Sept. 4, 1959, pp. 215–216.

[75] School of Mines and Metallurgy, University of Missouri, Fourth Ann. Symposium on Mining Research, November 13–15, 1958, Rolla, Mo.: Bull. Tech. Ser. No. 97, 1959, 223 pp.

Perlite

By L. M. Otis [1] and James M. Foley [2]

◆

PRODUCTION of crude perlite in the United States in 1959 was 19 percent greater than in 1958.

DOMESTIC PRODUCTION

Crude Perlite.—Producers used 9 percent more crude perlite for their own expanding operations than in 1958, while the quantity sold by them to be expanded by others was 12 percent greater.

Thirteen companies with 15 mines in 6 States produced crude perlite, compared with 12 companies producing from 14 mines in the same States during 1958.

Output of crude perlite in New Mexico continued to be greater than for any other State with 351,000 short tons, 38 percent more than in 1958, and comprised 79 percent of the total domestic crude output. Other States in order of their crude perlite production were: Nevada, Arizona, California, Colorado, and Utah.

Expanded Perlite.—In 1959, 56 companies expanded perlite in 83 plants in 30 States. California had the greatest number of expanding operations with nine plants, followed by Pennsylvania with seven, Texas with six, and New York, New Jersey, and Illinois each with four.

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	
		Quantity	Value	Quantity	Value			Quantity	Value
1950–54 (average)	186	120	$879	47	$263	167	150	149	$7,903
1955	335	198	1,779	88	503	286	247	246	12,585
1956	350	207	1,940	103	610	310	263	264	13,122
1957	422	194	1,730	107	832	301	249	245	12,511
1958	372	197	1,624	95	840	292	241	239	12,373
1959	443	221	1,846	104	891	325	276	273	14,346

---

[1] Commodity specialist.

[2] Supervisory statistical assistant.

Plans were announced to develop a perlite deposit in northwestern Oneida County, Idaho, including crushing and screening equipment and storage bins, with an expanding plant and storage and loading facilities at Malad, Idaho.

Announcement was made of the acquisition of all of the stock of F. E. Schundler & Co., of Joliet, Ill., by Johns-Manville Corp. of New York. The consideration was said to be 148,000 shares of Johns-Manville stock. The Schundler Co. owned and operated one of the largest perlite mines and mills at No Agua, Taos County, N. Mex., 70 miles north of Santa Fe. Storage silos and loading facilities are on the D & RGW Railroad at Antonito, Colo.

United Perlite Corp. announced the opening of a new perilte mine and mill near Tres Piedras, in northern Taos County, N. Mex., not far from the Johns-Manville operation. With a capacity of 200 to 250 tons of processed perlite ore per 8-hour shift, it is the third perlite plant established in the area.

TABLE 2.—Expanded perlite produced and sold by producers in the United States

(Thousand short tons and thousand dollars)

State	1958				1959			
	Quantity produced	Sold			Quantity produced	Sold		
		Quantity	Value	Average value per ton		Quantity	Value	Average value per ton
California	22	22	$1,292	$58.16	23	23	$1,422	$61.20
Florida	8	8	532	67.08	12	11	786	69.09
Illinois	23	23	1,373	59.60	(1)	(1)	(1)	(1)
Kansas	1	1	50	49.34	1	1	43	74.35
Michigan	(1)	(1)	(1)	(1)	8	8	412	50.69
New Jersey	10	10	631	61.33	11	11	657	60.99
New York	19	19	897	46.57	21	21	978	47.50
Pennsylvania	14	14	795	55.00	18	18	1,090	59.20
Texas	7	7	437	59.16	26	26	1,427	55.31
Other Western States [2]	53	51	2,211	43.10	56	56	2,449	43.66
Other Eastern States [3]	84	84	4,155	50.77	100	98	5,082	51.80
Total	241	239	12,373	51.83	276	273	14,346	52.53

[1] Included with "Other Eastern States" to avoid disclosing individual company confidential data.

[2] Includes Arizona, Colorado, Iowa, Louisiana, Minnesota, Missoure, Nebraska, Nevada, New Mexico, Oregon, and Utah.

[3] Includes Indiana, Maryland, Massachusetts, New Hampshire (1959 only), North Carilona, Ohio, Tennessee, Virginia, and Wisconsin.

CONSUMPTION AND USES

Producers reported the following end-use percentages for expanded perlite: Building-plaster aggregate 61, aggregate for concrete 14, fillers and extenders 1, filter aids 11, and 13 in miscellaneous uses which included oil-well drilling muds, oil-well concrete, loose fill insulation, horticulture, insecticides, catalysts, refractory brick and shapes, and absorbents.

PRICES

The average value of crude perlite crushed, cleaned, and sized, f.o.b. producers' plants, sold to expanders, was $8.37 per short ton, while the average value of crude used by prime producers in their own expanding operations was $8.55, compared with $8.44 and $8.84, respectively, in 1958. A weighted average price of these two categories of crude perilte was $8.43, virtually the same as in 1958.

The average price of all expanded perlite sold in 1959 was $52.53 per ton, an increase of 1 percent over the previous year.

FOREIGN TRADE

Crude perlite may be imported duty free under paragraph 1719 of the Tariff Act of 1930. On January 1, 1948, the duty on expanded perlite was reduced from 30 percent under paragraph 214 of the same act to 15 percent ad valorem.

WORLD REVIEW

Canada.—Expanded perlite production in 1958 was 3,553,000 cubic feet, increasing 28 percent in volume over 1957, and valued at Can$1,031,000, 46 percent more than in 1957. This was the greatest annual gain for any lightweight aggregate in Canada.

One new Canadian plant was built at Beauport, Quebec. Ninety-one percent of the product was consumed in lightweight plaster, 3 percent in concrete, and 6 percent in miscellaneous uses.

Although Canada has undeveloped perlite deposits in British Columbia, all perlite expanded in Canada came from the United States. Eight expanding plants operated during the year, situated at Caledonia and Hagersville, Ontario, at Montreal, Ville St. Pierre, and Beauport, Quebec; at Winnipeg, Manitoba; and at Calgary, Alberta, and New Westminster, British Columbia.

Cuba.—The first Cuban perlite expanding plant was completed in May in the Casablanca area of Havana. It operated under a franchise from Great Lakes Carbon Corp., which shipped crude perlite from New Mexico for expansion in Cuba.

Hungary.—The Hungarian Government aided in the mechanization and expansion of the perlite industry. Crude perlite was exported in granule sizes of from 0.3 mm. to 1.5 mm. through the State mineral export marketing board. Principal customers were Germany, Holland, and Switzerland.[3]

TECHNOLOGY

Mineral Products Division of Great Lakes Carbon Corp. issued a bulletin (No. CII–1959) giving specifications of its perlite for use in insulating concrete for roof decks and floor fills, instructions for mixing and applying insulating concrete, engineering data, and fire ratings.

An explanation of the physical-chemical processes which take place during expansion of perlite and its processing into lightweight aggregate in a rotary kiln appeared in a German text.[4]

---

[3] Mining Journal (London), Perlite in Hungary: Vol. 253, No. 6481, Nov. 6, 1959, p. 447.

[4] Albert, János, Expanded Perlite [Its Manufacture and Utilization as a Lightweight Aggregate]: Silikattechnik (Germany), vol. 9, October 1958, pp. 453–457.

The F. E. Schundler Co. issued a 16-page brochure on its perlite mining and refining operations and the many uses of perlite in modern industry.

A composition for making masonry water repellent and also providing a decorative finish was patented. It comprises a wax emulsion or solution of stearate or a silicone, potassium silicate, sodium silicate, latex, and a siliceous aggregate, such as expanded perlite.[5]

Methods for making fire-resistant filaments and fabrics for use in battery separators, filters, etc., were patented using expanded perlite or other similar materials as the principal aggregate.[6]

A British patent described a method of insulating underground pipes by placing the pipes on supports in a ditch, the latter being filled with a mixture of expanded perlite coated with a solvent-precipitated asphalt resin or other high-softening-point hydrocarbon and also a high-softening-point hydrocarbon in a dry powered state.[7]

In a patented method for direct field seeding of tomatoes or other plants commonly transplanted from beds to fields, the seeds are sown in the field and covered with a biocide- or insecticide-treated expanded perlite or other suitable medium.[8]

A method of producing filter aid and filler from perlite was patented. Ground perlite was treated with dilute HCl or H_2SO_4 prior to expansion, thus increasing the rate of expansion.[9]

A fertilizer carrier was patented which holds both an immediate and a prolonged fertilizing characteristic, made by mixing crude crushed perlite ore with a suitable plant nutrient in water-soluble salt form. The ore is then expanded and admixed with an additional nutrient, after which the perlite is crushed to pass 20 mesh. The expansion of the perlite locks much of the first nutrient within the cracks and fragile glass bubbles, to be released slowly after spreading on the soil. The second nutrient, absorbed on the large surface area of the expanded perlite, is released to the soil rapidly.[10]

A pipe insulation that will not crack with extreme expansion and contraction of the pipe was patented. A form is positioned around the pipe and the intervening space filled with expanded perlite or vermiculite particles which have been coated with asphalt or coal tar, forming a resilient jacket for the pipe.[11]

A patent described simultaneous spraying of a binder and fibrous or granulated material onto a surface.[12]

In the preparation of a patented insulating refractory, a mixture of expanded perlite, $CaCl_2$, and water glass is kneaded, molded,

---

[5] Nordstrom, J., Casting Composition Containing a Silicate, a Laytex Binder and a Waxlike Material: Canadian Patent 587,013, Nov. 17, 1959.

[6] Manning, F. W., Propulsion of Filaments by Secondary Solids in Fiberizing: Canadian Patent 586,981, Nov. 10, 1959.

[7] Kid, A. C., Insulation for Underground Conduits and Method of Producing the Same: British Patent 822,714, Oct. 28, 1959.

[8] Dresser H. A. (assigned to Zonolite Co., Chicago Ill.), Direct Field Seeding: U.S. Patent 2,909,869, Oct. 27, 1959.

[9] Houston, H. H. (assigned to International Minerals and Chemical Corp., a New York Corp.), Method of Expanding Perlite: U.S. Patent 2,898,303, Aug. 4, 1959.

[10] Chapman, E. P., Jr., and Wood, J. A. (assigned to Peerless Oil and Gas Co.), Agricultural Product and Method: U.S. Patent 2,904,424, Sept. 15, 1959.

[11] Goff, D.C. (assigned to Zonolite Co., Chicago, Ill.), Method of Insulating Pipe: U.S. Patent 2,901,775, Sept. 1, 1959.

[12] Stumpf, F. M. (assigned to U.S. Mineral Wool Co., Stanhope, N.J.), Method of and Apparatus for Spraying Lightweight Fibrous and Granular Particles: U.S. Patent 2,890,079, June 9, 1959.

dried, heated, cooled rapidly to 600° C., and thereafter cooled slowly to room temperature.[13]

A patented fiberized gypsum plaster consisted of mixing chrysotile asbestos fiber with crushed crude perlite, lime, and sodium silicate and heating in a rotary kiln at 1,500° to 2,100° F.[14]

A patented parting composition used to separate curved pipes from thermal insulation compositions consisted of a mixture of grease and expanded perlite or exfoliated vermiculite, permitting normal radial and axial expansion of the pipe without damaging the insulation jacketing.[15]

---

[13] Hamano, T. (assigned to Bureau of Industrial Technics), Japanese Patent 9875 (1959), Nov. 26, 1957.

[14] McCollum, L. S., and Gindoff, S. (assigned to International Minerals and Chemical Corp.), Fibrous Agglomerate: U.S. Patent 2,902,379, Sept. 1, 1959.

[15] Goff, D. C. (assigned to Zonolite Co., Chicago, Ill.), Parting Agent for Conduits: U.S. Patent 2,903,018, Sept. 8, 1959.

Phosphate Rock

By E. Robert Ruhlman [1] and Gertrude E. Tucker [2]

⁂

THE PHOSPHATE-ROCK industry in 1959 was characterized by increased production and sales. Marketable output of phosphate rock in the United States and the world increased 7 and 5 percent, respectively. U.S. exports were 13 percent above 1958.

TABLE 1.—Salient statistics of the phosphate-rock industry

(Thousand long tons and thousand dollars)

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Mine production..........quantity..	[1] 42, 862	39, 671	52, 198	45, 460	46, 459	49, 249
P_2O_5 content..........do....	[1] 5, 424	4, 984	5, 752	5, 315	5, 805	6, 048
Marketable production..........do....	12, 056	12, 265	15, 747	13, 976	14, 879	15, 869
P_2O_5 content..........do....	3, 848	3, 887	4, 960	4, 356	4, 668	4, 939
Value at mines..........	$72, 771	$75, 379	$97, 922	$87, 689	$93, 693	$98, 758
Average per ton..........	$6. 04	$6. 15	$6. 22	$6. 27	$6. 30	$6. 22
Sold or used by producers:						
Florida..........quantity..	8, 852	9, 565	10, 528	10, 644	10, 573	11, 760
P_2O_5 content..........do....	2, 963	3, 196	3, 473	3, 507	3, 500	3, 875
Value at mines..........	$52, 565	$59, 179	$65, 602	$67, 946	$67, 353	$72, 863
Average per ton..........	$5. 94	$6. 19	$6. 23	$6. 38	$6. 37	$6. 20
Tennessee..........quantity..	1, 516	1, 699	1, 663	1, 778	1, 923	1, 775
P_2O_5 content..........do....	407	448	434	459	501	462
Value at mines..........	$11, 154	$12, 579	$12, 792	$11, 857	$13, 160	$13, 266
Average per ton..........	$7. 36	$7. 40	$7. 69	$6. 67	$6. 84	$7. 47
Western States..........quantity..	1, 279	1, 921	1, 920	2, 175	2, 218	2, 530
P_2O_5 content..........do....	359	536	525	598	605	677
Value at mines..........	$6, 564	$11, 146	$10, 838	$11, 915	$12, 256	$13, 528
Average per ton..........	$5. 13	$5. 80	$5. 64	$5. 48	$5. 53	$5. 35
Total United States..quantity..	11, 647	13, 186	14, 111	14, 597	14, 714	16, 065
P_2O_5 content..........do....	3, 729	4, 180	4, 432	4, 564	4, 606	5, 014
Value at mines..........	$70, 283	$82, 904	$89, 232	$91, 718	$92, 769	$99, 657
Average per ton..........	$6. 03	$6. 29	$6. 32	$6. 28	$6. 31	$6. 20
Imports [2]..........quantity..	103	117	110	110	108	140
Value..........	$2, 102	$2, 703	$2, 626	$3, 090	$2, 944	$3, 421
Average per ton..........	$20. 45	$23. 05	$23. 90	$28. 21	$27. 21	$24. 45
Exports [3]..........quantity..	1, 836	2, 183	2, 685	3, 010	2, 694	3, 048
P_2O_5 content..........do....	608	720	876	977	887	956
Value at mines..........	$11, 668	$14, 269	$15, 649	$20, 070	$18, 060	$20, 466
Average per ton..........	$6. 36	$6. 54	$5. 83	$6. 67	$6. 70	$6. 71
Apparent consumption..........quantity..	9, 914	11, 120	11, 536	11, 697	12, 128	13, 157
World: Production..........do....	26, 435	29, 980	33, 680	32, 290	34, 770	36, 530

[1] Average for 1953–54.
[2] Data on P_2O_5 content not available.
[3] As reported to the Bureau of Mines by domestic producers.

---

[1] **Commodity specialist.**
[2] **Statistical assistant.**

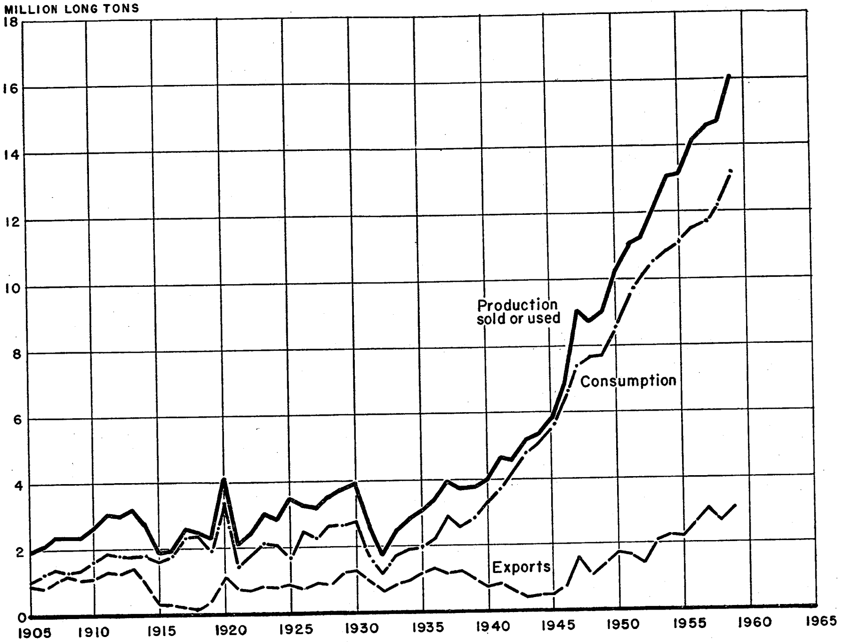

FIGURE 1.—Marketed production, apparent consumption, and exports of phosphate rock, 1905–1959.

DOMESTIC PRODUCTION

Production of phosphate-rock ore and of marketable phosphate rock increased 6 and 7 percent, respectively. Florida and the Western States (Idaho, Montana, Utah, and Wyoming) recorded greater marketable production than in the previous year, 7 and 20 percent, respectively, whereas Tennessee production was 8 percent below 1958.

At its new Orange Park (Fla.) mine, American Cyanamid Co., pumped matrix 5 miles to the washing plant. The wetwashed rock was shipped by rail 30 miles south to the drying plant at Brewster, Fla. Armour Agricultural Chemical Co. applied for permission to

TABLE 2.—Mine production of phosphate-rock ore in the United States, by States

(Thousand long tons)

Year	Florida		Tennessee [1]		Western States [2]		Total United States	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
1953-54 (average)	38,601	4,413	2,518	534	1,743	477	42,862	5,424
1955	34,491	3,884	2,980	510	2,200	590	39,671	4,984
1956	47,250	4,530	2,524	576	2,424	646	52,198	5,752
1957	40,584	4,173	2,752	587	2,124	555	45,460	5,315
1958	41,084	4,556	3,003	625	2,372	624	46,459	5,805
1959	43,365	4,679	2,709	556	3,175	813	49,249	6,048

[1] Includes brown and white rock in 1953–58, and blue rock in 1954–58.
[2] Includes Idaho, Montana, Utah, and Wyoming.

mine phosphate rock from a swampy area in the city of Bartow, Fla. Plans included restoring the land after mining and constructing a 26-acre lake. Virginia-Carolina Chemical Corp. grew citrus trees experimentally on restored mined-out phosphate areas. The company also announced plans to double the capacity of its triple superphosphate plant at Bartow, to 200,000 tons per year. Additional equipment to recover fluorine compounds was installed at the Plant City (Fla.) plant of Smith-Douglass Co., Inc. The Davison Chemical Co., Division of W. R. Grace & Co. began expanding its granular-fertilizer facilities at Ft. Pierce, Fla.

International Minerals & Chemical Corp. investigated the phosphate-rock deposits in Beaufort County, N.C. (described in the chapter of the 1957 Minerals Yearbook). Beaufort Mining and Development Co. was planning to mine phosphate rock in the Coosaw River area, S.C.

The former Victor Chemical Works, producer of phosphate rock in Tennessee and Montana and of elemental phosphorus in Florida, Tennessee, and Montana, merged with Stauffer Chemical Co. as a division. Stauffer owned 50 percent of San Francisco Chemical Co., also a phosphate-rock producer. The new division began construction of a fifth electric furnace at its Mount Pleasant (Tenn.) plant. Hooker Chemical Corp. announced plans to construct a third electric furnace at Columbia, Tenn. Monsanto Chemical Co. was expanding its elemental phosphorus plant at Columbia, Tenn.

The Bunker Hill Co. continued exploring its phosphate-rock deposits near Elliston, Mont., and started building a phosphoric acid plant at Kellogg, Idaho. Central Farmers Fertilizer Co., owned by National Farm Bureau Federation and other farm cooperatives, opened its phosphate-rock plant at Georgetown, Idaho. Facilities in addition to the mine included a beneficiation plant, rotary kiln, fluosolids reactor, 34,000-kw. electric furnace, phosphoric acid converter, and triple-superphosphate plant. Montana Phosphate Products Co. purchased the phosphate-rock holdings of International Minerals & Chemical Corp. near Hall, Mont. The J. R. Simplot Co. completed expansion of its phosphate fertilizer plant at Pocatello,

TABLE 3.—Marketable production of phosphate rock in the United States, by States

(Thousand long tons)

Year	Florida [1]		Tennessee [2]		Western States [3] [4]		Total United States	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
1950–54 (average)	9,156	3,055	1,499	401	1,401	392	12,056	3,848
1955	8,747	2,934	1,466	389	2,052	564	12,265	3,887
1956	11,822	3,910	1,685	438	2,240	612	15,747	4,960
1957	10,191	3,352	1,812	469	1,973	535	13.976	4,356
1958	10,851	3,593	1,903	495	2,125	580	14,879	4,668
1959	11,564	3,794	1,755	458	2,550	687	15,869	4,939

[1] Salable products from washers and concentrators of land pebble and hard rock and drier production of soft rock (colloidal clay).

[2] Salable products from washers and concentrators of brown rock, brown-rock ore (matrix) used directly, blue rock in 1954–58, and white rock in 1953–58.

[3] Mine production of ore (rock) plus a quantity of washer and drier production.

[4] Includes Idaho, Montana, Utah, and Wyoming.

Idaho, including facilities for making sulfuric acid from Wyoming sour-gas sulfur. This company began operating the phosphate-rock mine and beneficiating plant at Conda, Idaho, under an agreement with The Anaconda Co. San Francisco Chemical Co. acquired the phosphate-rock deposits of the former U.S. Phosphate Co. in the Crawford Mountains-Leefe area of Wyoming. The San Francisco-Stauffer Chemical Co. joint development of the Vernal (Utah) phosphate-rock deposit included plans for a beneficiation plant and a 35,000-kw. electric furnace. The estimated reserve was 700 million tons of rock, averaging 21 percent P_2O_5.

CONSUMPTION AND USES

Apparent consumption of phosphate rock again set a record by rising nearly 9 percent above 1958.

Phosphate rock was sold or used principally for ordinary superphosphate (28 percent in 1959 and 31 percent in 1958), triple superphosphate including wet-process phosphoric acid (24 percent in 1959 and 18 percent in 1958), elemental phosphorus (22 percent in 1959 and 24 percent in 1958), exports (19 percent in 1959 and 18 percent in 1958), and direct application to the soil (4 percent in 1959 and 6 percent in 1958).

The U.S. Department of Agriculture reported that 2,298,000 long tons of available P_2O_5 was consumed in fertilizer in the year ending June 30, 1959, compared with 2,045,000 long tons the preceding year.

TABLE 4.—Phosphate rock sold or used by producers and apparent consumption in the United States

(Thousand long tons and thousand dollars)

Year	Sold or used		Apparent consumption [1]
	Quantity	Value at mines	Quantity
1950–54 (average)	11,647	$70,283	9,914
1955	13,186	82,904	11,120
1956	14,111	89,232	11,536
1957	14,597	91,718	11,697
1958	14,714	92,769	12,128
1959	16,065	99,657	13,157

[1] Quantity sold or used by producers plus imports minus exports.

TABLE 5.—Florida phosphate rock sold or used by producers, by kinds

(Thousand long tons and thousand dollars)

Year	Hard rock		Soft rock [1]		Land pebble		Total	
	Quantity	Value at mines	Quantity	Value at mines	Quantity	Value at mines	Quantity	Value at mines
1950–54 (average)	77	$595	83	$472	8,692	$51,498	8,852	$52,565
1955	92	739	72	466	9,401	57,974	9,565	59,179
1956	103	872	59	376	10,366	64,354	10,528	65,602
1957	80	682	56	401	10,508	66,863	10,644	67,946
1958	76	639	51	405	10,446	66,309	10,573	67,353
1959	76	649	56	443	11,628	71,771	11,760	72,863

[1] Includes material from waste-pond operations.

TABLE 6.—Tennessee phosphate rock[1] sold or used by producers

(Thousand long tons and thousand dollars)

Year	Quantity	Value at mines	Year	Quantity	Value at mines
1950–54 (average)	1,516	$11,154	1957	1,778	$11,857
1955	1,699	12,579	1958	1,923	13,160
1956	1,663	12,792	1959	1,775	13,266

[1] Includes small quantity of Tennessee blue rock in 1954–58 and white rock in 1952–58.

TABLE 7.—Western States phosphate rock sold or used by producers

(Thousand long tons and thousand dollars)

Year	Idaho[1]		Montana[2]		Total	
	Quantity	Value at mines	Quantity	Value at mines	Quantity	Value at mines
1950–54 (average)	768	$2,886	[3] 511	[3] $3,678	1,279	$6,564
1955	1,122	5,551	799	5,595	1,921	11,146
1956	1,206	6,044	714	4,794	1,920	10,838
1957	1,418	6,589	[3] 757	[3] 5,326	2,175	11,915
1958	1,393	6,297	825	5,959	2,218	12,256
1959	1,590	6,625	940	6,903	2,530	13,528

[1] Idaho includes Utah in 1950–52, and Wyoming in 1950.

[2] Montana includes Utah in 1953–55, and Wyoming in 1951–59.

[3] Wyoming data published previously in Phosphate Rock chapters included as follows: 1950–54 (average): 63,000 long tons valued at $421,000, for 1951–52; 1957: 182,000 long tons valued at $1,197,000.

TABLE 8.—Phosphate rock sold or used by producers in the United States, by grades and States

(Thousand long tons)

Grades—B.P.L.[1] content (percent)	Florida		Tennessee		Western States		Total United States	
	Quantity	Percent of total	Quantity	Percent of total	Quantity	Percent of total	Quantity	Percent of total
1958								
Below 60	130	1	1,576	82	1,300	59	3,006	21
60 to 66	1,120	11	259	13	(2)	(2)	252	2
68 basis, 66 minimum					560	25	1,687	11
70 minimum	1,983	19	87	5	[2] 357	[2] 16	2,427	16
72 minimum	2,996	28	1	(3)	--------	--------	2,997	20
75 basis, 74 minimum	3,613	34	--------	--------	--------	--------	3,613	25
77 basis, 76 minimum	731	7	--------	--------	1	(3)	732	5
Total	10,573	100	1,923	100	2,218	100	14,714	100
1959								
Below 60	81	1	1,468	83	1,647	65	3,196	20
60 to 66	2,513	21	[2] 307	[2] 17	[2] 883	[2] 35	556	4
68 basis, 66 minimum							[4] 2,626	[4] 16
70 minimum	1,601	14	(2)	(2)	(2)	(2)	2,122	13
72 minimum	2,128	18	--------	--------	--------	--------	2,128	13
75 basis, 74 minimum	3,470	29	--------	--------	--------	--------	3,470	22
77 basis, 76 minimum	1,967	17	--------	--------	(2)	(2)	1,967	12
Total	11,760	100	1,775	100	2,530	100	16,065	100

[1] Bone phosphate of lime, $Ca_3(PO_4)_2$.

[2] Figures combined to avoid disclosing individual company confidential data.

[3] Less than 0.5 percent.

[4] Total 68/66 grade rock includes 77/76 grade in Western States.

TABLE 9.—Phosphate rock sold or used by producers in the United States, by uses and States

(Thousand long tons)

Uses	Florida		Tennessee		Western States		Total United States	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
1958								
Domestic:								
Agricultural:								
Ordinary superphosphate	4,421	1,491	(1)	(1)	(1)	(1)	4,594	1,548
Triple superphosphate	[2] 2,281	[2] 743	[1] 100	[1] 28	[1,2] 496	[1,2] 161	[2] 2,704	[2] 875
Nitraphosphate	(3)	(3)	--------	--------	(3)	(3)	(3)	(3)
Direct application to soil	704	220	96	28	10	3	810	251
Stock and poultry feed	268	85	--------	--------	(3)	(3)	268	85
Fertilizer filler	--------	--------	114	4	--------	--------	120	25
Other [5]	4	1			2	(4)		
Total agricultural	7,678	2,540	310	80	508	164	8,496	2,784
Industrial:								
Elemental phosphorus, ferrophosphorus, phosphoric acid	593	195	1,609	420	1,317	319	3,519	934
Other [6]	1	(4)	4	1	--------	--------	5	1
Total industrial	594	195	1,613	421	1,317	319	3,524	935
Exports [7]	2,301	765	--------	--------	393	122	2,694	887
Grand total	10,573	3,500	1,923	501	2,218	605	14,714	4,606
1959								
Domestic:								
Agricultural:								
Ordinary superphosphate	4,294	1,492	(1)	(1)	(1)	(1)	4,474	1,549
Triple superphosphate [2]	3,459	1,132	[1] 90	[1] 28	[1] 473	[1] 151	3,842	1,254
Nitraphosphate	(3)	(3)	--------	--------	--------	--------	(3)	(3)
Direct application to soil	598	186	70	21	(3)	(3)	668	207
Stock and poultry feed	351	110	--------	--------	(3)	(3)	351	110
Fertilizer filler	--------	--------	(3)	(3)	--------	--------	(3)	(3)
Other [5]	51	17	12	3	3	1	66	21
Total agricultural	8,753	2,937	172	52	476	152	9,401	3,141
Industrial:								
Elemental phosphorus, ferrophosphorus, phosphoric acid	341	102	1,594	408	1,672	405	3,607	915
Other [6]	--------	--------	9	2	--------	--------	9	2
Total industrial	341	102	1,603	410	1,672	405	3,616	917
Exports [7]	2,666	836	--------	--------	382	120	3,048	956
Grand total	11,760	3,875	1,775	462	2,530	677	16,065	5,014

[1] Rock for ordinary superphosphate and triple superphosphate are combined.
[2] Rock for phosphoric acid (wet process) included with triple superphosphate.
[3] Included with "Other" agricultural.
[4] Less than a thousand long tons.
[5] Includes phosphate rock used in calcium metaphosphate, fused tricalcium phosphate, nitraphosphate, and other applications.
[6] Includes phosphate rock used in pig iron blast furnaces, parting compounds, research, defluorinated phosphate rock, refractories, and other applications.
[7] As reported to the Bureau of Mines by domestic producers.

STOCKS

Producers' stocks on hand at the end of 1959 were 5 percent less than in 1958; they did not include quantities of crude ore reported by producers, except as noted.

TABLE 10.—Stocks of phosphate rock in the United States

(Thousand long tons)

Source	In producers' hands Dec. 31 [1]			
	1958		1959	
	Rock	P_2O_5 content	Rock	P_2O_5 content
Florida	2,610	868	2,414	788
Tennessee [2]	266	74	246	69
Western States	[3] 494	[3] 126	[3] 554	[3] 145
Total	3,370	1,068	3,214	1,002

[1] As reported to the Bureau of Mines by domestic producers.
[2] Includes a quantity of Washer-grade ore (matrix).
[3] Includes inventory adjustments.

PRICES

Prices for Florida land-pebble phosphate rock, as quoted by the Oil, Paint and Drug Reporter, remained steady until December 14, when they dropped about 8 percent. Prices for Tennessee and Western States phosphate rock were not quoted in the trade journals.

TABLE 11.—Prices per long ton of Florida land pebble unground, washed, and dried phosphate rock, in bulk, carlots, at mine, in 1959, by grades

[Oil, Paint and Drug Reporter of dates listed]

Grades (percent B.P.L.) [1]	January 5	December 28	Grades (percent B.P.L.) [1]	January 5	December 28
68/66	$5.16	$4.798	75/74	$7.21	$6.628
70/68	5.56	5.148	78/76	8.21	7.518
72/70	6.21	5.728			

[1] B.P.L. means bone phosphate of lime, $Ca_3(PO_4)_2$. (P_2O_5=0.458 times B.P.L.).

FOREIGN TRADE[3]

Imports.—Crude phosphate-rock imports were 29 percent greater than in 1958. Curacao, Mexico, and Makatea Islands supplied 83, 10, and 7 percent, respectively, of total imports. Imports of normal, concentrated, and ammoniated superphosphates, mostly from Canada, increased 95 percent above 1958. Imports of fertilizer-grade ammonium phosphate, 36 percent above 1958, originated mostly in Canada; small quantities came from the Netherlands and the United Kingdom. Other phosphatic fertilizers were imported mainly from Mexico, Peru, Egypt, Beligum-Luxembourg, and Italy.

TABLE 12.—Phosphate rock and phosphatic fertilizers imported for consumption into the United States

[Bureau of the Census]

Fertilizer	1958		1959	
	Long tons	Value	Long tons	Value
Phosphates, crude, not elsewhere specified	108,182	$2,944,075	139,891	$3,420,818
Superphosphates (acid phosphate):				
Normal (standard), not over 25 percent P_2O_5 content	83	3,830	128	7,716
Concentrated (treble), over 25 percent P_2O_5 content	495	33,253	856	57,955
Ammoniated	1,329	95,389	2,733	223,893
Total superphosphates	1,907	132,472	3,717	289,564
Ammonium phosphates, used as fertilizer	141,716	10,216,355	192,596	13,633,209
Bone dust, or animal carbon and bone ash, fit only for fertilizer	10,282	609,469	14,111	887,938
Guano	8,135	718,168	35,878	1,162,309
Slag, basic, ground, or unground	160	6,861	237	6,665
Dicalcium phosphate (precipitated bone phosphate) all grades	4,078	244,354	3,287	196,747

Exports.—Exports of phosphate rock, as reported by the Bureau of the Census, increased 15 percent, compared with 1958; Japan continued to be the major recipient of Florida rock (40 percent), followed by West Germany (11 percent), Canada (10 percent), Italy (7 percent), United Kingdom (7 percent), and the Netherlands (7 percent). Exports of "Other phosphate rock," mainly to Canada increased 4 percent, compared with 1958. Most phosphate rock exported to Canada was reimported into the United States in the form of manufactured fertilizers. Superphosphate exports were 19 percent less than in 1958 and went mainly to Canada, South Korea, Brazil, Cuba, and Chile.

---

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 13.—Phosphate rock exported from the United States, by grades and countries of destination

[Bureau of the Census]

Grade and country	1958		1959	
	Long tons	Value	Long tons	Value
Florida phosphate rock:				
North America:				
Canada	220,452	$2,009,824	281,357	$2,466,967
Cuba	20,718	146,298	20,000	154,537
El Salvador	357	11,369	--------	--------
Mexico	45,261	278,713	48,553	318,739
South America:				
Brazil	61,420	622,761	59,668	605,722
Chile	--------	--------	2,001	31,125
Colombia	1,503	24,025	2,295	34,369
Peru	1,472	13,336	11,033	100,811
Uruguay	8,329	106,600	10,047	105,050
Venezuela	201	4,916	237	3,884
Europe:				
Austria	--------	--------	4,939	39,315
Czechoslovakia	7,494	67,899	5,987	53,883
Denmark	29,405	266,408	30,769	277,972
Germany, West	180,860	1,483,693	316,088	2,543,098
Greece	12,412	82,105	14,484	97,335
Italy	184,042	1,706,537	204,867	1,781,091
Netherlands	258,778	2,202,522	199,348	1,730,038
Norway	8,333	75,497	798	8,187
Spain	--------	--------	115,070	1,039,174
Sweden	66,017	651,163	61,268	553,042
United Kingdom	219,360	1,760,499	200,742	1,592,682
Asia:				
Hong Kong	--------	--------	908	6,002
India	2,986	27,053	11,287	112,863
Japan	1,006,043	7,417,176	1,124,337	8,363,094
Korea, Republic of	--------	--------	7,781	134,732
Laos	--------	--------	496	8,250
Philippines	31,370	279,681	20,489	180,390
Taiwan	19,894	190,160	--------	--------
Turkey	--------	--------	26,491	176,132
Viet Nam	2,661	41,272	9,269	170,961
Africa: Union of South Africa	16,028	145,214	20,085	181,969
Total	2,405,396	19,614,721	2,810,694	22,871,414
Other phosphate rock:[1]				
North America:				
Canada	407,780	5,547,572	409,198	5,503,924
Costa Rica	--------	--------	259	3,221
Cuba	301	3,541	268	3,870
El Salvador	163	3,061	45	1,372
Mexico	434	16,294	559	25,558
South America:				
Brazil	3,972	46,578	1,479	15,187
Venezuela	--------	--------	4,009	64,745
Europe: Belgium-Luxembourg	--------	--------	12,714	104,254
Asia:				
Iran	9	500	--------	--------
Philippines	18	1,282	--------	--------
Viet Nam	--------	--------	497	8,245
Total	412,677	5,618,828	429,028	5,730,376
Grand total	2,818,073	25,233,549	3,239,722	28,601,790

---

[1] Includes colloidal matrix, sintered matrix, soft phosphate rock, and Tennessee, Idaho, and Montana rock.

TABLE 14.—Superphosphates (acid phosphates) exported from the United States, by countries of destination

[Bureau of the Census]

Destination	1958		1959	
	Long tons	Value	Long tons	Value
North America:				
Bahamas	54	$2,949	174	$6,260
British Honduras	156	9,934	49	3,113
Canada	191,525	5,995,049	166,760	5,583,192
Costa Rica	1,030	49,352	1,719	94,747
Cuba	33,046	1,124,337	31,134	1,257,628
Dominican Republic	6,574	406,401	9,814	640,923
El Salvador	1,023	51,347	295	20,140
Guatemala	138	7,353	68	3,857
Mexico	11,061	892,321	18,049	1,235,204
Nicaragua	45	3,075	53	3,412
Panama	97	7,759	----------	----------
Trinidad and Tobago	440	29,542	500	31,696
Other	230	14,133	270	16,619
South America:				
Argentina	----------	----------	140	10,000
Brazil	121,119	6,130,663	45,124	2,433,132
Chile	11,837	741,810	25,646	1,568,819
Colombia	10,923	754,155	769	50,151
Ecuador	576	33,614	256	15,695
Paraguay	----------	----------	18	1,800
Peru	605	41,560	103	10,638
Venezuela	2,603	175,098	4,476	221,524
Europe:				
Greece	9,465	512,190	----------	----------
Ireland	10,454	320,119	----------	----------
Sweden	107	6,860	----------	----------
Asia:				
Indonesia	----------	----------	10	880
Korea, Republic of	97,103	5,765,781	104,405	6,127,141
Philippines	----------	----------	473	30,893
Viet-Nam	----------	----------	1,969	33,000
Africa:				
Rhodesia and Nyasaland, Federation of	----------	----------	357	8,400
Union of South Africa	179	11,120	----------	----------
Total	510,390	23,086,522	412,631	19,408,864

WORLD REVIEW

NORTH AMERICA

Canada.—Electric Reduction Co., subsidiary of Albright and Wilson, Ltd., of England, purchased the phosphate fertilizer plant of Dominion Fertilisers, Ltd., at Port Maitland, Ontario. Plans were announced to expand the facilities for production of sulfuric acid, wet-process phosphoric acid, and phosphate chemicals.[4]

Multi-Minerals, Ltd., reported a reserve of apatite-magnetite-columbium ore of 30 million tons near Nemegos, 160 miles northwest of Sudbury, Ontario.[5]

Mexico.—The Mexican Government placed the large low-grade phosphatic-sand deposits in Baja California in the National Mineral Reserve.[6] The Comision de Fomento Minero was operating a pilot plant to develop a commercial method of beneficiating 18-percent

---

[4] Chemical Trade Journal and Chemical Engineer (London), A. and W. Canadian Subsidiary to Make Fertilisers: Vol. 144, No. 3757, June 5, 1959, p. 1282.

[5] Fertiliser and Feeding Stuffs Journal (London), Potential Phosphate Source: Vol. 51, No. 7, Nov. 4, 1950, p. 327.

[6] Chemical Week, Phosphate/Mexico: Vol. 84, No. 24, June 13, 1959, p. 42.

P_2O_5 rock.[7] Monsanto Mexicano S.A. began operating its plant at Lecheria to produce phosphoric acid and sodium tripolyphosphate.[8] Annual capacity of the plant was 22,500 tons of acid and 30,000 tons of tripolyphosphate. The Hooker Chemical Corp. of the United

TABLE 15.—World production of phosphate rock, by countries [1] [2]

(Thousand long tons)

[Compiled by Liela S. Price and Berenice B. Mitchell]

Country [1]	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
United States	12,056	12,265	15,747	13,976	14,879	15,869
West Indies:						
Jamaica (guano)	[3] 1	(4)	(4)	(4)	(4)	(4)
Netherlands Antilles (exports)	107	109	104	105	85	97
Total	12,164	12,374	15,851	14,081	14,964	15,966
South America:						
Brazil	[5] 24	[5] 49	44	82	144	246
Chile:						
Apatite	46	52	62	32	18	20
Guano	40	41	24	34	31	21
Peru (guano)	249	285	331	280	164	[5] 98
Venezuela	-------	-------	30	30	-------	-------
Total	[5] 360	427	491	458	357	385
Europe:						
Belgium	59	19	13	16	18	13
France	101	101	89	74	76	[5] 74
Spain	23	23	8	1	3	[5] 1
Sweden (apatite)	8	-------	-------	-------	-------	-------
U.S.S.R.:						
Apatite [5]	2,530	3,445	3,690	3,940	3,940	3,940
Sedimentary rock [5]	1,130	1,425	1,575	1,720	1,970	1,970
Total [1] [5]	4,240	5,260	5,620	6,000	6,250	6,240
Asia:						
British Borneo (guano)	1	(4)	(4)	(4)	(4)	1
China [5]	105	100	150	200	300	500
Christmas Island (Indian Ocean), exports	326	390	341	336	374	[5] 375
India (apatite)	2	6	9	9	15	14
Indonesia	1	(4)	3	4	2	[5] 2
Israel	[3] 19	84	118	150	206	201
Jordan	29	161	205	258	289	234
Philippines (guano)	9	(4)	8	4	8	(4)
Viet-Nam:						
Phosphate rock	(6)	(6)	32	22	32	[5] 34
Apatite	(6)	(6)	23	65	137	[5] 138
Total [1] [5]	560	800	910	1,080	1,390	1,520
Africa:						
Algeria	700	740	596	596	556	523
United Arab Republic (Egypt Region)	480	636	605	576	549	475
French West Africa [7]	54	112	75	91	104	95
Madagascar	1	2	3	3	5	7
Morocco: Southern zone	4,275	5,245	5,435	5,480	6,235	7,050
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	(4)	-------	-------	-------	-------	2
Seychelles Islands (exports)	9	1	4	6	17	6
South-West Africa (guano)	1	2	-------	3	-------	1
Tunisia	1,774	2,166	2,044	2,035	2,243	2,150
Uganda	3	3	3	3	2	3
Union of South Africa	80	134	154	166	213	228
Total	7,377	9,041	8,919	8,959	9,924	10,540

See footnotes at end of table.

---

[7] Engineering and Mining Journal, In Latin America—Mexico: Vol. 160, No. 11, November 1959, pp. 170, 172.

[8] Chemical Trade Journal and Chemical Engineer (London), Chemical Industry in Mexico: Vol. 145, No. 3782, Nov. 27, 1959, p. 1033.

TABLE 15.—World production of phosphate rock, by countries [1] [2]—Continued

(Thousand long tons)

Country [1]	1950–54 (average)	1955	1956	1957	1958	1959
Oceania:						
Angaur Island (exports)	122	137	-------	-------	-------	-------
Australia	5	6	7	11	7	[5] 8
Makatea Island (French Oceania)	249	222	255	303	315	363
Nauru Island (exports)	1,093	1,401	1,333	1,105	1,234	[5] 1,211
Ocean Island (exports)	264	309	297	292	324	[5] 295
Total	1,733	2,075	1,892	1,711	1,880	1,877
World total (estimate) [1] [2]	26,435	29,980	33,680	32,290	34,770	36,530

[1] North Korea and Poland produce phosphate rock, but data of output are not available; estimates for these countries have been included in total. A negligible amount is produced in Angola, British Somaliland, Japan, and Tanganyika.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Average for 1951–54.

[4] Less than 500 tons.

[5] Estimate.

[6] Data not available; estimate by senior author of chapter included in total.

[7] Includes calcium phosphate, production of which is reported in thousand long tons as follows: 1952–54 (average), 23; 1955, 9; 1956, 7; 1957, 2; 1958, 1; 1959, 1.

States formed a Mexican subsidiary, Hooker Mexican S.A., to produce and market phosphate chemicals in Mexico.[9]

SOUTH AMERICA

Brazil.—Phosphate rock was produced by Fosforita Olinda, S.A., near Recife; Serrana S.A. de Mineracão near Jacupiranga (apatite); and Mineracão de Ruberia, Ltda. (apatite).[10] Fosforita Olinda, S.A., concentrated its 25 percent P_2O_5 ore by washing and flotation to produce 35 percent P_2O_5 material.[11] Nitro Quimica Brasileira announced plans to construct a dicalcium phosphate plant using a process developed by Fertilizers & Chemicals, Ltd., of Israel.[12]

Peru.—The Jorge Alberto Mining Co. was conducting a phosphate rock exploration program in Yerba Blanca, Sechura.[13]

EUROPE

U.S.S.R.—Phosphate rock occurrences were reported near Katangsk, near Lake Baikal, and in the Angaro-Ilimsk district in eastern Siberia.[14] To supply the growing fertilizer demand in eastern Siberia, plans were being made to construct electric furnaces at Bratsk, Krasnoyarsk, and Eniseisk to use low-grade phosphates.

Defluorination was reported applicable to apatite.[15]

---

[9] Chemical Trade Journal and Chemical Engineer (London), Phosphates Industry for Mexico: Vol. 144, No. 3752, May 1, 1959, p. 992.

[10] Bureau of Mines, Mineral Trade Notes: Vol. 48, No. 5, May 1959, pp. 30–33.

[11] Evans, W. H., How Fosforita Olinda S/A Processes Brazilian Phosphate: Eng. Min. Jour., vol. 160, No. 5, May 1959, pp. 86–87, 90–93.

[12] Fertiliser and Feeding Stuffs Journal (London), Di-Calcium Phosphate Plant for Brazil: Vol. 50, No. 9, May 6, 1959, p. 419.

[13] Mining World, vol. 21, No. 3, March 1959, p. 88.

[14] Cas, W. G., Mineral Fertilizers in E. Siberia: Fertilizer & Feeding Staffs Jour. (London), vol. 51, No. 5, Oct. 7, 1959, pp. 205–206, 208.

[15] Vol'fkovich, S. I. [Hydrothermal Conversion of Natural Phosphates to Fertilizers]: Vestnik Moskogovskogo Universiteta-seriya Matematiki, Mekhaniki, Astronomii, Fiziki, Khimii (Moscow), vol. 13, No. 4, November 1958, pp. 215–221.

United Kingdom.—Albright and Wilson (Manufacturing), Ltd., closed its 25-year-old elemental phosphorus plant at Widnes.[16] Production continued at Portishead and Oldbury. Additions to the Oldbury plant were completed for making phosphorus pentasulfide and alkyl phosphates.[17]

ASIA

A review of recent developments in present and proposed fertilizer facilities was published.[18] The report excluded U.S.S.R., China, and North Korea.

China.—Phosphate deposits containing 11 to 32 percent P_2O_5 were reported in the provinces of Yunnan, Szechwan, Kweichow, Anhwei, and Kiangsu.[19] Production was started at a new phosphate-rock mine near New Hailieh, in Kiangsu province.[20] Plans were announced for constructing phosphatic-fertilizer plants in Nanking, Kaifeng, and Kwangtung.[21]

Israel.—The Negev Phosphate Co. completed a flotation plant for treating the fines from the air separation concentrator. Exploration continued in the Ein Yahav area, 70 miles north of Eilat.[22] Plans were completed to construct an elemental phosphorus furnace at Dimona in the Central Negev.[23] A British company and Koor Industries and Crafts Co., Ltd., of Haifa, with the Israeli Government, planned to build a 10,000-ton-per-year furnace.

Jordan.—The Jordan Phosphate Mines Co., Ltd., obtained a U.S. loan to finance expansion of phosphate mines at Ruseifa.[24] An agreement was made to increase exports of phosphate rock to Poland.[25] It was reported that the Jordan Phosphate Mines Co., Ltd., had established a superphosphate plant at Ruseifa to supply the local market.

Philippines.—Phosphate rock deposits were reported on Negros and Iloiola Islands.[26] Plans were underway for developing the deposits on Negros Island.[27]

Viet-Nam.—It was reported that two phosphatic-fertilizer plants began operating in 1959, adjacent to the phosphate-rock mines at Vinh Tinh in Lan Son Province and at Ham Rong, Thanh Hoa Province.[28]

---

[16] Chemical Age (London), Widnes Phosphorus Plant Closing Down: Vol. 81, No. 2066, Feb. 14, 1959, p. 290.

[17] Chemical Age (London), Three New Plants For A. & W. Group on Stream at Oldbury: Vol. 82, No. 2104, Nov. 7, 1959, pp. 645–646.

[18] Jacob, K. D., Notes on Fertilizer Facilities in Asia: Department of Agriculture Special Rept. 86, Aug. 10, 1959, 11 pp.

[19] Department of Scientific and Industrial Research Lending Library Unit, Llu Translations Bull., October 1959, par. 8, p. 9.

[20] Mining Journal (London), vol. 253, No. 6487, Dec. 18, 1959, p. 637.

[21] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 1, July 1959, pp. 42–43.
Chemical Trade Journal and Chemical Engineer (London), Fertilisers in China: Vol. 145, No. 3762, July 10, 1959, p. 1470.

[22] Chemical Age (London), Israel Phosphate Exports: Vol. 82, No. 2106, Nov. 21, 1959, p. 742.

[23] Chemical Trade Journal and Chemical Engineer (London), Israeli Phosphorus Decision: Vol. 144, No. 3738, Jan. 23, 1959, p. 206.

[24] Foreign Commerce Weekly, Jordan Company to Expand Phosphate Mining Output: Vol. 62, No. 20, Nov. 16, 1959, p. 31.

[25] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 3, March 1960, p. 30.

[26] Mining World, Philippine Company Finds Rock Phosphate Deposits: Vol. 21, No. 7, June 1959, p. 28.

[27] Mining World, vol. 21, No. 12, November 1959, p. 85.

[28] Mining Journal (London), vol. 252, No. 6460, June 12, 1959, p. 650.

AFRICA

Algeria.—The Société des Phosphates de Constantine was developing a new phosphate-rock mine about 55 miles south of Tebessa. Production of the 25-percent P_2O_5 rock was scheduled to start in 1963. The company planned to market a 34-percent P_2O_5 concentrate.

United Arab Republic (Egypt Region).—Plans for constructing a triple superphosphate industry were being made.[29]

French West Africa.—The Compagnie Sénégalaise des Phosphates de Taïba completed its beneficiation plant near Thiès in Senegal.[30] This

TABLE 16.—Phosphate rock exports from Algeria, Morocco, and Tunisia, by countries of destination [1]

(Long tons)

[Compiled by Corra A. Barry]

Country	1958	1959
South America:		
Brazil	45, 190	33, 893
Chile	6, 889	--------
Uruguay	7, 762	4, 872
Europe:		
Austria	61, 710	88, 097
Belgium	549, 393	578, 756
Czechoslovakia	51, 868	77, 851
Denmark	226, 854	216, 662
Finland	91, 630	84, 052
France	1, 708, 842	1, 681, 587
Germany:		
East	57, 875	854, 733
West	734, 239	
Greece	158, 149	146, 515
Ireland	117, 078	128, 762
Italy	1, 105, 945	1, 095, 902
Netherlands	442, 299	486, 697
Norway	48, 766	85, 622
Poland	259, 644	258, 388
Portugal	220, 228	252, 760
Rumania	--------	10, 147
Spain	914, 650	844, 388
Sweden	203, 766	230, 168
Switzerland	21, 999	23, 641
United Kingdom	693, 558	721, 565
Yugoslavia	31, 148	7, 450
Asia:		
China	179, 537	502, 351
India	35, 028	94, 960
Indonesia	8, 924	2, 954
Japan	156, 942	281, 742
Taiwan	57, 154	68, 329
Turkey	28, 040	17, 484
Viet-Nam, Laos and Cambodia	7, 382	7, 381
Africa:		
Canary Islands	18, 680	--------
Union of South Africa	389, 836	357, 394
Oceania:		
Australia	12, 283	--------
New Zealand	--------	4, 500
Intercountry shipments [2]	465, 746	466, 001
Total	9, 119, 034	9, 715, 604
Algeria	605, 306	548, 462
Morocco: Southern Zone	6, 278, 861	7, 046, 449
Tunisia	2, 234, 867	2, 120, 693

[1] Compiled from Customs Returns of Algeria, Morocco, and Tunisia.
[2] Trade between Algeria, Morocco, and Tunisia.

TABLE 17.—Exports of phosphate rock from Egypt, by countries of destination [1] [2]

(Long tons)

[Compiled by Corra A. Barry]

Country	1957	1958
Ceylon	41, 886	37, 008
Czechoslovakia	51, 412	47, 854
Finland	--------	[3] 3, 120
Germany, West	--------	[3] 13, 478
Greece	39, 400	33, 468
India	47, 086	52, 674
Japan	192, 014	152, 061
Spain	--------	[3] 46, 892
Yugoslavia	1, 919	11, 379
Others	--------	18, 647
Total	373, 717	416, 581

[1] Compiled from Customs Returns of Egypt.
[2] This table incorporates some revisions.
[3] Detail shown by country of importation.

---

[29] Fertilizer and Feeding Stuffs Journal (London), Phosphates in the United Arab Republic: Vol. 50, No. 11, June 3, 1959, pp. 498–499.

[30] Chemistry and Industry (London), Senegal Phosphate Deposits: No. 37, Sept. 12, 1959, p. 1146.

plant will turn out some 2,000 tons per day of 38-percent P_2O_5 product from 25-percent P_2O_5 ore. The process includes washing, sizing, desliming, and flotation.

Rhodesia and Nyasaland, Federation of.—Dorowa Minerals, Ltd., a subsidiary of African Explosives and Chemical Industries, Ltd., reported proved ore reserves of 37 million tons averaging 8 percent P_2O_5 in the Dorowa apatite deposit.[31]

The pilot plant for upgrading the ore consisted of washing, screening, and magnetic separation processes.

Togo, Republic of.—The Compagnie Togolaise des Mines du Bénin (formerly Société Minière du Bénin) began developing phosphate deposits in the Hahotoé Akoumapé area some 25 miles northeast of Lomé, Togo.[32] The mine, having a capacity of 600,000 tons per year, was scheduled to be in operation late in 1960. Facilities will include a washing plant, railroad to the coast, power station, and docking facilities.

TECHNOLOGY

Results of a geological study indicated that apatite was deposited in sea water by two means: (1) replacement of deposited calcium carbonate, and (2) direct deposition of apatite particles.[33]

A new uranium phosphate mineral was discovered in association with autunite in Japan's largest uranium mine.[34]

Details of uranium content in the calcium and aluminum phosphate zones in the Florida land-pebble district were published.[35]

Investigation of phosphate-bearing geologic horizons in the Bone Valley Formation was reported.[36] The geologic age of this formation was still under study. Geology of the early phosphate-producing region in South Carolina was published.[37]

Further information regarding the geology of the Western phosphate-rock field was published.[38]

Phosphate-rock beds were discovered in formations of Mississippian and Triassic age along the north front of the Brooks Range, Alaska.[39]

The phosphatic zone (Mississippian) in theTiglukpuk Creek area was 36 feet thick and averaged 8 percent P_2O_5; in the upper Kiruktagiak River area it was 38 feet thick and averaged 12 percent P_2O_5. Individual beds contained up to 30 percent P_2O_5. Samples from the Triassic phosphate rock contained up to 35.8 percent P_2O_5.

---

[31] Smith, W. H., The Geology of the Dorowa Ring Complex: Rhodesian Min. & Eng., vol. 24, No. 9, September 1959, pp. 45–46.

[32] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 6, December 1959, p. 49–50.

[33] Hamilton, E. L., and Rex, R. W., Lower Eocene Phosphatized Globigerina Ooze From Sylvania Guyot: Geol. Survey Prof. Paper 260–(w), 1959, pp. 785–798.

[34] Muto, T., Meyrowitz, R., Pommer, A. M., and Murano, T., Ningyoite, A New Uraneous Phosphate Mineral From Japan: Am. Mineral., vol. 44, No. 5–6, May–June 1959, pp. 633–650.

[35] Cathcart, J. B., and McGreevy, L. J., Results of Geologic Exploration by Core Drilling, 1953, Land-Pebble Phosphate District, Florida: Geol. Survey Bull. 1046–(k), 1959, pp. 221–298.

[36] Carr, W. J., and Alverson, D. C., Stratigraphy of Middle Tertiary Rocks in Part of West-Central Florida: Geol. Survey Bull. 1092, 1959, 111 pp.

[37] Malde, H. E., Geology of the Charleston Phosphate Area, South Carolina: Geol. Survey Bull. 1079, 1959, 105 pp.

[38] Cressman, E. R., Geologic Map of Georgetown Canyon and Vicinity, Bear Lake and Caribou Counties, Idaho: Geol. Survey Open File Rept., April 1959, 1 p.

McKelvey, V. E., and Others, The Phosphoria, Park City, and Shedhorn Formations in the Western Phosphate Field: Geol. Survey Prof. Paper 313–(a), 1959, 47 pp.

[39] Patton, W. W., Jr., and Matzko, J. J., Phosphate Deposits in Northern Alaska: Geol. Survey Prof. Paper 302–(a), 1959, 17 pp.

Solution mining of phosphate rock was proposed as a method to produce a high-grade dicalcium phosphate.[40]

Pumping phosphate-rock ore through pipelines as much as 5 miles in length was discussed.[41] Pipeline wear was decreased by periodic 120° rotation of the pipe.

A three-step process for upgrading calcareous phosphate rock was reported.[42]

Removing the organic content of Western phosphate rock in a fluosolids reactor increased the P_2O_5 and improved the acidulation properties of the rock.[43]

A method of upgrading phosphate rock by dissolving calcium and magnesium carbonates with ammonium nitrate or chloride was reported.[44]

An improved process for preparing the phosphate charge for electric furnaces by using a moving grate in place of the rotary kiln was reported.[45]

A process for producing a phosphatic fertilizer (calcium magnesium phosphate) as a byproduct in making nickel matte from smelting garnierite was reported.[46] Phosphate rock was used instead of limestone in preparing the charge for the blast furnace. The resulting slag, calcium magnesium phosphate, contained 17 to 18 percent P_2O_5, mostly soluble in an ammonium citrate solution.

Improvements in methods for producing phosphatic fertilizer materials and the trend in the use of higher-analysis materials were reviewed.[47]

The use of wet-process phosphoric acid in liquid fertilizers eliminated the problems of solid material handling and enabled the production of higher analysis fertilizers.[48]

Techniques for production of higher analysis, liquid phosphatic fertilizer centered on superphosphoric acid containing 76 percent P_2O_5 (105 percent H_3PO_4).[49]

---

[40] Pirson, S. J., Recovery of Phosphates by Insitu Fluid Mining: Pres. at Ann. Meeting AIME, San Francisco, Calif., Feb. 15–19, 1959, 19 pp.

[41] Crolius, P. C., Pipelines Now Move a Variety of Solids: Farm Chemicals, vol. 122, No. 9, September 1959, p. 36.

[42] Masson, M. J., Enrichissement par Calcination des Minerais de Phosphate Carbonatés: Rev. Ind. Min., vol. 41, No. 8, August 1959, pp. 651–661.

[43] King, D. L., Calcining Phosphate Rock: Chem. Eng. Progress, vol. 55, No. 12, December 1959, pp. 77–78.

[44] Mel'nik, B. D., Remen, R. Ye., and Saradzhev, L. V., [A Method for Concentrating Phosphorites]: Byulleten izobreteniy (U.S.S.R.), No. 4, 1958, p. 7.

[45] Mining World, Agglomeration Tests Start at A–C Plant: Vol. 21, No. 11, October 1959, p. 35.

[46] Ando, Jumpei, Simultaneous Production of Nickel Matte and Calcium Magnesium Phosphate: Ind. Eng. Chem., vol. 51, No. 10, October 1959, pp. 1267–1270.

[47] Jacob, K. D., Fertilizer Production and Technology; ch. in Norman, A. G., Advances in Agronomy: Academic Press, Inc., New York, Ann. pub., vol. 9, 1959, pp. 234–332.

[48] Agricultural Chemicals, Liquid Fertilizers Using Wet-Process Phosphoric Acid: Vol. 14, No. 8, August 1959, pp. 43–44, 101.

Aldrich, S. R., Liquid Fertilizers: Agricultural Chem., vol. 14, No. 5, May 1959, pp. 41, 104.

Byck, L. C., Jr., The Future of Phosphatic Fertilizer Solution: Farm. Chem., vol. 122, No. 2, February 1959, pp. 22–25.

Chemical Age (London), Phosphatic Fertiliser: Vol. 82, No. 2090, Aug. 1, 1959, p. 79.

Chemical Week, Liquid Fertilizer Route: Vol. 84, No. 11, Mar. 14, 1959, pp. 58, 60.

Oil, Paint and Drug Reporter, TVA Wants to be a Help to Liquid Fertilizer Makers: Vol. 175, No. 10, Mar. 2, 1959, pp. 5, 42.

[49] Chemical Engineering, Stronger Acid Cuts Fertilizer Costs: Vol. 66, No. 17, Aug. 24, 1959, p. 58.

Striplin, M. M., Jr., Liquid Fertilizer From Superphosphoric Acid: Commercial Fertilizer, vol. 99, No. 2, August 1959, pp. 51–52.

Improvements in producing phosphatic fertilizers included the cone mixer, continuous dens, reduced acid requirements, and the use of surfactants.[50]

A new way to produce wet-process phosphoric acid was reported, a high-quality gypsum byproduct.[51]

New techniques for granulating phosphatic and other fertilizers were described.[52]

A technique for measuring phosphoric acid by positive displacement was described.[53]

Methods to enable commercial use of aluminum phosphate were sought by the Tennessee Valley Authority (TVA).[54] Electric-furnace smelting, sintering, alkali extraction, calcination, and acid extraction were tried in bench tests. Acid extraction, using a mixture of nitric and sulfuric acids, was selected for pilot-plant development.

Test results by TVA demonstrated the advantages of a rotating electric furnace over a stationary furnace for producing elemental phosphorus.[55]

Research to develop new polymers capable of withstanding high temperatures was reported.[56] Preliminary results indicated phosphinoborines were promising compounds and were especially resistant to attack by heat, water, and oxidation.

Techniques for processing uranium-plutonium mixtures and for operating nuclear reactors utilized phosphate compounds and phosphoric acid.[57] Direct conversion of heat into electricity at temperatures of 850° to 1,500° F. was accomplished using an indium arsenide phosphide semiconductor.[58]

---

[50] Slack, A. V., Developments in Superphosphate Production: Farm. Chem., vol. 122, No. 4, pt. 1, April 1959, pp. 61–65; No. 5, pt. 2, May 1959, pp. 54–57.

[51] Chemical Age (London), Phosphoric Acid Process: Vol. 82, No. 2089, July 25, 1959, p. 73.

Chemical Engineering, vol. 66, No. 14, July 13, 1959, p. 190.

Chemical Week, A New Phosphoric Acid Process: Vol. 84, No. 25, June 20, 1959, p. 82.

[52] Agricultural Chemicals, Screening Granulated Mixed Fertilizers Between the Dryer and Cooler: Vol. 14, No. 8, August 1959, p. 46; Batch Vs. Continuous Fertilizer Manufacture, p. 50.

Chemical Age (London), Fertiliser Society Hears Report of Work on Mechanism of Granule Formation: Vol. 81, No. 2067, Feb. 21, 1959, pp. 321–322.

Chemical and Engineering News, Fertilizers Pelletized New Way: Vol. 37, No. 25, June 22, 1959, pp. 38–39.

Chemical Trade Journal and Chemical Engineer (London), Granular Fertilisers: Vol. 144, No. 3744, Mar. 6, 1959, p. 551.

Lang, G. E., Fertilizer Drying: Agr. Chem., vol. 14, No. 4, April 1959, pp. 44, 46.

Schmalz, T. R., Failure or Success in Using Steam For Granulation: Agr. Chem., vol. 14, No. 6, June 1959, pp. 51, 121; Basmen, T. J., Steam in Granulation, p. 51.

[53] Jones, W. E., Measurement of Flow of Phosphoric Acid and Nitrogen Solutions: Agr. Chem., vol. 14, No. 5, May 1959, p. 47.

[54] Hignett, T. P., Siegel, M. R., Kelso, T. M., and Meline, R. S., Utilization of High Alumina Phosphate Ore From the Florida Leached-Zone Ore Deposits: TVA Chem. Eng. Bull. 3, August 1957, 32 pp.

[55] Striplin, M. M., Jr., Potts, J. M., and Marks, E. C., Comparison of the Life of Linings in Rotating and Stationary Phosphorus Furnaces: Jour. Electrochem. Soc. vol. 106, No. 2, February 1959, pp. 146–147.

[56] Chemical Age (London), U.S. Chemists Produce Phosphinoborines For High Temperature Usage: Vol. 81, No. 2082, June 6, 1959, p. 940.

Chemical and Engineering News, Seek Polymers Stable at 1,000° F.: Vol. 37, No. 24, June 15, 1959, p. 40.

[57] Chemical Week, Heat Reactor Has Heart of Gold: Vol. 84, No. 15, Apr. 11, 1959, p. 100.

Morgan, W. W., Mathers, W. G., and Hart, R. G., Processing of Irradiated Reactor Fuels: Ind. Eng. Chem., vol. 51, No. 7, July 1959, pp. 817–820.

[58] Chemical Week, A New High-Temperature Thermoelectric Material: Vol. 84, No. 15, Apr. 11, 1959, p. 84.

Platinum-Group Metals

By J. P. Ryan[1] and Kathleen M. McBreen[2]

⁂

REFLECTING the sharp upturn in the Nation's business, domestic consumption of platinum-group metals rose to a new peak of 896,000 ounces in 1959. Imports likewise rose, aggregating over 1 million ounces and only slightly below the alltime record in 1956. Increased demand and a tighter supply situation brought advances in the prices of all platinum-group metals except osmium. In contrast with 1958, a more orderly selling policy of the U.S.S.R. contributed to better balance between supply and demand and greater price stability. The declining trend in prices of the major platinum-group metals in 1956–58 was sharply reversed. Published wholesale prices of platinum and palladium advanced to $77 and $22 an ounce, respectively, the highest prices since late 1957.

World production of platinum-group metals increased 12 percent from a 4-year low of 890,000 ounces in 1958 to 1 million ounces in 1959. Both Rustenburg Platinum Mines, Ltd., and International Nickel Co. of Canada, Ltd., the leading producers, reported higher mine output and sales.

LEGISLATION AND GOVERNMENT PROGRAMS

The regulations established under the Defense Materials System by Business and Defense Services Administration of the U.S. Department of Commerce, governing the flow of raw materials to defense agencies, applied to platinum-group metals. Purchase orders for materials needed in national defense work continued to have priority rating over unrated commercial business orders.

All platinum-group metals through the semifabricated stage required a validated license for export to Soviet bloc countries.

Exploration for platinum-group metals was eligible for 50-percent financial assistance under the program of the Office of Mineral Exploration (OME); no projects were active in 1959.

DOMESTIC PRODUCTION

Domestic mine production of platinum-group metals, virtually all of which is derived from platinum placers in Alaska and from refining gold and copper ores, increased 8 percent. Total platinum-group metals recovered by domestic refiners from both domestic and foreign

---

[1] Commodity specialist.
[2] Statistical assistant.

ores rose 2 percent to 49,300 ounces valued at $3.2 million; increases in the output of the major metals, platinum and palladium, more than offset lower output of the four minor metals of the group. Of the new metals produced, 30 percent came from domestic sources.

Refiners recovered nearly 136,000 ounces of secondary platinum-group metals chiefly from scrap, sweeps, and outmoded jewelry, an alltime record and an increase of 67 percent over 1958. Recoveries were higher for all platinum-group metals except iridium and ruthenium. In addition to the secondary metals recovered, about 538,000 ounces of wornout catalysts, spinnerets, laboratory ware, and other equipment was reworked or refined on toll.

Domestic ores and secondary materials furnished about 16 percent of domestic requirements of platinum-group metals in 1959.

TABLE 1.—Salient statistics of platinum-group metals, in troy ounces

	1950–54 (average)	1955	1956	1957	1958	1959
United States: Production:						
Mine production from crude platinum placers, and byproduct platinum-group metals recovered largely from domestic gold and copper ores	31, 904	23, 170	21, 398	18, 531	[1] 14, 359	15, 485
Value	(2)	$1, 874, 271	$1, 884, 487	$1, 428, 642	[1] $740, 583	$913, 736
Refinery production:						
New metal:						
Platinum	45, 792	52, 011	50, 516	37, 109	35, 409	37, 296
Palladium	7, 207	6, 123	4, 389	4, 031	5, 913	7, 525
Other	6, 141	3, 347	3, 745	6, 088	6, 873	4, 500
Total	59, 140	61, 481	58, 650	47, 228	48, 195	49, 321
Secondary metal:						
Platinum	29, 174	32, 901	60, 916	49, 022	36, 426	58, 945
Palladium	27, 278	26, 124	37, 774	31, 294	38, 883	68, 279
Other	3, 674	5, 311	7, 579	7, 205	6, 205	8, 772
Total	60, 126	64, 336	106, 269	87, 521	81, 514	135, 996
Consumption:						
Platinum	268, 837	467, 065	430, 644	347, 983	[1] 263, 681	363, 490
Palladium	208, 728	351. 663	399. 991	367, 287	395, 100	488, 071
Other	28, 024	32, 083	28, 277	28, 755	30, 912	44, 842
Total	505, 589	850, 811	858, 912	744, 025	[1] 689, 693	896, 403
Stocks in hands of refiners, importers, and dealers, Dec. 31:						
Platinum	192, 916	304, 462	353, 778	306, 988	295, 274	290, 691
Palladium	132, 431	153, 092	163, 730	154, 005	151, 572	158, 706
Other	41, 964	45, 534	47, 025	46, 196	46, 580	46, 454
Total	367, 311	503, 088	564, 533	507. 189	493, 426	495, 851
Imports for consumption:						
Unrefined materials	49, 714	50, 953	41, 221	32, 794	36, 252	86, 053
Refined metals	494, 750	958, 987	992, 656	649, 219	634, 179	924, 280
Total	544, 464	1, 009, 940	1, 033, 877	682, 013	670, 431	1, 010, 333
Exports: (Except manufactures)	35, 459	28, 968	42, 072	40, 354	47, 368	31, 405
World: Production	770, 000	[1] 1, 090, 000	[1] 1, 110, 000	[1] 1, 320, 000	[1] 890, 000	1, 000, 000

[1] Revised figure.

[2] Data not available.

TABLE 2.—New platinum-group metals recovered by refiners in the United States, by sources, in troy ounces

	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1950–54 (average)	45,792	7,207	3,065	1,259	1,051	766	59,140
1955	52,011	6,123	2,056	689	324	278	61,481
1956	50,516	4,389	2,476	500	363	406	58,650
1957	37,109	4,031	2,693	1,349	1,056	990	47,228
1958							
From domestic sources:							
Crude platinum Gold and copper refining	9,025	4,691	1,685	368	271	22	16,062
From foreign crude platinum	26,384	1,222	1,461	646	958	1,462	32,133
Total	35,409	5,913	3,146	1,014	1,229	1,484	48,195
1959							
From domestic sources:							
Crude platinum Gold and copper refining	9,791	4,179	767	103	83	92	15,015
From foreign crude platinum	27,505	3,346	933	388	847	1,287	34,306
Total	37,296	7,525	1,700	491	930	1,379	49,321

TABLE 3.—Secondary platinum-group metals recovered in the United States, in troy ounces

Year	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1950–54 (average)	29,174	27,278	939	353	816	1,566	60,126
1955	32,901	26,124	1,499	231	1,763	1,818	64,336
1956	60,916	37,774	1,751	447	3,246	2,135	106,269
1957	49,022	31,294	1,406	398	3,014	2,387	87,521
1958	36,426	38,883	1,223	335	2,639	2,008	81,514
1959	58,945	68,279	1,188	361	5,631	1,592	135,996

CONSUMPTION AND USES

Platinum-group metals sold to or used by domestic industries rose 30 percent to an alltime peak of 896,000 ounces. The gain reflected the increased demand for these metals resulting from a general improvement in business conditions. Sales of palladium to electrical industries represented more than 80 percent of the gain. Higher sales were recorded in all other industrial categories except dental and medical. Domestic consumers absorbed nearly 90 percent of the 1959 world output of platinum-group metals.

Sales of platinum increased 38 percent, and all consuming industries recorded gains. Chemical industries, including petroleum refining and glass, absorbed 57 percent of the total platinum sold, electrical uses 22 percent, jewelry and decorative uses 14 percent, and dental and medical uses 4 percent.

Palladium sales gained 24 percent over 1958, owing principally to the sharp increase in demand for electrical and electronic uses, which absorbed over three-fourths of all palladium sold. The increased demand from electrical industries more than offset the decline in requirements for chemical uses and dental and medical uses, which dropped to 9 and 6 percent, respectively, of all sales. Jewelry and

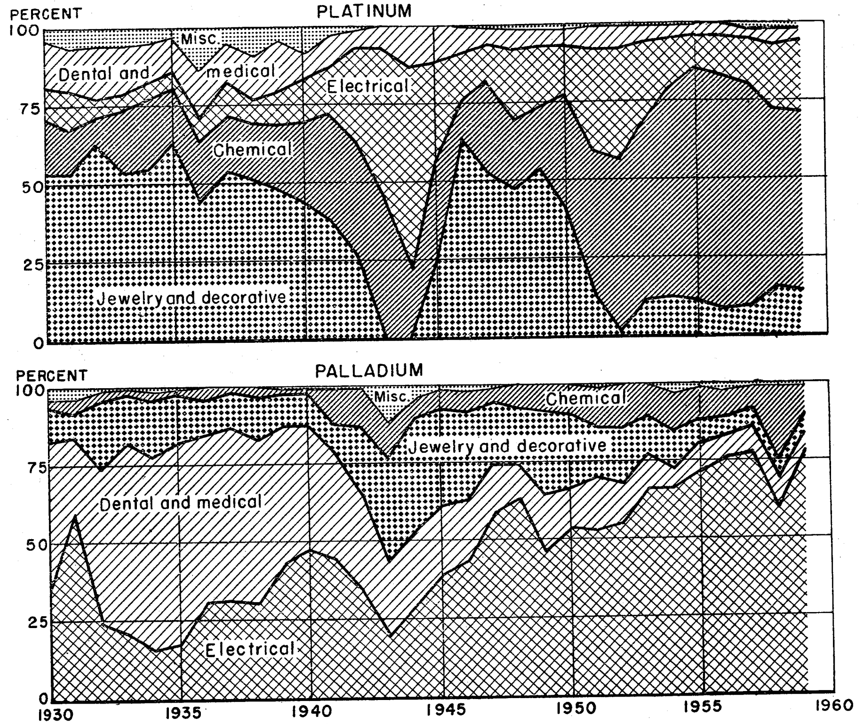

FIGURE 1.—Sales of platinum and palladium to various consuming industries in the United States, 1930–59, as percent of total.

decorative uses increased 36 percent and totaled about 7 percent of all sales.

Sales of minor platinum-group metals—iridium, osmium, rhodium, and ruthenium—rose 45 percent to 44,800 ounces. About half of these sales, chiefly of rhodium, went to chemical industries, including petroleum and glass; 22 percent was sold for jewelry and decorative uses, 18 percent for electrical use, and 3 percent for dental and medical uses.

The principal industrial usefulness of platinum-group metals is based on characteristics such as high resistance to both heat and oxidation, superior catalytic activity, high resistance to chemical corrosion and high enough electrical conductivity for use in control equipment. Platinum-group metal catalysts were essential elements in the production of nitric acid, hydrogen peroxide, perchlorates, and similar oxidants used in manufacturing rocket fuels, in various hydrogenation and dehydrogenation processes, and in the synthesis of hydrocarbons and hydroxylation. Platinum catalysts were used extensively in petroleum refining for producing high-octane gasoline. Other special applications of platinum and platinum alloys included laboratory ware, pressure rupture disks, insoluble anodes, catalytic gauze for ammonia oxidation, thermocouples, equipment for drawing glass fiber, spinnerets for extruding synthetic fiber, furnace windings, gas ignitors, spark-plug electrodes, electrical contacts, jewelry, and dental and medical devices. Probably more than half of the low-current electrical contacts used in relays to control communication networks were made of palladium.

TABLE 4.—Platinum-group metals sold to consuming industries in the United States, in troy ounces

Industry	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total	Percent of total
1958								
Chemical	148,276	93,215	1,161	340	12,790	435	[1] 256,217	37
Petroleum	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Glass	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Electrical	53,553	238,815	2,166	38	1,714	643	296,929	43
Dental and medical	14,414	36,139	193	4	51	271	[1] 51,072	7
Jewelry and decorative	[1] 41,711	25,129	3,343	3	3,523	1,293	[1] 75,002	11
Miscellaneous	5,727	1,802	79	316	503	2,046	[1] 10,473	2
Total	[1] 263,681	395,100	6,942	701	18,581	4,688	[1] 689,693	100
1959								
Chemical	80,107	42,394	637	496	12,023	1,330	136,987	15
Petroleum	44,327	603	--------	--------	45	--------	44,975	5
Glass	82,997	--------	20	--------	8,375	--------	91,392	10
Electrical	84,837	374,080	2,010	37	5,649	538	467,151	52
Dental and medical	15,379	31,291	319	6	138	936	48,069	5
Jewelry and decorative	50,096	34,113	4,357	20	4,407	1,560	94,553	11
Miscellaneous	5,747	5,590	165	220	176	1,378	13,276	2
Total	363,490	488,071	7,508	779	30,813	5,742	896,403	100

[1] Revised figure.
[2] Figure not segregated; included with "Chemical."

The minor metals of the platinum group—iridium, rhodium, osmium, and ruthenium—were used principally as alloying elements for modifying the properties of platinum and palladium.

The addition of these metals to platinum and palladium increases the hardness and tensile strength of the principal metals and improves their resistance to corrosion. Each of these elements also may be used as pure metal or cladding. Rhodium electroplate, because of its decorative and reflective properties, was used widely as a finish for costume jewelry, accessories, and musical instruments and in reflectors for motion-picture projectors and various laboratory devices. Rhodium plates improve the efficiency of electrical contacts where freedom from oxidation and corrosion is required.

Platinum-clad stainless-steel laboratory ware and chemical processing equipment was developed for use in chemical and biological laboratories.

Platinum metals were used in air-vehicle structures as protective coatings for missile nose cones and jet-engine fuel nozzles, also as materials in highly reflective surfaces for heat shields.

A new instrument for oxygen analysis developed during the year is based on the use of a platinum microelectrode as a capacitor.

STOCKS

Total working stocks of platinum-group metals held by refiners and dealers, in process or in transit at the end of 1959, were slightly higher than at the end of 1958. Substantial quantities of palladium and ruthenium acquired by barter of surplus agricultural commodities were added to Government stockpiles.

TABLE 5.—Stocks of platinum-group metals held by refiners, importers, and dealers in the United States, December 31, 1955–59, in troy ounces

Year	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1955	304, 462	153, 092	13, 830	4, 396	14, 983	12, 325	503, 088
1956	353, 778	163, 730	13, 248	4, 092	17, 764	11, 921	564, 533
1957	306, 988	154, 005	13, 272	4, 420	18, 998	9, 506	507, 189
1958	295, 274	151, 572	10, 548	4, 241	20, 883	10, 908	493, 426
1959	290, 691	158, 706	11, 127	4, 218	20, 720	10, 389	495, 851

PRICES

The price of platinum advanced sharply, reversing the declining trend of 1956–58, and reflecting increased demand and a tighter supply situation. Palladium prices rose to the highest level since 1957 and prices of the minor platinum-group metals, except osmium, like-

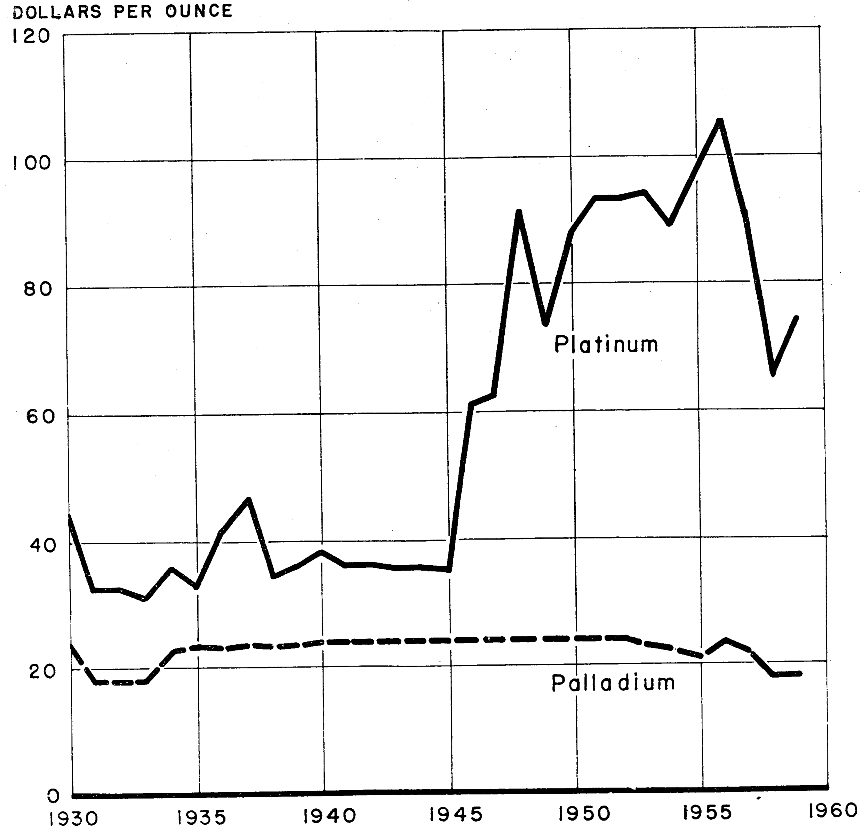

FIGURE 2.—Average price per ounce of platinum and palladium, 1930–59.

wise advanced. In addition to increased demand from consumers and speculators, a more orderly selling policy by the U.S.S.R. was a significant factor in the platinum-metals market. Acquisition for government stockpiles under the agricultural surplus commodities barter program contributed to the increased price of palladium.

Official prices of platinum-group metals, as published by E&MJ Metal and Mineral Markets, were as follows per fine troy ounce: The price of platinum increased 50 percent in several stages from a low of \$51–\$55 at the beginning of 1959 to \$76–\$80 in May and remained virtually unchanged thereafter. Palladium prices advanced from \$15–\$17 in January to \$18–\$20 in March and remained unchanged until October and November when two successive advances brought the price to \$22–\$24, nearly 50 percent above the low figure. Iridium prices rose from \$70–\$80 in January to \$75–\$80 in the middle of February and remained unchanged thereafter. The price of osmium was unchanged at \$70–\$90. Rhodium and ruthenium prices advanced in February from \$118–\$125 to \$122–\$125 and from \$45–\$55 to \$55–\$60, respectively, then remained unchanged to the end of the year.

Considerable trading in the "platinum futures" market on the New York Mercantile Exchange in the early part of the year was prompted by restricted sales of Soviet platinum and strong domestic demand. Over 1,000 "platinum futures" contracts of 50 ounces each were traded in 1959.

FOREIGN TRADE [3]

Imports.—Foreign countries continued to supply more than 80 percent of domestic requirements of platinum-group metals. Reflecting the improvement in industrial demand, U.S. imports of these metals increased 51 percent to 1.01 million ounces valued at \$36.9 million. Imports included palladium and ruthenium acquired for the supplemental stockpile under the Government surplus agricultural commodities barter program.

Imports of platinum both refined and unrefined increased substantially. Imports of refined palladium rose nearly 70 percent, and large increases also were recorded for iridium, osmium, rhodium, and ruthenium.

TABLE 6.—Platinum-group metals imported for consumption in the United States

[Bureau of the Census]

Year	Troy ounces	Value (thousands)	Year	Troy ounces	Value (thousands)
1950–54 (average)	544,464	[1] \$31,959	1957	682,013	[1] \$35,783
1955	1,009,940	[1] 48,163	1958	670,431	24,972
1956	1,033,877	[1] 57,755	1959	1,010,333	36,912

[1] Data known to be not comparable with years before 1954.

---

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 7.—Platinum-group metals (unmanufactured) imported for consumption in the United States, by countries, in troy ounces[1]

[Bureau of the Census]

Country	Unrefined material[2]				Refined metals						Total
	Ores and concentrates of platinum metals	Platinum grain and nuggets (including crude, dust, and residues)	Platinum sponge and scrap	Osmiridium	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	
1958											
North America:											
Canada		55			68,539	42,141	5		10,400		121,140
Mexico						110					110
Total		55			68,539	42,251	5		10,400		121,250
South America:											
Chile			226								226
Colombia		19,619			3,019						22,638
Total		19,619	226		3,019						22,864
Europe:											
Czechoslovakia					3,215						3,215
France					1,344	51,513					52,857
Germany, West			5,129			1,302					6,431
Italy			3,693								3,693
Netherlands					3,093	24,633					27,726
Norway		1,400			1,725	2,325					5,450
Switzerland					32,379	152,405					184,784
U.S.S.R.					31,416	62,167					93,583
United Kingdom		561		1,450	103,033	23,418	1,151	145	6,880	7,758	144,396
Total		1,961	8,822	1,450	176,205	317,763	1,151	145	6,880	7,758	522,135
Asia:											
Japan			2,938								2,938
Lebanon			76								76
Total			3,014								3,014
Oceania: Australia			1,105			63					1,168
Grand total: Troy ounces		21,635	13,167	1,450	247,763	360,077	1,156	145	17,280	7,758	670,431
Value		$1,341,317	$823,320	$85,452	$15,363,045	$5,210,719	$77,914	$8,304	$1,803,162	$259,009	$24,972,242

1959											
North America:											
Canada		38,750			53,855	134,061	3,654		17,079	61	247,460
Cuba			535								535
Mexico			30			700					730
Total		38,750	565		53,855	134,761	3,654		17,079	61	248,725
South America:											
Colombia	503	31,498			3,424						35,425
Venezuela		161	4								165
Total	503	31,659	4		3,424						35,590
Europe:											
Czechoslovakia					1,536	33,577					35,113
France		2,476			5,625	59,408					67,509
Germany, West			772		2,000	2,522	60				5,354
Italy			118								118
Netherlands					12,332	34,508					46,840
Norway		1,800			4,565	6,225					12,590
Spain			613								613
Switzerland					25,495	160,553					186,048
U.S.S.R.					51,505	78,926					130,431
United Kingdom		3,078		2,112	100,187	100,005	4,058	1,223	12,263	14,618	237,544
Total		7,354	1,503	2,112	203,245	475,724	4,118	1,223	12,263	14,618	722,160
Asia:											
Japan			3,412			255					3,667
Lebanon			85								85
Total			3,497			255					3,752
Oceania: Australia			97	9							106
Grand total: Troy ounces	503	77,763	5,666	2,121	260,524	610,740	7,772	1,223	29,342	14,679	1,010,333
Value	$26,905	$5,447,330	$420,388	$75,711	$17,240,966	$9,373,802	$401,907	$64,664	$3,368,905	$491,900	$36,912,478

---

[1] On the basis of detailed information received by the Bureau of Mines from importers, certain items recorded by the Bureau of the Census as "sponge and scrap" have been reclassified and included with "platinum refined metal" in this table.

[2] Bureau of the Census categories are in terms of metal content. It is believed, however, that in many instances gross weight is actually reported.

Canada and the United Kingdom, which normally supply the bulk of U.S. imports, accounted for only 48 percent of the total in 1959. Continental European countries, including the Soviet Union, furnished most of the remaining imports. The metals imported from Switzerland, Netherlands, and Czechoslovakia were reported to be largely of Soviet origin.

Exports.—U.S. exports of platinum-group metals declined 34 percent to 31,400 ounces valued at $1.5 million. Canada, United Kingdom, Japan, and West Germany were the largest buyers, taking more than 90 percent of all exports.

TABLE 8.—Platinum-group metals exported from the United States, by countries of destination [1]

[Bureau of the Census]

Year and destination	Platinum (ore, concentrates, ingots, bars, sheets, wire, sponge, and other forms, including scrap)		Palladium, rhodium, iridium, osmiridium, ruthenium, and osmium (metal and alloys including scrap)		Platinum-group manufactures, except jewelry [2] (value)
	Troy ounces	Value	Troy ounces	Value	
1950-54 (average)	9,583	$794,757	25,876	$709,986	$1,185,221
1955	[3] 17,073	[3] 1,306,011	[3] 11,895	[3] 469,774	[3] 1,208,784
1956	[3] 23,823	[3] 2,383,443	[3] 18,249	[3] 634,293	[3] 2,489,260
1957	17,199	1,328,551	23,155	373,728	1,960,062
1958					
North America:					
Canada	4,828	311,194	1,416	39,359	1,755,915
Cuba	60	3,976	30	564	2,793
Mexico	685	57,648	795	16,400	125,397
Other North America	--------	--------	--------	--------	3,338
Total	5,573	372,818	2,241	56,323	1,887,443
South America:					
Brazil	137	12,206	--------	--------	12,638
Colombia	--------	--------	--------	--------	3,727
Peru	--------	--------	--------	--------	8,292
Uruguay	324	20,868	--------	--------	--------
Venezuela	32	590	236	4,660	6,749
Other South America	--------	--------	--------	--------	3,322
Total	493	33,664	236	4,660	34,728
Europe:					
France	--------	--------	--------	--------	11,201
Germany, West	3,619	229,963	4,556	174,555	19,337
Iceland	--------	--------	--------	--------	19,800
Netherlands	834	48,156	--------	--------	--------
Spain	--------	--------	1,154	28,848	33,035
Switzerland	1,623	156,503	10	580	4,228
United Kingdom	22,662	375,272	3,327	76,971	19,058
Other Europe	--------	--------	442	12,263	16,302
Total	28,738	809,894	9,489	293,217	122,961
Asia:					
India	41	4,324	--------	--------	--------
Japan	230	12,650	327	25,175	26,680
Philippines	--------	--------	--------	--------	7,758
Taiwan	--------	--------	--------	--------	11,868
Other Asia	--------	--------	--------	--------	6,433
Total	271	16,974	327	25,175	52,739
Africa	--------	--------	--------	--------	2,957
Oceania	--------	--------	--------	--------	1,738
Grand total	35,075	1,233,350	12,293	379,375	2,102,566

See footnotes at end of table.

TABLE 8.—Platinum-group metals exported from the United States, by countries of destination [1]—Continued

[Bureau of the Census]

Year and destination	Platinum (ore, concentrates, ingots, bars, sheets, wire, sponge, and other forms, including scrap)		Palladium, rhodium, iridium, osmiridium, ruthenium, and osmium (metal and alloys including scrap)		Platinum-group manufactures, except jewelry [2] (value)
	Troy ounces	Value	Troy ounces	Value	
1959					
North America:					
Canada	3,914	$197,322	7,999	$137,699	$1,997,389
Cuba	40	3,220	------	------	72,725
Guatemala	------	------	------	------	543
Mexico	525	47,711	349	5,857	118,409
Total	4,479	248,253	8,348	143,556	2,189,066
South America:					
Brazil	66	9,930	------	------	10,566
Chile	10	1,394	(4)	1,400	8,219
Colombia	86	2,852	------	------	1,996
Venezuela	202	15,000	211	3,910	11,690
Other South America	21	1,946	------	------	24,952
Total	385	31,122	211	5,310	57,423
Europe:					
France	30	2,448	------	------	------
Germany, West	539	34,876	2,425	112,900	4,400
Sweden	------	------	10	1,040	------
Switzerland	38	3,200	------	------	6,350
United Kingdom	9,877	579,718	1,046	41,032	31,932
Other Europe	------	------	------	------	2,314
Total	10,484	620,242	3,481	154,972	44,996
Asia:					
India	62	9,508	------	------	1,155
Japan	3,028	233,451	717	84,655	3,353
Philippines	80	2,500	88	1,495	1,077
Other Asia	42	1,719	------	------	4,933
Total	3,212	247,178	805	86,150	10,518
Africa	------	------	------	------	902
Oceania	------	------	------	------	2,950
Grand total	18,560	1,146,795	12,845	389,988	2,305,855

---

[1] Quantities are gross weight.
[2] Beginning Jan. 1, 1952, quantity not recorded. Quantity, troy ounces: 1950—12,640, 1951—17,348.
[3] Owing to changes in classification, data not strictly comparable with years before 1955.
[4] Data not available.

WORLD REVIEW

World production of platinum-group metals increased 12 percent to 1 million ounces. The Union of South Africa and Canada, the leading producers, supplied about 70 percent of the world output; the Soviet Union supplied most of the remainder.

Canada.—Production of platinum-group metals from Canadian mines, virtually all of which is recovered as a byproduct of smelting and refining nickel-copper ores of the Sudbury district, Ontario, increased 6 percent to 319,700 ounces valued at $16.6 million. About 47 percent of the total output was platinum and nearly all of the remainder was palladium.

The International Nickel Co. of Canada, Ltd., the leading producer, reported platinum-metal deliveries of 384,600 ounces in 1959, more than double those of 1958 and the second largest ever recorded by the company.

The platinum-group-metals content of nickel-copper ore reserves of the company in the Sudbury district was estimated at 6.6 million ounces as of December 31, 1958.[4]

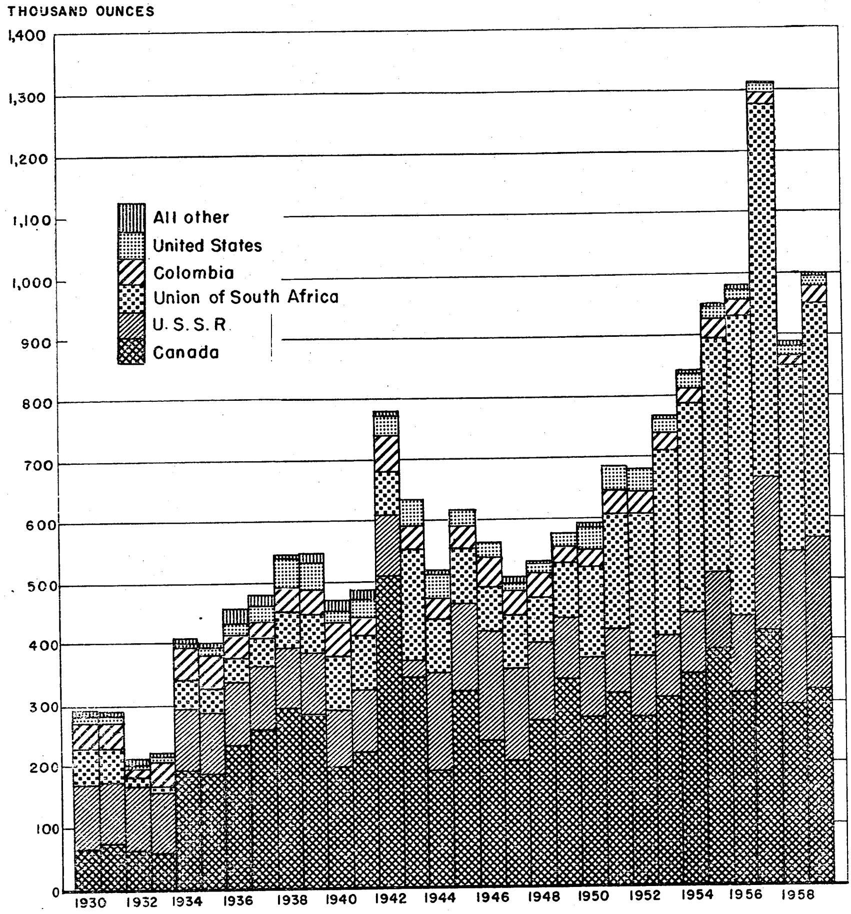

FIGURE 3.—World production of platinum-group metals, 1930–59.

Colombia.—Production of platinum-group metals in Colombia in 1959 was estimated at 31,500 ounces compared with 19,600 in 1958.

South American Gold & Platinum Co., the leading producer, reported an output of 17,120 ounces of crude platinum from dredging operations in Choco and Narino, 4 percent less than in 1958. The company reported a decrease in operating costs through modification of the effective taxes on exported metals. Developed gravel reserves were estimated at 55.8 million cubic yards with a recoverable content of

---

[4] Allen, C. C., Platinum Metals: Review 18, Dept. Mines and Tech. Surveys, April 1959, pp. 1–3.

2.16 grains of crude gold and 0.62 grain of crude platinum per cubic yard, equivalent to 21.9 cents per cubic yard at a platinum price of $77 per ounce.[5]

Union of South Africa.—Output of platinum-group metals in South Africa increased about 25 percent.

TABLE 9.—World production of platinum-group metals, in troy ounces [1]

[Compiled by Augusta W. Jann]

Country	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada:						
Platinum: Placer and from refining nickel-copper matte	138, 454	170, 494	151, 357	199, 565	146, 092	149, 510
Other platinum-group metals: From refining nickel-copper matte	165, 284	214, 252	163, 451	216, 582	154, 366	170, 160
United States: Placer platinum and from domestic gold and copper refining	31, 904	23, 170	21, 398	18, 531	14, 359	15, 485
Total	335, 642	407, 916	336, 206	434, 678	314, 817	335, 155
South America: Colombia: Placer platinum (U.S. imports)	32, 829	40, 674	32, 947	24, 267	19, 619	31, 498
Europe: U.S.S.R.: Placer platinum and from refining nickel-copper ores [2]	155, 000	250, 000	250, 000	250, 000	250, 000	250, 000
Asia: Japan:						
Palladium from refineries	97	221	218	233	240	341
Platinum from refineries	643	628	483	354	442	472
Iridium from refineries	----------	9	15	3, 215	643	[3] 600
Total	740	858	716	3, 802	1, 325	1, 413
Africa:						
Belgian Congo: Palladium from refineries [4]	35	----------	160	325	161	----------
Ethiopa: Placer platinum	284	251	244	248	180	68
Sierra Leone: Placer platinum	----------	----------	----------	[5] 5	[5] 8	----------
Union of South Africa:						
Platinum-group metals from platinum ores	240, 995	381, 732	484, 574	603, 704	[3] 300, 000	[3] 375, 000
Osmiridium from gold ores	6, 529	7, 021	6, 696	5, 361	[6] 5, 262	5, 352
Total	247, 843	389, 004	491, 674	609, 643	305, 611	380, 420
Oceania:						
Australia:						
Placer platinum	9	7	18	17	22	[3] 20
Placer osmiridium	41	21	26	66	42	[3] 40
New Guinea	4	10	9	14	28	18
Total	54	38	53	97	92	78
World total (estimate) [1]	770, 000	1, 090, 000	1, 110, 000	1, 320, 000	890, 000	1, 000, 000

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[2] Revised estimates based on imports, as reported by the United States and West European countries, and estimates of internal consumption.

[3] Estimate.

[4] Includes platinum.

[5] Exports.

[6] Sales.

Although production figures were not disclosed, the chairman of Rustenburg Platinum Mines, Ltd., the world's leading producer of platinum, stated at the company's annual meeting in February 1960:

> Of the major producers in the free world, Rustenburg Platinum Mines alone is in a position to vary its output to suit the circumstances of the market. * * *

---

[5] South American Gold & Platinum Co., Forty-third Annual Report 1959, p. 5.

> * * * It is considered essential in the overall long term interests of the company to maintain reasonably large stocks of refined metal. * * * Since the commencement of the current financial year, production at both mines has been increased to a combined rate which is in excess of the present average level of sales, in order that stocks of refined platinum may build up to suitable levels.
>
> The rate of production will continue to be adjusted in the light of estimates of changes in the situation from time to time. The Waterval reduction plant, completed in 1957 and not yet commissioned, is fully maintained and is available for immediate use, while the output of the two mines operated by the company is capable of further expansion on short notice as and when required to meet the full capacity of the reduction plants.

TECHNOLOGY

Union Carbide Metals Co. developed a new titanium alloy containing about 0.1 percent palladium which has greater corrosion resistance to reducing acids.[6] The new alloy should give greater flexibility to processing equipment and protection against sudden changes in chemical environment. It is expected to have potential use in marine equipment under brakish water conditions and in chemical operations involving hot acids.

Platinum microelectrodes inserted in lead anodes greatly reduce corrosion and improve efficiency in electrolytic processes; bielectrodes of platinum with lead and lead alloys may be used in such electrolytic processes as cathodic protection, electroplating, and electroprecipitation.[7]

Enrichment of heavy water through high-pressure exchange between hydrogen and an aqueous platinum catalyst suspension was said to have distinct economic advantages over other processes.[8] If the process can be operated with natural water instead of hydrogen as feed material, it may prove of great value in future large-scale production of heavy water.

Texas Instruments' Metals and Controls Division developed platinum-clad stainless-steel laboratory ware for handling corrosive chemicals at temperatures up to 1,000° F. The new laboratory ware is produced by a solid-phase bonding process which enables cladding of a platinum-rhodium alloy (0.5 percent rhodium) to a corrosion-resistant stainless-steel alloy. The clad material is four times as strong and costs about one-sixth as much as pure platinum.

Platinum plating of titanium has greatly improved the efficiency of titanium electrode systems and has thus made available an anode material as efficient as platinum at a much lower cost. The development of platinized titanium may lead to other applications in electrolytic processes, such as cathodic descaling, electrogalvanizing, and rhodium electroplating and in manufacturing caustic soda and chlorine.

Patent offices in the United States and the United Kingdom issued nearly 150 patents, most of which were for preparing and applying platinum and palladium catalysts in petroleum refining, hydrogenation, dehydrogenation, and miscellaneous chemical processes.[9] Several patents were issued on the use of platinum-group metals in electrical, electrochemical, and metallurgical products.

---

[6] Journal of Metals, New Titanium Alloy Improves Corrosion Resistance: Vol. 11, No. 5, May 1959, p. 8.

[7] Platinum Metals Review, vol. 3, No. 2, April 1959, pp. 44–46.

[8] Platinum Metals Review, vol. 3, No. 4, October 1959, pp. 118–124.

[9] Platinum Metals Review, vol. 3, Nos. 1–4, 1959.

Potash

By E. Robert Ruhlman [1] and Gertrude E. Tucker [2]

MORE THAN 4 million tons of marketable potassium salts was produced in the United States in 1959. The total supply of potash (K_2O equivalent), including stocks, available in the United States, was 2.7 million short tons.

TABLE 1.—Salient potash statistics

[Thousand short tons and thousand dollars]

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Production of potassium salts (marketable)...quantity..	2,835	3,514	3,679	3,840	3,640	4,033
Approximate equivalent K_2O...do....	1,647	2,067	2,172	2,266	2,147	2,383
Value [1]...	$60,805	$78,602	$82,107	$84,612	$75,000	$80,393
Sales of potassium salts by producers quantity..	2,733	3,405	3,572	3,625	3,954	4,191
Approximate equivalent K_2O...do....	1,587	2,006	2,103	2,137	2,336	2,476
Value at plant...	$58,604	$76,176	$79,768	$79,628	$81,577	$83,903
Average per ton...	$21.44	$22.37	$22.33	$21.97	$20.64	$20.02
Imports of potash materials..quantity..	358	331	334	339	366	432
Approximate equivalent K_2O...do....	191	178	181	182	199	234
Value...	$12,718	$11,769	$12,018	$11,823	$14,736	$17,578
Exports of potash materials..quantity..	110	229	398	467	507	572
Approximate equivalent K_2O...do....	61	130	226	234	254	337
Value...	$5,473	$9,203	$14,937	$17,506	$18,276	$18,496
Apparent consumption of potassium salts...quantity..	2,981	3,507	3,508	3,497	3,813	4,051
Approximate equivalent K_2O...do....	1,717	2,054	2,058	2,085	2,281	2,373
World: Production (marketable):						
Approximate equivalent K_2O...do....	6,200	8,000	8,350	8,700	8,800	9,400

[1] Derived from reported value of "Sold or used."

LEGISLATION AND GOVERNMENT PROGRAMS

U.S. Government potash leasing regulations were amended to permit greater flexibility in potash mining on public lands. The amended regulations made it possible to hold 25,600 acres in a single mining unit, instead of the 12,800 acres formerly permitted. Total acreage that could be leased by any person, association, or corporation remained the same. The new regulations also provided for a 25 cent per acre annual rental on prospecting permits, in addition to the filing fee previously required.

---

[1] Commodity specialist.
[2] Statistical assistant.

DOMESTIC PRODUCTION

Output of marketable potassium salts in the United States reached a record high—11 percent above 1958.

New Mexico, California, and Utah were the principal States producing domestic marketable potassium salts. New Mexico supplied 92 percent of the domestic output. Small quantities were produced in Maryland and Michigan.

The plant locations of potash-producing companies in the United States were the same as in 1957 (see Minerals Yearbook, Vol. 1, 1957, p. 950). During the year, the A. M. Blumer concern became Agricultural Minerals and Mineral Feeds. This plant produced byproduct potassium materials from cement-plant dust at Davenport, Calif.

Mine production of crude potassium salts in the Carlsbad region of New Mexico rose 14 percent to a new high. The calculated grade of crude salts mined was 18.58 percent K_2O equivalent (potash), a record low, compared with 18.89 in 1958 and 18.85 in 1957. In 1939, the calculated grade of crude salts had been 25.21 percent K_2O equivalent.

The six companies in the Carlsbad region—Duval Sulphur & Potash Co., International Minerals & Chemical Corp., National Potash Co., Potash Company of America, Southwest Potash Corp., and United States Borax & Chemical Corp.—mined sylvinite (potassium and sodium chlorides) and processed the ore to yield various grades of muriate. International Minerals & Chemical Corp. also mined and processed langbeinite to yield potassium sulfate and potassium-magnesium sulfate.

Manure salts production in the United States was about 11,500 tons, containing 2,700 tons of K_2O equivalent, and was valued at $53,000. Production was reported from New Mexico and Utah.

TABLE 2.—Production and sales of potassium salts in New Mexico

(Thousand short tons and thousand dollars)

Year	Crude salts[1]		Marketable potassium salts					
	Mine production		Production			Sales		
	Gross weight	K_2O equivalent	Gross weight	K_2O equivalent	Value[2]	Gross weight	K_2O equivalent	Value
1950–54 (average)	7,869	1,617	2,504	1,453	$53,081	2,412	1,397	$51,093
1955	10,956	2,159	3,221	1,899	71,839	3,122	1,841	69,641
1956	11,941	2,305	3,384	1,997	75,122	3,279	1,931	72,802
1957	12,893	2,430	3,528	2,080	77,197	3,353	1,977	73,243
1958	12,224	2,309	3,355	1,978	69,106	3,650	2,157	75,343
1959	13,932	2,588	3,707	2,189	74,117	3,821	2,258	76,725

[1] Sylvite and langbeinite.
[2] Derived from reported value of "Sold or used."

National Potash Co. improved refinery recovery by installing facilities to dry crude ore before processing. This company began to purchase ore from Southwest Potash Corp. to blend with its ore.

Additional facilities for producing granular potash and a fifth warehouse were constructed by United States Borax & Chemical Corp.

at Carlsbad, N. Mex. A granulation plant also was built by American Potash & Chemical Corp. at Trona, Calif. The granulation plant of Bonneville, Ltd., at Wendover, Utah, was shut down.

Delhi-Taylor Oil Corp., Dallas, Tex., continued its potash exploration program initiated in 1953 in the Moab, Utah, area. Mine and refinery flowsheets were being made.

Amalgamated Chemical Co., Utah, acquired about 50,000 acres in Utah and Colorado under potash-prospecting permits.

Superior Oil Co., California, reported potash discoveries in San Juan County, Utah. No details of the occurrence were published.

Alunite deposits were reported by the Federal Geological Survey in the Cerro La Tiza area of Puerto Rico.[3]

CONSUMPTION AND USES

The apparent consumption of potassium salts in the United States continued its upward trend and was 6 percent above 1958.

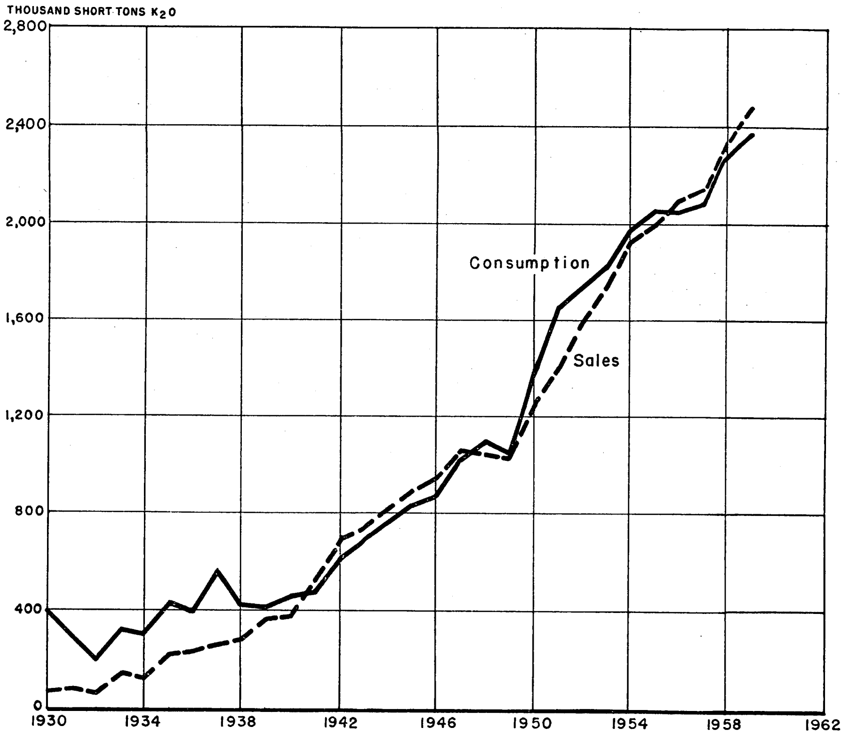

FIGURE 1.—Comparison of apparent domestic consumption of potash (K_2O) and sales of domestic producers of potash in the United States, 1930–59.

---

[3] Hildebrand, F. A., and Smith R. J., Occurrences of Alunite, Pyrophyllite and Clays in the Cerro La Tiza Area, Puerto Rico: Geol. Survey Open File Rept., Jan. 26, 1959, 82 pp.

TABLE 3.—Deliveries of potash salts in 1959, by States of destination, in short tons of K_2O

[American Potash Institute]

State	Agricultural potash	Chemical potash	State	Agricultural potash	Chemical potash
Alabama	80, 800	14, 325	Nebraska	3, 004	----------
Arizona	1, 420	63	Nevada	----------	1, 187
Arkansas	38, 962	80	New Hampshire	24	40
California	19, 228	7, 629	New Jersey	29, 854	1, 802
Colorado	1, 036	24	New Mexico	172	----------
Connecticut	2, 536	157	New York	40, 227	65, 561
Delaware	8, 900	537	North Carolina	106, 241	450
District of Columbia	519	----------	North Dakota	2, 953	----------
Florida	128, 044	813	Ohio	174, 515	4, 877
Georgia	158, 861	275	Oklahoma	4, 317	474
Idaho	882	----------	Oregon	4, 824	377
Illinois	227, 039	2, 494	Pennsylvania	42, 530	2, 354
Indiana	180, 459	2, 141	Rhode Island	1, 492	25
Iowa	66, 434	429	South Carolina	68, 263	----------
Kansas	2, 297	603	South Dakota	470	----------
Kentucky	48, 488	5, 655	Tennessee	83, 705	5
Louisiana	24, 660	447	Texas	60, 752	7, 561
Maine	12, 913	51	Utah	257	273
Maryland	77, 404	856	Vermont	2, 314	----------
Massachusetts	16, 869	195	Virginia	132, 054	231
Michigan	66, 007	779	Washington	6, 421	567
Minnesota	76, 200	----------	West Virginia	928	9, 647
Mississippi	40, 998	48	Wisconsin	73, 322	150
Missouri	55, 817	1, 412			
Montana	169	1	Total	2, 175, 581	134, 595

STOCKS

Producer-held stocks of potash (K_2O) declined 26 percent. Year-end stocks in the potash industry include material sold for delivery in the spring planting season that begins in February.

TABLE 4.—Stocks of potassium salts in the United States

(Thousand short tons)

Year	Number of producers	Stocks on hand Dec. 31[1]	
		Potassium salts	Equivalent potash (K_2O)
1950–54 (average)	9	254	148
1955	11	633	372
1956	10	739	440
1957	11	939	560
1958	11	625	372
1959	11	464	277

[1] May include an inventory adjustment during the year, as reported by producers.

PRICES

The 1959–60 prices of domestic potash remained about the same as in 1958. Prices varied with the date of shipment.

The American Potash & Chemical Corp. quoted agricultural-grade Trona muriate of potash, 60 percent K_2O minimum, f.o.b. Trona, Calif., in bulk, minimum carlots at 38 to 42.5 cents per unit of K_2O, according to date of shipment for the 1959–60 season. These prices were for contracts signed before July 1, 1959. On contracts made after this date, the price was 2 cents higher per unit. Prices for granular muriate of potash were 1 cent higher per unit than for standard muriate.

Prices for New Mexico potash were quoted by producers, f.o.b. Carlsbad, in bulk, minimum carlots of 40 tons at 30 to 34½ cents per unit of K_2O for standard muriate (60 percent K_2O minimum); 30½ to 35 cents per unit for granular muriate (60 percent K_2O minimum); 17.65 cents per unit of K_2O (22 percent K_2O minimum) for manure salts; 59½ to 67½ cents per unit K_2O (50 percent K_2O minimum) for potassium sulfate; and $13.65 per ton for Sul-Po-Mag (22 percent K_2O and 18 percent MgO). These prices applied to contracts made before July 1, 1959. On contracts made after this date, the price was 2 percent to 2 cents higher per unit. Bagged material was $4.90 higher per ton.

Quotations for Canadian potash at Potasco, Saskatchewan, were the same as Carlsbad, N. Mex., prices, with shipments from either Potasco or Carlsbad at the seller's option.

FOREIGN TRADE [4]

Imports.—Beginning with this yearbook, potash imports statistics are compiled from data furnished by the American Potash Institute, Inc., in addition to the Bureau of the Census. Figures on potassium muriate (chloride) and potassium sulfate are from the Institute; other figures are from Census.

Imports of fertilizer and chemical potash materials continued to increase and were 18 percent higher than in 1958. West Germany, France, Spain, Chile, and Canada were the principal supplying countries. East Germany, a major supplier in 1958, withdrew from the U.S. market. The last shipment to the United States from East Germany was received in February 1959.

Exports.—Exports of fertilizer and chemical potash materials reached a new high, 13 percent above 1958. Japan, the major market, received 48 percent of exports. Countries in the Western Hemisphere received 30 percent of U.S. exports of potash materials. Other major recipients were New Zealand, Taiwan, and the Union of South Africa.

---

[4] Figures on U.S. imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census and the American Potash Institute, Inc.

TABLE 5.—Potash materials imported for consumption in the United States

[Bureau of the Census]

Material	Approximate equivalent as potash (K_2O) (percent)	1958				1959			
		Short tons	Approximate equivalent as potash (K_2O)		Value	Short tons	Approximate equivalent as potash (K_2O)		Value
			Short tons	Percent of total			Short tons	Percent of total	
Used chiefly in fertilizers:									
Muriate (chloride)[1]	60	261,819	157,091	79.0	$9,498,522	313,760	188,256	80.5	$11,157,586
Potassium nitrate, crude	40	546	218	.1	60,973	473	189	.1	57,367
Potassium-sodium nitrate mixtures, crude	14	23,508	3,291	1.7	922,838	36,438	5,101	2.2	1,403,229
Potassium sulfate, crude [1]	50	68,685	34,343	17.3	2,004,335	72,478	36,239	15.5	2,102,040
Other potash fertilizer-materials	6	3,048	183	.1	100,870	41	2	.0	1,622
Total fertilizer	----------	357,606	195,126	98.2	12,587,538	423,190	229,787	98.3	14,721,844
Used chiefly in chemical industries:									
Bicarbonate	46	----------	----------	1.8	----------	12	5	1.7	2,681
Bitartrate:									
Argols	20	2,041	408		334,690	491	98		92,065
Cream of tartar	25	459	115		214,492	1,719	430		881,644
Carbonate	61	221	135		29,485	170	104		23,297
Caustic	80	541	433		163,687	695	556		177,398
Chlorate and perchlorate	36	466	168		110,321	526	189		130,104
Chromate and dichromate	40	2	(2)		701	2	(2)		654
Cyanide	70	805	564		453,796	643	450		362,491
Ferricyanide	42	276	116		156,096	308	129		187,128
Ferrocyanide	44	544	239		207,088	608	268		232,823
Nitrate	46	2,045	941		236,754	1,856	854		242,029
Permanganate	29	6	2		2,612	481	139		192,531
Rochelle salts	22	89	20		39,751	81	18		36,710
All other	50	1,060	530		199,091	1,332	666		294,581
Total chemical	----------	8,555	3,671	1.8	2,148,564	8,924	3,906	1.7	2,856,136
Grand total	----------	366,161	198,797	100.0	14,736,102	432,114	233,693	100.0	17,577,980

---

[1] Quantities furnished by American Potash Institute, Inc.; values adjusted by Bureau of Mines; 1958 data will differ from that shown on p. 870, Minerals Yearbook, 1958.

[2] Less than 1 ton.

TABLE 6.—Potash materials imported for consumption in the United States, by countries, in short tons

[Bureau of the Census]

Country	Bitartrate		Caustic (hydroxide)	Chlorate and perchlorate	Cyanide	Muriate (chloride)[2]	Potassium nitrate, crude	Potassium sodium nitrate mixtures, crude	Potassium nitrate (saltpeter), refined	Potassium sulfate, crude[2]	All other[3]	Total	
	Argols or wine lees (20)[1]	Cream of tartar (25)[1]	(80)[1]	(36)[1]	(70)[1]	(60)[1]	(40)[1]	(14)[1]	(46)[1]	(50)[1]		Short tons	Value
1958													
Algeria	428											428	$67,250
Chile								23,483				23,483	920,223
France	245			33	189	80,555	421		13	28,100	33	109,589	3,744,088
Germany:													
East						57,811			33		96	57,940	2,240,812
West			215	5	456	91,358	125	25	1,977	40,585	3,506	138,252	5,443,141
Italy	612	249							22		66	949	251,313
Netherlands					5						1,135	1,140	304,487
Portugal	534											534	82,155
Spain		110				32,095						32,205	1,135,794
Sweden			326	315								641	208,568
United Kingdom		100		5	134						286	525	183,000
Other countries	222			108	21						124	475	155,271
Total	2,041	459	541	466	805	261,819	546	23,508	2,045	68,685	5,246	366,161	14,736,102
1959													
Canada						14,359		3			41	14,403	292,635
Chile								36,240				36,240	1,378,435
France	28			11	144	107,870	228			36,150	32	144,463	4,803,395
Germany:													
East						9,086			467		80	9,633	454,081
West			368	35	340	133,960	245	195	1,217	36,328	539	173,227	6,802,205
Italy	17	642							172		81	912	370,932
Netherlands			5		2						1,681	1,688	554,377
Portugal	446											446	82,415
Spain		327				48,485						48,812	1,891,196
Sweden			322	334								656	203,888
United Kingdom		750		3	146						392	1,291	567,705
Other countries				143	11						189	343	176,716
Total	491	1,719	695	526	643	313,760	473	36,438	1,856	72,478	3,035	432,114	17,577,980

---

[1] Figures in parentheses indicate, in percent, approximate equivalent as potash (K_2O).

[2] Quantities furnished by American Potash Institute, Inc.; values adjusted by Bureau of Mines; 1958 data will differ from that shown on p. 871, Minerals Yearbook, 1958.

[3] Approximate equivalent as potash (K_2O): 1958, 39 percent; 1959, 38 percent.

TABLE 7.—Potash materials exported from the United States, by countries of destination

[Bureau of the Census]

Destination	Fertilizer				Chemical			
	1958		1959		1958		1959	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
North America:								
Canada	91,158	$3,124,254	73,286	$2,446,699	6,685	$1,093,723	7,431	$1,174,427
Costa Rica	1,811	97,562	416	15,794	27	9,677	9	4,660
Cuba	18,537	591,232	9,792	390,069	62	21,900	59	18,982
Dominican Republic	996	34,398	1,344	49,795	9	4,600	7	3,480
El Salvador	--------	----------	--------	----------	23	6,930	16	3,600
Guatemala	537	21,498	15	1,917	20	5,747	46	13,606
Honduras	65	5,736	78	3,568	12	3,990	8	3,140
Mexico	14,995	398,832	16,158	566,273	784	155,428	845	162,431
Panama	31	1,158	10	1,601	1	2,380	17	6,340
Other	262	15,626	158	6,734	(1)	107	5	5,701
Total	128,392	4,290,296	101,257	3,482,450	7,623	1,304,482	8,443	1,396,367
South America:								
Argentina	--------	----------	--------	----------	--------	----------	53	22,061
Brazil	56,725	1,954,977	58,163	1,690,414	501	53,954	123	39,263
Chile	440	23,476	496	11,773	24	12,486	44	14,247
Colombia	320	12,254	66	2,270	90	22,715	90	20,932
Ecuador	--------	----------	390	44,709	10	2,729	21	4,786
Peru	--------	----------	259	11,540	4	2,465	6	8,332
Uruguay	--------	----------	68	3,508	(1)	636	11	2,159
Venezuela	55	2,315	1,057	33,642	237	58,068	151	45,904
Other	--------	----------	--------	----------	3	5,277	10	7,892
Total	57,540	1,993,022	60,499	1,797,856	869	158,330	509	165,576
Europe:								
Belgium-Luxembourg	--------	----------	3,308	78,401	20	10,080	556	32,237
Germany, West	--------	----------	--------	----------	39	14,663	167	65,408
Ireland	--------	----------	5,377	143,200	--------	----------	--------	----------
Italy	--------	----------	3,306	92,965	104	25,774	94	28,282
Sweden	400	19,032	--------	----------	401	20,803	1,047	66,161
United Kingdom	3,529	105,182	112	4,680	230	72,736	13	3,890
Other	--------	----------	--------	----------	6	3,002	37	16,734
Total	3,929	124,214	12,103	319,246	800	147,058	1,914	212,712
Asia:								
India	--------	----------	--------	----------	16	13,323	19	11,246
Japan	240,525	7,913,191	274,363	7,909,240	(1)	3,060	1	8,450
Korea, Republic of	299	10,886	2,330	111,202	20	5,628	--------	----------
Philippines	14,261	490,043	8,161	350,948	149	43,350	125	35,520
Taiwan	20,571	690,285	27,869	621,022	(1)	450	--------	----------
Other	11	573	55	4,235	42	12,316	16	30,335
Total	275,667	9,104,978	312,778	8,996,647	227	78,127	161	85,551
Africa:								
Belgian Congo	--------	----------	--------	----------	7	11,565	--------	----------
Libya	--------	----------	5,852	162,843	--------	----------	--------	----------
Union of South Africa	17,785	581,612	25,328	777,744	41	26,230	14	12,083
Other	50	2,750	--------	----------	1	730	2	2,978
Total	17,835	584,362	31,180	940,587	49	38,525	16	15,061
Oceania:								
Australia	--------	----------	12,656	306,917	302	71,610	615	118,755
New Zealand	13,442	380,707	29,528	658,200	1	685	--------	----------
Total	13,442	380,707	42,184	965,117	303	72,295	615	118,755
Grand total	496,805	16,477,579	560,001	16,501,903	9,871	1,798,817	11,658	1,994,022

---

[1] Less than 1 ton.

WORLD REVIEW

Canada.—The Potash Company of America, Ltd., made its initial shipment of potash from Floral, Saskatchewan, to eastern Canadian markets in March.[5] Other shipments were made to the United States and Japan. Total shipments in 1959 were about 74,000 tons, of which 14,000 tons went to the United States. The operation closed temporarily early in November because of a water problem in the shaft. The company expected to resume production within 3 months.[6]

International Minerals & Chemical Corp. reported its progress as follows:

> Work continued on the 3,400 foot-shaft, * * * 12 miles northeast of Esterhazy, Saskatchewan. Operations throughout the year were conducted at the 1,200-foot level during which freezing operations brought the temperature level through the Blairmore formation to below minus 20° F. Contemplated modifications of design required adjustment of the schedule for production to early 1961 at an annual capacity rate of 400,000 tons of K_2O. The surface construction at the end of the year was about 90 percent complete. Market modifications suggested the installation of compactor equipment for the production of granular potash. These facilities will be completed early in 1961.[7]

Construction of housing was completed in 1959.[8]

Continental Potash Corp. began installing a freezing station at a depth of 1,650 feet to freeze a water-bearing horizon occurring 1,750 to 2,050 feet beneath the surface.[9] Bata Petroleums Ltd., acquired an interest in Continental.

The Sims Oil Co. of Calgary began exploring a 10-foot carnallite bed near Wilkie, Saskatchewan, and investigating solution mining for recovery of magnesium and potassium chlorides.[10]

In addition, the following companies explored the Saskatchewan potash deposits: Alwinsal Potash of Canada, Commonwealth Potash Chemical, Ltd., Consolidated Morrison Explorations, Duval Sulphur & Potash Co., General Petroleums of Canada, National Potash Co., Southwest Potash Corp., S.A.M. Explorations, Ltd., Tombill Mines, and U.S. Borax & Chemical Corp. About 1.8 million acres in the 340-mile-long belt were held under permit, withdrawal, reservation, or lease.

Potash occurrences also were reported in western Manitoba.[11]

Denmark.—The Danish government sponsored a $600,000 drilling program to investigate the potash occurrences discovered in 1949 near Suldrup, North Jutland.[12] If preliminary exploration is promising, it will be followed by shaft sinking to explore the deposit.

Finland.—Byproduct potash was recovered from cement mills.[13] Electrostatic precipitators were used to produce a 7 percent K_2O product.

---

[5] Rock Products, First Potash From Canada Leaves Plant: Vol. 62, No. 7, July 1959, p. 57.

[6] Chemical Week, vol. 85, No. 22, Nov. 28, 1959, p. 100.

[7] Stark, D. J., International Minerals & Chemical Corp., Letter to Bureau of Mines: Jan. 19, 1960.

[8] Signer, M. I., Jr., International Nears Production at Esterhazy: Western Miner & Oil Rev. (Vancouver), vol. 32, No. 4, April 1959, pp. 75–78.

[9] Northern Miner (Toronto), Continental Potash Resuming Shaft Job: Vol. 45, No. 19, July 30, 1959, p. 17.

[10] Northern Miner, Magnesium Prospect Studies by Sims Oil: Vol. 44, No. 50, Mar. 5, 1959, p. 24.

[11] Cummings, J. B., Potash in the United States and Canada: Pres. at Nat. Western Min. Conf., Colorado Min. Assoc., Denver, Colo., Feb. 5, 1959, 4 pp.

[12] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 2, August 1959, p. 53.

[13] Rock Products, vol. 62, No. 9, September 1959, p. 11.

TABLE 8.—World production of potash (marketable, unless otherwise stated) in equivalent K_2O, by countries,[1] in short tons [2]

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country [1]	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada	----------	----------	----------	----------	----------	46,500
United States	1,646,754	2,066,706	2,171,584	2,266,481	2,147,671	2,383,259
Crude (including brines) [3]	1,811,266	2,326,946	2,479,463	2,615,808	2,478,725	2,781,960
South America: Chile	3,450	11,000	12,000	11,000	[4] 11,000	[4] 11,000
Europe:						
France	1,034,791	1,310,961	1,463,006	1,545,267	1,630,436	[4] 1,653,000
Crude [3]	1,174,219	1,490,764	1,653,465	1,736,800	1,835,033	1,828,732
Germany:						
East [4]	1,443,000	1,582,000	1,598,000	1,653,000	1,700,000	1,764,000
Crude [3] [4]	1,668,000	1,820,000	1,840,000	1,900,000	1,960,000	2,028,000
West	1,379,608	1,870,848	1,823,221	1,862,904	1,886,052	2,026,046
Crude [3]	1,650,134	2,226,666	2,166,039	2,190,290	2,225,564	2,364,455
Spain	202,850	242,539	263,468	251,460	262,672	[4] 274,500
U.S.S.R.[4]	442,000	870,500	983,600	1,040,000	1,100,000	1,160,000
Asia:						
Israel [4]	926	12,000	31,000	50,000	80,000	80,000
Japan	278	461	474	[4] 1,650	[4] 1,900	[4] 1,900
Africa: Eritrea	742	----------	----------	----------	450	----------
Oceania: Australia	[5] 37	----------	----------	----------	----------	----------
World total (marketable) (estimate) [1] [2]	6,200,000	8,000,000	8,350,000	8,700,000	8,800,000	9,400,000

[1] In addition to countries listed, Ethiopia, Italy, and Poland are reported to produce potash salts, but statistics of production are not available; estimates by senior author of chapter included in totals.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] To avoid duplication of figures, data on crude potash are not included in the total.

[4] Estimate.

[5] Average for 1950–52.

TABLE 9.—Exports of potash materials from France, by countries of destination, in short tons [1]

[Compiled by Bertha M. Duggan and Corra A. Barry]

Country	1957	1958	Country	1957	1958
North America:			Asia:		
Canada	30,516	28,752	Ceylon	21,279	23,255
Cuba	14,979	5,751	China (including Taiwan)	31,734	[2] 9,039
Martinique	7,014	6,462	India	12,657	6,073
United States	55,734	104,212	Japan	140,720	187,210
South America:			Turkey	661	----------
Brazil	25,242	18,743	Africa:		
Colombia	7,055	2,756	Algeria	18,350	22,621
Europe:			Morocco: Southern zone	4,431	10,340
Austria	29,343	34,721	Rhodesia and Nyasaland,		
Belgium-Luxembourg	186,714	214,218	Federation of	8,068	17,360
Denmark	58,938	34,177	Union of South Africa	17,299	11,475
Finland	3,481	7,256	Oceania:		
Ireland	40,771	43,174	Australia	27,916	34,276
Italy	58,188	66,241	New Zealand	16,860	22,361
Netherlands	145,136	163,642	Other countries	92,687	71,058
Norway	16,648	16,807			
Sweden	49,797	33,395	Total	1,468,080	1,527,163
Switzerland	54,502	63,007			
United Kingdom	279,504	268,781			
Yugoslavia	11,856	----------			

[1] Compiled from Customs Returns of France. Figures include salts, carbonate, chloride, and nitrate of potash.

[2] Taiwan only.

TABLE 10.—Exports of potash materials from West Germany, by countries of destination, in short tons [1] [2]

[Compiled by Bertha M. Duggan and Corra A. Barry]

Country	1958	1959
North America:		
Canada	21, 590	23, 832
Mexico	4, 413	2, 206
Puerto Rico	9, 949	23, 246
United States	132, 650	171, 602
South America:		
Brazil	28, 733	16, 941
Dominican Republic	5, 518	6, 940
Europe:		
Austria	34, 626	44, 142
Belgium-Luxembourg	137, 463	135, 718
Denmark	157, 316	216, 520
Finland	2, 209	8, 338
Greece	2, 894	5, 512
Ireland	18, 185	27, 967
Italy	39, 121	38, 466
Netherlands	188, 167	169, 315
Norway	9, 355	3, 048
Portugal	1, 910	1, 262
Sweden	31, 141	28, 672
Switzerland	35, 605	31, 376
United Kingdom	208, 744	230, 551
Asia:		
Ceylon	11, 312	13, 943
India	8, 896	7, 057
Indonesia	2, 275	9, 062
Japan	164. 307	141, 132
Korea, Republic of	7, 937	----------
Malaya	6, 107	9, 075
Philippines	1, 650	5, 502
Taiwan	8, 322	21, 495
Africa:		
Rhodesia and Nyasaland, Federation of	12, 239	15, 065
Union of South Africa	19, 674	20, 709
Zanzibar	2, 971	3, 543
Oceania:		
Australia	23, 510	30, 230
New Zealand	20, 839	28, 461
Other countries	22, 285	43, 572
Total	1, 381, 913	1, 534, 500

[1] Compiled from Customs Returns of West Germany. Data include crude salts, chloride, sulfate, magnesium sulfate, and beet ash.

[2] This table incorporates some revisions.

Israel.—A fifth pumping station and additional evaporating pans, covering 1,750 acres, were put into use during 1959 at Sodom by the Dead Sea Works, Ltd., increasing capacity by 40,000 tons per year.[14] Output was less than the 154,000 tons of K_2O equivalent planned, because of a cool summer resulting in slow evaporation.

Jordan.—The 5,000-ton-per-year pilot plant of the Arab Potash Co. began to produce near the end of 1959. This plant was to be operated for 1 year by Chemibau, West Germany, after which a commercial-scale plant was to be constructed.

Morocco.—The Societe des Mines Dominiales de Potasse d'Alsace and the Moroccan Bureau de Recherches & de Participations Minieres explored for potash in the Khemisset basin near Meknes.[15]

Pakistan.—Potash-bearing brines were discovered near Dhariala in the Jhelum district.[16] Tentative plans were to construct a 100-ton-per-day pilot plant. The brine also contained salts of sodium, calcium, magnesium, and bromine.[17]

Italy (Sicily).—In 1958, Montecatini Co. at S. Cataldo and Edison Co. at Santo Caterina each reported production of 33,000 tons of kainite containing 13.5 percent K_2O. Both companies stockpiled the ore pending completion of the potassium sulfate plants. The Societa Sali Potassici Trinacris was exploring the Calascibetta-Villarosa deposits.

U.S.S.R.—Discovery of extensive potash deposits near Novo-Starobinsk in what was formerly White Russia were reported.[18]

---

[14] Mining Journal (London), vol. 253, No. 6476, Oct. 2, 1959, p. 318.

[15] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 6, December 1959, p. 50.

[16] Chemical Trade Journal and Chemical Engineer (London), Pakistan Brine Discovery: Vol. 144, No. 3754, May 15, 1959, p. 1116.

[17] Canadian Mining Journal (Gardenvale), Brine Deposits in Pakistan: Vol. 80, No. 8, August 1959, p. 127.

[18] Mining Journal (London), vol. 253, No. 6471, Aug. 28, 1959, p. 190.

TABLE 11.—Exports of potash materials from Spain, by countries of destination, in short tons [1] [2]

[Compiled by Bertha M. Duggan and Corra A. Barry]

Country	1957	1958
North America: United States	57,935	30,027
South America: Chile	3,307	10,803
Europe:		
Belgium-Luxembourg	53,556	37,677
Ireland	1,364	661
Italy	22,156	20,332
Netherlands	25,739	15,052
Norway	59,416	60,561
Portugal	19,769	14,311
United Kingdom	73,093	58,237
Asia:		
Japan	41,189	44,093
Other countries	4,753	----------
Total	362,277	291,754

[1] Compiled from Customs Returns of Spain.
[2] This table incorporates some revisions.

Plans were announced to recover byproduct potash from nonferrous metallurgical plants in the Vzhursk area of Siberia.[19]

TECHNOLOGY

Research on the use of prilled ammonium-nitrate field-compounded explosives in underground potash mines indicated large savings in explosive cost.[20] Holes 1⅝-inches in diameter were filled with 1⅛-inch cartridges. The resulting fragmentation was good.

Belt haulage from continuous mining of rolling potash beds improved efficiency, decreased hoisting delays, and lowered haulage costs.[21]

West German potash plants adopted a 4-stage crushing system.[22] This system not only reduced the quantity of fines but increased mineral liberation by breakage along cleavage planes and eliminated the need to handpick clay impurities.

Improved clay separation enabled more economical production of higher grade potassium chloride with lower reagent consumption.[23]

A hydrothermal process was reported for converting a mixture of kainite and langbeinite into potassium sulfate fertilizer.[24] The mixture was reduced by heating to over 800° C. in the presence of methane.

Processing of potash minerals including insoluble materials such as alunite, jarosite, potash feldspars, and granite was reviewed.[25]

---

[19] Mining Journal (London), vol. 253, No. 6474, Sept. 18, 1959, p. 265.

[20] Mitterer, A. V., Nelson, R. B., and Scott, S. A., Ammonium Nitrate Blasting Tests in Potash Mining: Pres. at Ann. Meeting, AIME, San Francisco, Calif., February 15–19, 1959, 9 pp.

[21] Knill, R. R., 7½-Mile Belt Conveyor System Solves Haulage Problem for Potash Company of America: Pit & Quarry, vol. 51, No. 9, March 1959, pp. 100–103.

[22] Schmidlapp, Kurt, Why Germans Crush Potash By Impact: Min. World, pt. 1, vol. 21, No. 2, February 1959, pp. 48–51; pt. 2, No. 3, March 1959, pp. 40–43.

[23] Chemical and Engineering News, IMC Revises Potash Process: Vol. 37, No. 38, Sept. 21, 1959, pp. 46, 48.

[24] Kushnir, S. V., [Reduction of Potassium Sulfate by Methane]: Zhurnal prikladnoy Khimii (U.S.S.R.), Nr. 1., 1959, pp. 216–218.

[25] Jacob, K. D., Fertilizer Production and Technology; chap. in Advances in Agronomy: Academic Press Inc., New York, N.Y., Ann. pub., vol. 11, 1959, pp. 290–292.

Investigations were underway in New Zealand to improve methods for recovering potash from sea water.[26]

Similar work was conducted in the Netherlands and Norway (see Minerals Yearbook, 1954, vol. 1, p. 944).

The relation betwen moisture and the availability of potash to crops was investigated.[27]

The proceedings of the Potassium Symposium, 1957, were published. The volume contained 16 technical articles related to potash uses.[28]

An abrasive-resistant catalyst composed of silica gel impregnated with potassium sulfate, vanadium pentoxide, and silver oxide or cerium oxide was developed.[29]

In searching for new propellants, an improved method was devised for producing potassium dioxide.[30]

Lower blasting costs were achieved in underground mines in Sweden by using potassium chlorate as an explosive.[31]

---

[26] Fertiliser and Feeding Stuffs Journal (London), Potash From Sea-Water: Vol. 50, No. 11, June 3, 1959, p. 511.

[27] Farm Chemicals, Purdue Researchers Study Effect of Soil Moisture on Availability of Potassium: Vol. 122, No. 6, June 1959, p. 48.

[28] International Potash Institute, Ltd., Potassium Symposium 1957: Berne, Switzerland, 1959, 420 pp.

[29] Chemical Age (London), American Cyanamid's Abrasion Resistant Catalyst: Vol. 81, No. 2073, Apr. 4, 1959, p. 577.

[30] Klyashtornyy, M. I., [A Direct Electrochemical Synthesis of KO_2]: Donets Ind. Inst. (Moscow), vol. 32, No. 2, February 1959, pp. 337–342.

[31] Bjorkling, H., Chlorate Explosives: Min. World, vol. 21, No. 12, November 1959, pp. 44–45.

Pumice

By L. M. Otis[1] and James M. Foley[2]

◆

DOMESTIC pumice and pumiceous materials sold or used by producers in 1959 increased 15 percent in quantity over 1958, but the average price decreased 4 percent. (Pumice in this chapter includes pumicite, volcanic ash, volcanic cinder, scoria, or other forms of pumiceous materials ejected during volcanic eruptions.)

DOMESTIC PRODUCTION

Fourteen States reported pumice production by 97 companies, individuals, railroads, or highway departments at 99 operations in 1959.

TABLE 1.—Pumice[1] sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Pumice and pumicite		Volcanic cinder		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1950–54 (average)	740	$2,428	(2)	(2)	(2)	(2)
1955	842	2,442	962	$927	1,804	$3,369
1956	887	3,222	595	1,527	1,482	4,749
1957	1,055	3,091	772	1,537	1,827	4,628
1958	925	3,091	1,048	2,196	1,973	5,287
1959	784	3,267	1,492	2,596	2,276	5,863

[1] Includes volcanic cinder.
[2] Includes 669,831 short tons of volcanic cinder in 1953, valued at $565,846, and 690,056 short tons, valued at $475,424, in 1954. Volcanic cinder not reported before 1953.

Total production of pumice was 2.3 million tons—15 percent more than in 1958. California, with 33 active pumice mines and 25 percent of total 1959 production, had the greatest output, followed by New Mexico with 22 percent from 13 operations, and Arizona with 21 percent from 5 pits.

A decision during the year may influence future court actions to nullify mining claims filed on pumice deposits. A U.S. hearing examiner had declared a pumice claim on public lands null and void under Public Law 167–84c, on the grounds that it was a "common variety" of pumice and that "chemical composition and commercial

---

[1] Commodity specialist.
[2] Supervisory statistical assistant.

uses of pumice are the same throughout the world." The decision was reversed on appeal to the Director of the Bureau of Land Management.[3]

TABLE 2.—Pumice sold or used by producers in the United States

(Thousand short tons and thousand dollars)

State	1958		1959	
	Quantity	Value	Quantity	Value
Arizona	401	$1,025	487	$1,153
California	377	1,670	574	2,162
Colorado	34	65	40	66
Hawaii	260	481	276	548
Idaho	108	172	93	137
New Mexico	507	959	493	1,023
North Dakota	11	11	---	---
Oregon	138	331	(1)	(1)
Utah	41	84	39	81
Washington	(1)	(1)	9	112
Wyoming	45	40	94	77
Other States [2]	51	449	171	504
Total	1,973	5,287	2,276	5,863

(1) Included with "Other States" to avoid disclosing individual company confidential data.
[2] Includes States indicated by footnote 1 and Kansas, Nebraska, Nevada, Oklahoma, and Texas (1958 only).

Twenty-one pumice properties in Washington were sampled and tested by the Washington State Institute of Technology, State College of Washington, for pozzolanic properties, grindability, density, surface area, available alkalies, drying shrinkage, and compressive strength.[4]

CONSUMPTION AND USES

The consumption of natural pumiceous materials, other than pumice and pumicite, increased 42 percent over 1958, due principally to their use as lightweight aggregate, railroad ballast, and road surfacing, where color and quality were not important. Although the use of all lightweight aggregates increased, new expanded clay, slate, and shale plants located close to principal cities absorbed much of the increased demand. Therefore many pumice producers were restricted to the smaller scale uses and to areas where expanded clay, slate, and shale were not available at competitive prices.

Of all domestic pumice consumed in 1959, 37 percent was used as railroad ballast and 43 percent as aggregate and admixtures in concrete.

---

[3] Bureau of Land Management, Decision on Appeal in United States v. Henry Westmore, et al., contest 1670 (Montana), rendered July 28, 1959.

[4] Klemgard, E. N., Wash. State Inst. of Technol., State College of Wash., Bull. 242, 1958.

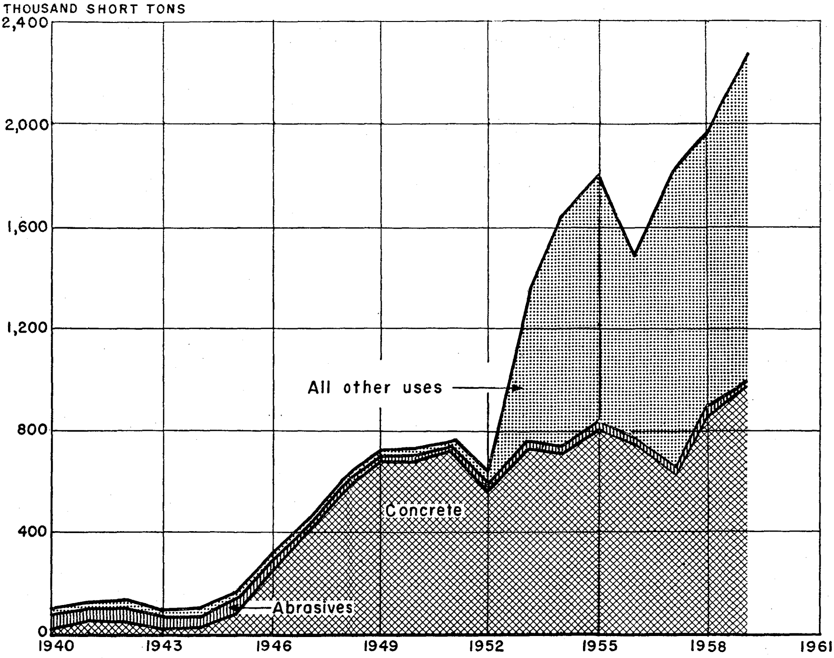

FIGURE 1.—Trends in pumice by uses, 1940–59.

TABLE 3.—Pumice sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

	1958		1959	
	Quantity	Value	Quantity	Value
Abrasive:				
Cleansing and scouring compounds	26	$612	12	$685
Other abrasive uses	(1)	(1)	(1)	(1)
Acoustic plaster	2	41	1	31
Concrete admixture and concrete aggregate	862	2,562	975	2,754
Railroad ballast	666	874	841	1,071
Other uses [2]	417	1,198	447	1,322
Total	1,973	5,287	2,276	5,863

[1] Included with "Other uses."

[2] Insecticides, insulation, brick manufacture, filtration, other abrasive uses, roads (surfacing and ice control), absorbents, soil conditioner, and miscellaneous uses.

PRICES

Nominal price quotations on domestic and inported prepared pumice, carried in trade publications, covered the higher quality ground and sized pumice of light color, suitable for various abrasive uses. The Oil, Paint and Drug Reporter quoted the following average prices per pound, bagged, in ton lots: Domestic, coarse to fine, $0.03625; imported, Italian, silk-screened, coarse, $0.0650; the same but fine, $0.04. Imported, Italian, sundried, coarse, was quoted at $60 per ton.

E&MJ Metal and Mineral Markets quoted nominal yearend prices per pound, f.o.b. New York or Chicago, in barrels: Powered, 3 to 5 cents; lump, 6 to 8 cents.

Average prices per ton for pumice in various use categories (1958 prices in parentheses) were: Cleansing and scouring compounds, $58.66 ($23.86); other abrasive uses, $55.13 ($72.44); concrete admixtures and aggregate, $2.97 ($2.97); acoustic plaster, $22.24 ($22.36); insulation, $4.37 ($3.78); railroad ballast, $1.27 ($1.25); other and unclassified uses, $2.85 ($2.86).

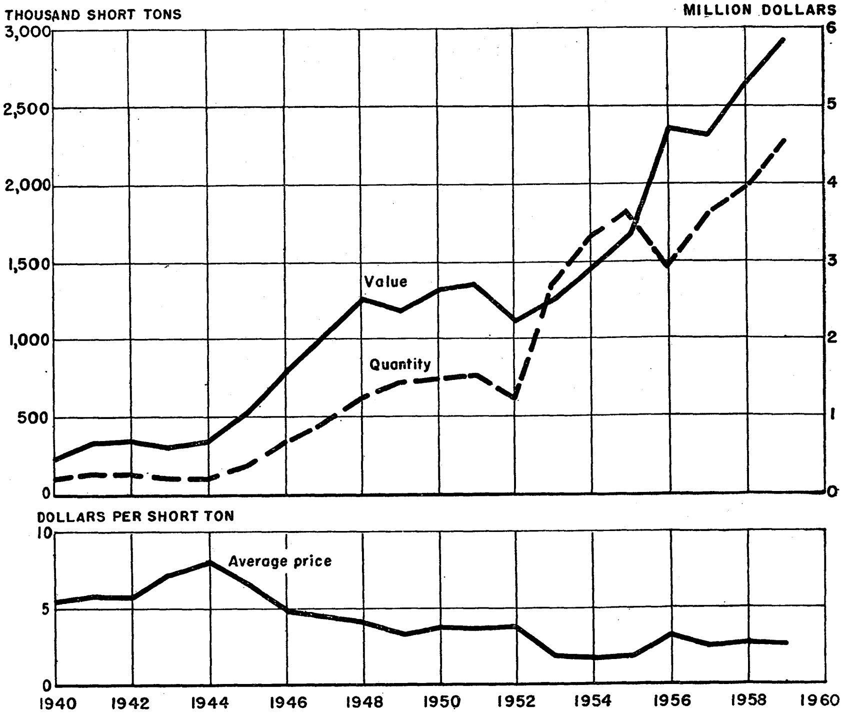

FIGURE 2.—Total value, quantity, and price per ton of pumice, 1940–59.

If all domestic pumice marketed in 1959 is classed as prepared or crude, 1,441,775 tons of prepared pumice had an average value, f.o.b. producers' plants, of $2.91 per ton and 834,345 tons of crude had a value of $2 per ton. The corresponding values for 1958 were $3.06 and $1.92, respectively. The weighted average of the two categories in 1959 was $2.58 per ton, or 4 percent less than in 1958.

FOREIGN TRADE[5]

Imports.—Imported pumice valued at $15 a ton or less comprised 83 percent of the total tonnage, compared with 95 percent in 1958. Of the total pumice imports, 61 percent came from Greece and averaged $6.52 per ton, a drop of 6 percent in value from 1958. The balance, virtually all from Italy, had an average value of $14.12 per ton, compared with $11.62 in 1958. All pumice imports valued at over $15 a ton came from Italy. The per-ton value in this class was $19.45; in 1958 the average was $18.38.

Exports.—Canada reported receiving Can$78,000 worth of pumice from the United States in 1958. U.S. statistics of pumice exports were grouped with other mineral commodities and were therefore not available separately.

Tariff.—Duty per pound on imported pumice in 1959 was: Crude valued at $15 a ton and under, 0.045 cent; crude value over $15 a ton, 0.12 cent; wholly or partly manufactured, 0.45 cent.

A bill to amend the Tariff Act of 1930, by placing certain types of imported pumice on the free list, was passed in 1959. A new law provided that pumice stone, when imported for use in making building blocks, bricks, tiles, or other masonry products, under such regulations as the Secretary of the Treasury might prescribe, could be imported duty free.

TABLE 4.—Pumice imported for consumption in the United States, by countries

[Bureau of the Census]

Country	Crude or unmanufactured				Wholly or partly manufactured				Manufactured, n.s.p.f.	
	1958		1959		1958		1959		1958	1959
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Value	
Germany, West	-------	-------	-------	-------	2	$397	-------	-------	$12,513	$18,482
Greece	31,857	$221,590	15,668	$102,121	-------	-------	-------	-------	-------	-------
India	-------	-------	-------	-------	-------	-------	-------	-------	896	-------
Italy	6,756	52,905	6,053	50,074	1,871	47,344	3,988	$91,706	595	-------
Japan	-------	-------	-------	-------	-------	-------	-------	-------	267	1,424
United Kingdom	-------	-------	-------	-------	-------	-------	-------	-------	472	575
Total	38,613	274,495	21,721	152,195	1,873	47,741	3,988	91,706	14,743	20,481

WORLD REVIEW

Canada.—Plans were made to develop a pumice deposit in British Columbia, 38 miles up the Lillooet River from Pemberton on a 563-acre lease. A cliff exposes the pumice to a thickness of 220 feet, and the reserve was estimated at 20 million cubic yards.

French West Indies.—An agreement made between the French Government and Meekins Materials Co., of Hollywood, Fla., would allow the latter to bring to Martinique, French West Indies, about $500,000

---

[5] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

in equipment, duty free, to exploit the pumice on the island. The Meekins firm had been developing plans to mine and export pumice from Martinique since 1955.

TABLE 5.—World production of pumice, by countries,[1] in short tons[2]

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country [1]	1950–54 (average)	1955	1956	1957	1958	1959
Argentina [3]	------------	49, 604	15, 708	20, 278	20, 230	[4] 20, 000
Austria: Trass	38, 309	53, 050	37, 499	38, 875	29, 784	34, 885
France:						
Pumice	14, 319	10, 141	14, 337	8, 781	7, 385	[4] 7, 400
Pozzolan	185, 306	352, 650	423, 041	468, 228	418, 878	[4] 419, 000
Germany, West (marketable)	[4] 2, 205, 000	3, 105, 207	3, 966, 111	3, 261, 735	3, 255, 121	4, 039, 966
Greece:						
Pumice	27, 767	60, 627	77, 162	61, 242	49, 604	16, 535
Santorini earth	38, 918	66, 139	93, 696	87, 634	94, 428	110, 231
Iceland	[5] 12, 125	[4] 14, 600	[4] 19, 000	15, 102	[4] 15, 000	[4] 15, 000
Italy:						
Pumice	124, 131	181, 892	211, 959	221, 990	145, 413	[4] 3, 300, 000
Pumicite	43, 045	16, 722	18, 150	37, 302	137, 899	
Pozzolan	1, 337, 157	1, 452, 282	2, 750, 702	2, 897, 620	2, 992, 880	
Kenya	------------	------------	1, 831	2, 319	821	1, 171
New Zealand	8, 729	6, 870	8, 527	16, 991	25, 851	27, 558
Spain (Canary Islands)	713	944	1, 681	------------	------------	------------
United Arab Republic (Egypt Region)	489	154	[4] 170	1, 836	1, 185	1, 100
United States (sold or used by producers):						
Pumice and pumicite	740, 398	842, 962	887, 553	1, 054, 594	925, 026	783, 873
Volcanic cinder	(6)	961, 526	594, 661	772, 384	1, 047, 930	1, 492, 247
World total (estimate)[1] [2]	4, 800, 000	7, 200, 000	9, 200, 000	9, 000, 000	9, 200, 000	10, 300, 000

[1] Pumice is also produced in Japan, Mexico, U.S.S.R., and a few other countries, but data on production are not available; estimates by senior author of chapter included in total.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Includes volcanic ash and cinders and pozzolan.

[4] Estimate.

[5] Average for 1 year only, as 1954 was first year of commercial production.

[6] Volcanic cinder not reported before 1953.

TECHNOLOGY

An article described methods of accelerating the drying of pumice building block, reducing contained moisture from the usual 30 percent to an average of 6 percent. Drying kilns with natural-gas burners developed a kiln temperature of 400° F. The method reduced drying time by 67 percent.[6]

Pumice was one of the suggested materials in a patented tile suitable for making stable floors sanitary. A mixture of pumice, sawmill waste, portland cement, and an aqueous alkaline earth metal salt was molded and cured.[7]

A patented wall plaster to replace gypsum consisted of a scratch coat made from a mixture of pumicite, sand, cement, cellulose glycollate, an alkyl sulfate, and exfoliated vermiculite. The finish coat was of vermiculite, sand, cement, cellulose sulfite, and a fungicide and was applied by a spray gun.[8]

---

[6] Concrete, Drying Time Cut by 48 Hours at Layrite: Vol. 67, No. 7, July 1959, pp. 26–29.

[7] Schwarzwalder, K., and Wagner, A., Tile Composition and Product Suitable for Floors of Stables: U.S. Patent 2,877,135, Mar. 10, 1959.

[8] Schneebeli, W., British Patent 813,009, May 6, 1959.

A patented composition for coating pipes before encasing them in concrete comprised a mixture of grease and a porous aggregate such as pumice or vermiculite. A coating of this type permitted moderate expansion of the pipe without damage to the concrete.[9]

Pumice was one of the suggested aggregates mentioned in a patent for making masonry water repellent and providing a decorative surface finish. The pumice was sprayed with a wax emulsion or solution of stearate, potassium silicate, sodium silicate, or latex.[10]

The ingredients of a patented soil stabilizer were 5 to 25 percent pumicite, diatomite, or fly ash; 35 to 75 percent plastic soil; 20 to 50 percent aggregate; and 2 to 9 percent brine.[11]

A stabilizer for soils to improve roads comprised lime, soil, water, and crude or calcined pumicite.[12]

A composition filler material, patented for asphaltic bitumens, was made by mixing lime or ground limestone with pulverized pumicite.[13]

---

[9] Goff, D. C. (assigned to Zonolite Co.), Canadian Patent 577,436, June 9, 1959.

[10] Nordstrom, J., Canadian Patent 587,013, Nov. 17, 1959.

[11] Havelin, J. E., and Kahn, F. (assigned to G. & W. H. Corson, Inc.), Canadian Patent 585,628, Oct. 20, 1959.

[12] Havelin, J. E., and Kahn, F. (assigned to G. & W. H. Corson, Inc.), Canadian Patent 584,502, Oct. 6, 1959.

[13] Keyzer, P., British Patent 808,785, Feb. 11, 1959.

Quartz Crystal (Electronic Grade)

By Thomas E. Howard[1] and Gertrude E. Tucker[2]

DOMESTIC consumption of Electronic-grade quartz crystal and the number of piezoelectric units produced in 1959 increased 33 and 14 percent, respectively, compared with 1958.

DOMESTIC PRODUCTION

There was no domestic production of natural Electronic-grade quartz in 1959. Sawyer Research Products, Inc., reported an increase in sales of cultured quartz crystal for electronic and optical applications, from 384 pounds in 1958 to 3,880 pounds in 1959. Most of the sales were in the United States, however, a small amount went to free Europe and Japan.[3] Plant annual capacity was increased to between 8,000 and 10,000 pounds.[4]

Western Electric Co., North Andover, Mass., moved closer to commercial production with further pilot-plant work to scale up the Bell Telephone Laboratories process for producing synthetic quartz crystal.[5]

CONSUMPTION

Consumption of raw quartz crystal for producing piezoelectric units, reached 210,000 pounds, the highest since 1953. Quartz-crystal cutters consumed 52,000 pounds more than in 1958. A small quantity of synthetic quartz was consumed commercially. The number of piezoelectric units produced was 6 million, an increase of 14 percent above 1958. However, the yield, 28.6 units per pound of raw quartz consumed, decreased 14 percent below the 33.1 figure reported for 1958, and was the lowest since 1954. Yields from synthetic quartz were reported to be 5 to 10 times more than those obtained from raw natural quartz.[6]

Forty-one consumers, representing 40 companies in 17 States, reported to the Bureau of Mines in 1959. Thirty-nine of the 41 quartz-

---

[1] Chief, Branch of Ceramic and Fertilizer Materials.

[2] Statistical assistant.

[3] Sawyer Research Products, Inc., Letter to the Bureau of Mines: Apr. 20, 1960.

[4] Electronic News, vol. 4, No. 154, July 20, 1959, pp. 1, 5.

[5] Sullivan, R. A., Volume Production of Single Crystals: Ceram. Age, vol. 74, No. 1, July 1959, pp. 34–40.

[6] Work cited in footnote 3.

crystal consumers also produced piezoelectric units, 2 produced only semifinished blanks. About 90 percent of the total quartz consumed was reported by 24 consumers in 8 States. Pennsylvania was the leading State, with 33 percent of the total consumption. Other important consuming States were Illinois, Kansas, Massachusetts, and Missouri.

Piezoelectric units were reported by 53 producers (50 companies) in 20 States. Fourteen of the 53 producers did not consume raw quartz crystal, but manufactured finished units from partly processed blanks. About 90 percent of the total production (including piezoelectric units produced from reprocessed blanks and crystal units) was from 30 plants in 10 States. Pennsylvania was first in production, with 27 percent of the total. Illinois, Kansas, Massachusetts, and Missouri were important producing States. Oscillator plates were produced in all 20 States and constituted 92 percent of the total number of piezoelectric units. Filter and telephone-resonator plates, transducer crystals, radio bars, and other miscellaneous uses supplied the remaining 8 percent.

TABLE 1.—Salient Electronic- and Optical-grade quartz crystal statistics

	1950–54 (average)	1955	1956	1957	1958	1959
Imports of Electronic- and Optical-grade quartz crystal (estimated)[1] thousand pounds	773	705	521	432	274	[2] 367
Value thousands	$1,903	$1,394	$1,142	$652	$341	$638
Consumption of raw Electronic-grade quartz[3] thousand pounds	286	134	150	[4] 182	[4] 158	[4 5] 210
Production, piezoelectric units, number, thousands	4,400	4,090	5,045	[4 6] 5,687	[4 6] 5,243	[4 5 6] 6,000

[1] Data for 1950–52 are total Brazilian pebble imports less the imports of fusing-grade quartz from Brazil. Data for 1953–59 are imports of Brazilian pebble valued at 35 cents or more per pound.

[2] Excludes quartz crystal imported from Brazil and accepted under Government agricultural barter contracts.

[3] For 1954 and subsequent years, data include some reworked scrap quartz included in consumption for earlier years.

[4] Data not comparable with 1954–56.

[5] Includes a small quantity of synthetic quartz.

[6] Excludes finished crystal units reported produced from reprocessed blanks and crystal units cut from raw quartz previously reported as consumption, as follows: 1957: 100,000; 1958: 267,000; 1959: 820,000.

PRICES

Prices of natural Electronic-grade quartz crystal sold domestically declined. Crystals in the most widely used weight classes, 201 to 300 grams and 301 to 500 grams, sold from $4 to $9 per pound and $7 to $12 per pound, respectively. Prices for the larger sizes varied with weight and specifications with crystals in the 1,001- to 2,000-gram class bringing up to $40 per pound.

Prices for cultured quartz crystal, quoted by Sawyer Research Products, Inc., were from $27.50 to $35 per pound, depending on quantity commitments.

Approximate prices for lasca, used to produce clear fused quartz, ranged from $0.50 to $1 per pound, depending on crystal size.

FOREIGN TRADE [7]

Imports of Electronic- and Optical-grade quartz crystal, valued at more than 35 cents per pound, increased 34 percent in quantity and 87 percent in value compared with 1958, reversing a downward trend which began in 1956. Part of the increase was the result of Government agricultural barter transactions as a substantial quantity of quartz, not meeting the specifications of barter contracts, was disposed of through commercial channels.

Of the total imports, Brazil supplied 358,000 pounds (98 percent). The remaining 9,000 pounds came from the United Kingdom, Japan, and France. Shipments from France were believed to have originated in Madagascar. Part of the imports credited to Japan probably comprised material sent from the United States for partial processing.

Imports of quartz valued at less than 35 cents per pound—classed as lasca—totaled 235,000 pounds valued at $18,200, an increase of 18 and 21 percent, respectively, compared with 1958. Of this total, 87 percent came from Brazil and 13 percent from Japan. The increased imports of lasca indicated a moderate rise in demand for Fusing-grade quartz.

Exports and reexports of quartz crystal declined sharply. Exports were valued at $165,794, a decrease of 42 percent compared with 1958. Japan, Canada, and the United Kingdom, in the order named, were the principal countries of destination. Much of the material going to Japan comprised ornamental quartz. Reexports dropped 58 percent to $34,150. Canada and West Germany were the principal countries of destination for reexports.

WORLD REVIEW

Brazil.—Exports of Electronic- and Fusing-grade quartz crystal from Brazil increased to 2,086,000 pounds valued at US$1,103,000. Although a breakdown is not available, a substantial part of the total was lasca or Fusing-grade quartz. Production for 1958 was reported at 2,255,700 pounds.[8]

Madagascar.—Production of Electronic-grade quartz crystal in Madagascar in 1958 declined to 23,370 pounds valued at US$78,200, a decrease of 23 percent in production and 34 percent in value compared with 1957. Exports decreased also totaling 27,100 pounds valued at US$104,350.

Production and exports of ornamental quartz were 15,210 pounds valued at US$2,830 and 32,400 pounds valued at US$6,930, respectively, in 1958. Production of Fusing-grade material was 9,920

---

[7] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

[8] U.S. Embassy, Rio de Janeiro, Brazil, State Department Dispatch 1044: Apr. 28, 1960, encl. 1, p. 6.

pounds valued at US$550; exports totaled 18,960 pounds valued at US$1,217.[9]

China.—Production data for China are not available, but exports to the U.S.S.R. in 1958 were reported as 1,065,000 pounds of Electronic-grade quartz crystal.[10] This is an eightfold increase compared with 1957 and indicates that China ranks as a major world producer.

TECHNOLOGY

Results of an investigation, in 1943, of quartz crystal deposits in southwestern Virginia and western North Carolina were reported.[11] It was concluded that the outlook for production was unfavorable. Pegmatites in central Kazakhstan, U.S.S.R., containing quartz crystal of piezoelectric quality, were described.[12] A deposit of quartz crystal was discovered in the vicinity of Baja, Verapaz, Guatemala, in 1958.[13]

Synthetic quartz crystal-process development continued and additional patents were issued on methods of growing quartz crystals.[14] Further details of pilot-plant production of synthetic quartz crystals at Western Electric Company Merrimack Valley Works, North Andover, Mass., were released [15] and studies of the factors affecting growth rates in quartz synthesis were described.[16]

Under a contract with the United States Army Signal Corps Supply Agency, Sawyer Research Products, Inc., of Eastlake, Ohio, conducted research on growing superior quality optical quartz. The contract also provided for continuing research to produce Electronic-grade quartz from domestic feed material.[17]

Results of studies on aging in quartz crystal units were presented.[18]

A patent was granted on a method of changing the resonant frequency of a crystal unit.[19]

---

[9] U.S. Consulate, Johannesburg, Union of South Africa, State Department Dispatch 65: Sept. 16, 1959, p. 2.

[10] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 1, Spec. Supplement No. 58, January 1960, p. 30.

[11] Mertie, J. B., Jr., Quartz Crystal Deposits of Southwestern Virginia and Western North Carolina: Geol. Survey Bull. 1072–d, 1959, pp. 233–298.

[12] Dmitriev, S. D. [Pegmatites of Central Kazakhstan]: Doklady Akad. Nauk S.S.S.R., vol. 23, 1958, pp. 1108–1111; Chem. Abs., vol. 53, No. 9, May 10, 1959, col. 7880–a.

[13] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 4, October 1959, p. 51.

[14] Kohman, G. T. (assigned to Bell Telephone Laboratories, Inc., New York), Growing of Quartz Crystals: U.S. Patent 2,895,812, July 21, 1959.

Charbonnet, W. H. (assigned to Clevite Corp., Cleveland, Ohio), Method for Growing Quartz: U.S. Patent 2,914,389, Nov. 24, 1959.

[15] Laudise, R. A., and Sullivan, R. A. Pilot Plant Production—Synthetic Quartz: Chem. Eng. Progress, vol. 55, No. 5, May 1959, pp. 55–59.

[16] Laudise, R. A., Factors Influencing the Rate of Growth of Synthetic Quartz Crystals: Proc. 13th Ann. Symposium on Frequency Control, U.S. Army Signal Research and Development Laboratory, Fort Monmouth, N.J., May 12–14, 1959, pp. 17–36.

[17] Work cited in footnote 3.

[18] Belser, R. B., and Hicklin, W. H., Stability Studies of Industrially and Laboratory Fabricated AT-Cut Quartz Resonators of 16.25 Mc Fundamental Frequency: Proc. 13th Ann. Symposium on Frequency Control, U.S. Army Signal Research and Development Laboratory, Fort Monmouth, N.J., May 12–14, 1959, pp. 71–108.

Mulvihill, P. E., Aging Characteristics of Quartz Crystal Units: Proc. 13th Ann. Symposium on Frequency Control, U.S. Army Signal Research and Development Laboratory, Fort Monmouth, N.J., May 12–14, 1959, pp. 109–122.

[19] Wenden, H. E. (assigned to the United States of America as represented by the Secretary of the Army), Method of Changing the Resonant Frequency of a Quartz Crystal: U.S. Patent 2,898,243, Aug. 4, 1959.

Rare-Earth Minerals and Metals

By Walter E. Lewis[1]

⁂

MINE SHIPMENTS of domestic rare-earth oxides in 1959 were virtually unchanged from 1958. The Union of South Africa remained the principal exporter of monazite, but imports from that nation ceased in March when sales contracts in the United States lapsed. Industrial stocks of rare-earth products remained high.

The Office of Minerals Exploration (OME) continued government financial participation in exploration for monazite and other rare-earth minerals. The Government will contribute as much as 50 percent of the allowable costs of exploration. The thorium procurement program of the Atomic Energy Commission (AEC), which was related to the buildup of coproduct rare-earth metal stocks, expired at the end of 1959. The Commission had not indicated that the program would be renewed.

DOMESTIC PRODUCTION

Concentrate.—Domestic shipments of monazite, bastnasite, and thorite concentrates and of a thorium-rare earth residue obtained from processing euxenite totaled 1,143 tons valued at $206,000. Of this quantity, 898 tons of monazite and bastnasite concentrates containing about 600 tons of rare-earth oxides (REO) was processed into metal and compounds.

The Molybdenum Corp. of America produced bastnasite concentrate from its Mountain Pass (Calif.) property. The Rutile Mining Co. of Florida shipped monazite from its stockpile created from 1958 dredging operations near Jacksonville, Fla. Titanium Alloy Manufacturing Division, National Lead Co., produced byproduct monazite from its South Jacksonville (Fla.) mine. Monazite was recovered as a byproduct by Baumhoff-Marshall, Inc., from re-treatment of stockpiled titanium concentrate from its plant at Boise, Idaho. Monazite was also recovered as a byproduct from Porter Bros. Corp. plant at Lowman, Idaho, where rough concentrate from the company's columbium-tantalum dredging operations in Bear Valley was reconcentrated.

Metals and Compounds.—Processors of rare-earth concentrates and producers of separated metals and compounds were Davison Chem-

---

[1] Assistant chief, Branch of Rare and Precious Metals.

ical Co., Division of W. R. Grace & Co., Pompton Plains, N.J.; Electro Metallurgical Co., Niagara Falls, N.Y.; Lindsay Chemical Division, American Potash and Chemical Corp., West Chicago, Ill.; Lunex Co., Pleasant Valley, Iowa; Maywood Chemical Works, Maywood, N.J.; Michigan Chemical Corp., St. Louis, Mich.; Molybdenum Corp. of America, Pittsburgh, Pa.; Research Chemicals, Inc., Burbank, Calif.; St. Eloi Corp., Newtown Station, Cincinnati, Ohio; and Vitro Chemical Co., Chattanooga, Tenn. Mallinckrodt Chemical Works, St. Louis, Mo., continued to recover columbium, tantalum, and uranium from Idaho euxenite concentrate; residues containing rare-earth elements, thorium, and yttrium were recovered as byproducts and stockpiled by the General Services Administration (GSA). This agency offered, through negotiated sale, about 3,000 tons of the residue averaging 20–30 percent rare-earth oxides by weight on a dry basis.

The principal producers of cerium and misch metal and rare-earth-bearing alloys and ferrocerium (including lighter flints) were American Metallurgical Products Co., Castalloy, Inc., The Dow Chemical Co., Electro Metallurgical Co., General Cerium Corp., Hills-McCanna, Mallinckrodt Chemical Works, and Ronson Metals Corp.

Company consolidations continued in 1959. Ronson Corp. purchased certain assets of Cerium Metals Corp. and changed the name of New Process Metals, Inc., to Ronson Metals Corp. Two principal divisions were formed by Ronson Metals Corp.: Cerium Metals and Alloys Division, for manufacturing rare-earth and thorium metal and alloy products, and New Process Metals Division, for the continued production of ferrocerium lighter flints. The research facilities of the company will be augmented by those of Th. Goldschmidt A. G., of Essen, West Germany. Michigan Chemical Corp. moved the Minerals Exploration unit of its Rare Earth and Thorium Division from Golden, Colo., to St. Louis, Mich. American Potash & Chemical Corp., Los Angeles, Calif., and Molybdenum Corp. of America reached an agreement whereby American Potash will exclusively develop and distribute Molybdenum Corp.'s rare-earth products in the glass industry, and Molybdenum Corp. will sell to all other fields. Vitro Corp. of America, the controlling company in Heavy Minerals Co., has combined its uranium, thorium, and rare-earth facilities under the name of Vitro Chemical Co.

CONSUMPTION AND USES

Apparent consumption of rare-earth elements was about 1,500 short tons of rare-earth oxides.

Commercial grades of rare-earth compounds were available in carload lots, and the major producers were able to supply almost any amount of high-purity grades on a contract order basis. Uses for the rare-earth elements remained essentially the same as in 1958; however, some new applications offered promise of increasing and broadening utilization. Praseodymium was used as a substitute for vanadium as a ceramic stain and produced a bright, clear yellow. Gadolinium was used in producing ferrites for gadolinium-iron-garnet crystals. The crystals are transparent in extremely thin sections and have excellent ferromagnetic possibilities.[2] A new magnesium-rare earth metal alloy containing 3.2 percent rare-earth metal, 0.6 percent zirconium, and the remainder magnesium was developed by Dow Chemical Co. The new alloy reportedly has excellent creep resistance and tensile properties below about 600° F.[3]

Rare-earth metal powders in sizes down to minus-325-mesh and in purities ranging from 99.5 to 99.9 percent were supplied for making rare-earth metal parts by powder metallurgy techniques.[4]

STOCKS

Thorium production for the AEC stockpile and nonenergy uses continued, and byproduct rare-earth products were recovered and stockpiled by industry. This rare-earth stock has been building up over a 4-year period, but the thorium procurement program ceased at the end of 1959.

PRICES

Nominal quotations on imported monazite were unchanged from 1957 and 1958: Per pound, c.i.f. U.S. ports, 55 percent total rare-earth oxides including thorium, massive, 14 cents; and sand, 55-percent grade, 15 cents; 66 percent, 18 cents; and 68 percent, 20 cents. Small-lot prices for imported monazite were considerably less than the nominal quotations. Domestic prices ranged from 9 to 10 cents per pound, depending upon the percentage of contained REO and ThO_2. Prices on domestic bastnasite, euxenite, and other rare-earth minerals were not available.

Prices of misch metal ranged from $3.00 to $3.50 per pound, depending upon the quantity ordered. Prices of the separated rare-earth metals and compounds were essentially the same as in 1958. Owing to the growing market in rare-earth elements, prices of rare-earth metals and compounds were published.[5] The prices are from the price lists of Lindsay Chemical Division, American Potash and Chemical Corp., the source from which the Bureau of Mines obtained its price lists in 1957 and 1958.

FOREIGN TRADE[6]

Imports.—Imports of cerium metal, ferrocerium, and other cerium alloys totaled 16,511 pounds valued at $59,898. Of this quantity, Austria shipped 76 percent, West Germany and Japan, 11 percent each, and the United Kingdom 2 percent. There were no imports of cerium compounds during the year. Monazite concentrate was imported from the Union of South Africa.

---

[2] Ceramic Industry, Produce Gadolinium Iron Garnet Crystals: Vol. 73, No. 3, September 1959, p. 67.

[3] Modern Metals, Magnesium-Rare Earth Missile Alloy Developed: Vol. 15, No. 6, July 1959, p. 85.

[4] Materials in Design Engineering, What's New in Materials: Vol. 50, No. 7, December 1959, p. 4.

[5] E&MJ Metal & Mineral Markets, Rare Earth Metal Prices: Vol. 30, No. 52, Dec. 24, 1959, p. 4; vol. 30, No. 53, Dec. 31, 1959, p. 4.

[6] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

Exports.—Exports of cerium ores, metals, alloys, and ferrocerium (including lighter flints) totaled 40,843 pounds valued at $67,238. France received 55 percent, Canada 31 percent, and United Kingdom 5 percent of the total. The remainder, in decreasing order of quantity received, went to West Germany, Venezuela, Trinidad, Colombia, Mexico, Cuba, Panama, Saudi Arabia, Philippines, and Hong Kong.

WORLD REVIEW

Argentina.—Ore discoveries in Tucuman Province included a rare-earth metal deposit in the Valle de Tafi.[7]

Australia.—From beach sand deposits near Capel in Western Australia, Western Titanium, N. L., produced monazite as a byproduct of ilmenite and zircon. Westralian Oil, Ltd., has installed a heavy-mineral concentration plant at Yoganup and a separation plant at Capel to concentrate and separate heavy minerals from beach sand deposits near Yoganup and Capel.[8] The plants have a reported capacity of about 100,000 tons of heavy minerals per year, including about 13,000 tons of monazite and zircon.

Canada.—In the Blind River region, Ontario, the conglomeratic uranium deposits contain monazite carrying a significant amount of uranium and thorium in addition to rare-earth elements.[9] Rio Tinto Mining Company of Canada, Ltd., has joined with other companies, including Dow Chemical of Canada, Ltd., in forming Rio Tinto Dow, Ltd., to build a thorium and rare-earth metals recovery plant in the area. The associated companies will supply waste liquors from the uranium recovery plants for processing to extract thorium and rare-earth metals. The plant started producing in March 1959.[10]

Ceylon.—Plant capacity of Ceylon's only monazite plant has been doubled to 250 tons of clean concentrate annually. The sources of the concentrate are the Beruwalu and Kaikawala beaches on the west coast.[11]

Madagascar.—The French Commissariat a l'Energie Atomique sponsored a new firm to develop monazite sands in southern Madagascar. The annual production is expected to be about 1,500 tons of monazite.[12]

Union of South Africa.—The monazite mine near Van Rhynsdorp, operated by Monazite and Mineral Venture, Ltd., a subsidiary of Anglo American Corp. of South Africa, Ltd., was placed on a caretaker basis on March 31. Sales contracts in the United States had not been renewed by December 31; however, it was reported that the mine had a large developed reserve and was prepared to reopen on short notice.

Uruguay.—The Uruguayan Government, through its Division of Scientific Investigations of the Administracion Nacional le Combustibles, Alcohol, y Portland (ANCAP), has been investigating Ura-

---

[7] Mining World, Latin America: Vol. 21, No. 2, February 1959, pp. 73–74.

[8] Mining Magazine (London), Western Australia, Beach Sands: Vol. 102, No. 1, January 1960, pp. 36–37.

[9] Roscoe, S. M., Monazite As An Ore Mineral in Elliot Lake Uranium Ores: Canadian Min. Jour., vol. 80, No. 7, July 1959, pp. 65–66.

[10] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 5, May 1960, p. 32.

[11] Mining World, Ceylon: Vol. 21, No. 7, June 1959, p. 88.

[12] Mining World, Madagascar: Vol. 21, No. 13, December 1959, p. 60.

guayan beaches since 1950 for heavy mineral concentrations.[13] At Atlantida Beach a 50-centimeter vertical section averaged about 31 percent heavy mineral sand containing about 5.4 percent monazite. The economic aspects of marketing all heavy mineral components of the sands were being investigated.

TECHNOLOGY

The results of 4 years of intensive research on the rare-earth elements by the Bureau of Mines were contained in 14 Reports of Investigations published in 1959. Two reports described methods of analysis and control in processing;[14] five were detailed thermodynamic studies on various rare-earth compounds;[15] and seven described solvent extraction, ion exchange, and other methods of extracting rare-earth metals and compounds from the minerals euxenite and bastnasite and an euxenite carbonate residue.[16]

The Rare Earth Research Group, an industry organization of seven producers of rare-earth metals and compounds, released a compilation of the properties of rare-earth and yttrium metals and compounds prepared as a handbook by Battelle Memorial Institute.[17] The known physical, crystal, chemical, mechanical, electrical, magnetic, nuclear, and thermodynamic properties of each element are included, together with phase diagrams of different alloy systems and properties of many rare-earth and yttrium compounds.

A technical report under U.S. Air Force Contract AF33(616)–5905 was prepared on rare-earth metals and yttrium.[18] The metallo-

---

[13] Bogert, John R., Uruguay's Beaches Show Heavy Mineral Concentrations: Min. World, vol. 21, No. 8, July 1959, pp. 48–49.

[14] White, L. Allan, Gerring, Margaret, and de la Haba, Dorothy S., Spectrographic Analysis of Rare-Earth Elements: Bureau of Mines Rept. of Investigations 5454, 1959, 13 pp.

Lytle, Farrel W., and Heady, Howard H., X-Ray Emission Spectrographic Analysis of High-Purity Rare-Earth Oxides: Bureau of Mines Rept. of Investigations 5526, 1959, 9 pp.

[15] Montgomery, R. L., Heats of Formation of Lanthanum Chloride, Lanthanum Sulfate, and Lanthanum Slufate Enneahydrate: Bureau of Mines Rept. of Investigations 5445, 1959, 12 pp.

Montgomery, R. L., Thermodynamics of Rare-Earth Compounds: Bureau of Mines Rept. of Investigations 5468, 1959, 23 pp.

King, E. G., and Weller, W. W., Low-Temperature Heat Capacities and Entropies at 298.15° K. of Cerium Monosulfide, Cerium Sesquisulfide and Thorium Disulfide: Bureau of Mines Rept. of Investigations 5485, 1959, 5 pp.

King, E. G., and Christensen, A. U., Low-Temperature Heat Capacity and High-Temperature Heat Content of Cerous Fluoride: Bureau of Mines Rept. of Investigations, 5510, 1959, 7 pp.

Montgomery, Robert L. and Hubert, Theodore D., Thermochemistry of Samarium: Bureau of Mines Rept. of Investigations 5525, 1959, 8 pp.

[16] Shaw, Van E., Extraction of Rare-Earth Elements From Bastnasite Concentrate: Bureau of Mines Rept. of Investigations 5474, 1959, 12 pp.

Douglass, D. A., and Bauer, D. J., Liquid-Liquid Extraction of Cerium: Bureau of Mines Rept. of Investigations 5513, 1959, 27 pp.

Shaw, Van E., Bauer, Donald J., and Gomes, John M., Extraction of Yttrium and Rare-Earth Elements From a Euxenite Carbonate Residue: Bureau of Mines Rept. of Investigations 5521, 1959, 15 pp.

Lindstrom, R. E., Separation of Rare-Earth Elements in Bastnasite by Ion Exchange: Bureau of Mines Rept. of Investigations 5523, 1959, 16 pp.

May, S. L., Tews, J. L., Henderson, A. W., and Gruzensky, W. G., Extractive Metallurgy of Euxenite: Bureau of Mines Rept. of Investigations 5531, 1959, 18 pp.

Bauer, D. J., Development of Equipment and Process for Extracting Cerium (IV): Bureau of Mines Rept. of Investigations 5336, 1959, 14 pp.

Rice, A. C., Preparation of Rare-Earth Chloride Solutions: Bureau of Mines Rept. of Investigations 5540, 1959, 10 pp.

[17] Gibson, John A., Miller, James F., Kennedy, Paul S., and Rengstorff, George W. P., The Properties of the Rare-Earth Metals and Compounds: Battelle Memorial Institute, Columbus, Ohio, May 1, 1959, 214 pp.

[18] Love, Bernard, Selection and Evaluation of Rare or Unusual Metals, Part II. The Metallurgy of Yttrium and the Rare-Earth Metals: Office of Technical Services, U.S, Department of Commerce, March 1959, 188 pp.

graphic, oxidation, corrosion resistance, and mechanical properties of the rare-earth elements and yttrium were discussed in detail, also possible alloy systems of rare-earth metals with titanium and beryllium.

The American Society of Metals and the AEC sponsored a symposium on the rare-earth metals, yttrium, and scandium at Chicago in November. The symposium was divided into four major classifications: Occurrence and extraction, applications of metals and compounds, preparation of rare-earth metals, and properties of the metals and their alloys. Many of the papers were reports on government-sponsored research that heretofore had not been made public.

Ethylenediaminetetraacetic acid (EDTA) and hydroxyethylethylenediaminetriacetic acid (HEDTA) are chelating agents that show the greatest promise for use in separating rare-earth elements by ion exchange.[19] EDTA, as the eluant, and copper, as the retaining ion, have proved to be the most successful; however, certain separations may require combinations of EDTA and other chelating agents.

A deposit of rare-earth minerals in the Scrub Oaks iron mine, Morris County, N.J., mapped and sampled in 1955, was described in a publication released in 1959.[20] The rare-earth minerals occur in coarse-grained magnetite ore and in pegmatite adjacent to the magnetite ore. Xenotime and doverite aggregates and bastnasite with intermixed leucoxene are the most abundant minerals. The deposit appears to be a potential source of the rare-earth elements, yttrium, thorium, and uranium as a byproduct of iron.

Two general reviews of the sources, world occurrences, applications, methods of extracting and separating the rare-earth elements, and methods of preparing metals were published.[21] High-purity europium and samarium metals were prepared on a laboratory scale by lanthanum and zirconium reduction of the oxides.[22] The laboratory results indicate that the process may be adaptable to commercial use. Experiments with cerium and aluminium as reductants were not as successful. These reductants were found to volatilize at the operating temperatures along with the samarium and europium metals. The advantages and disadvantages of methods of processing rare-earth concentrates were discussed.[23] Two producers have selected different methods of converting monazite concentrate to commercial rare-earth products. One producer chose the sulfuric acid process and the other the caustic soda process. Each had reasons based primarily on secondary objectives or products produced from monazite.

---

[19] Powell, J. E., and Spedding, F. H., The Separation of Rare Earths by Ion Exchange: Transactions of the Metallurgical Society of AIME, vol. 215, No. 3, June 1959, pp. 457–463.

[20] Klemic, Harry, Heyl, A. V., Jr., Taylor, A. R., and Stone, Jerome, Radioactive Rare-Earth Deposit at Scrub Oaks Mine, Morris County, N.J.: Geol. Survey Bull. 1082–B, 1959, pp. 29–59.

[21] Williamson, D. R., and Burgin, Lorraine, "The Rare Earths (Lanthanons)" Colorado School of Mines, Mineral Ind. Bull., vol. 2, No. 1, January 1959, 16 pp.

Gammill, Odrian M., "Heavy Rare Earth Industry": Mines Mag., vol. 49, No. 9, May 1959, pp. 25–26, 33–34.

[22] Campbell, T. T., and Block, F. E., "Europium and Samarium Reduction", Jour. Metals, vol. 11, No. 11, November 1959, pp. 744–746.

[23] Chemical Engineering, "Which Process to Free Rare Earths", Vol. 66, No. 15, July 27, 1959, pp. 62–64.

Salt

By R. T. MacMillan [1] and James M. Foley [2]

◆

SALT output of more than 25 million tons in 1959 established a new peak in the United States, exceeding the previous record of 1956 by nearly 1 million tons. Production of all types of salt increased, but the greatest gain was for salt in brine.

DOMESTIC PRODUCTION

Louisiana, with 19 percent of the total production, became the leading salt-producing State. Texas, with 18 percent, was second. Michigan, traditionally the leading salt producer, was third with slightly under 18 percent. New York, Ohio, and California ranked fourth, fifth, and sixth with 16, 11, and 6 percent, respectively. These six States produced 88 percent of the salt output.

Salt was produced at 85 plants operated by 53 companies. About 48 percent of the salt was produced by 4 companies in 14 plants and 35 percent by 6 other companies in 21 plants. The remaining plants supplied 17 percent of the output.

Over 1 million tons of salt was produced by each of 8 plants; 5 plants reported production ranging from 500,000 to 1 million tons each; and 33 plants produced 100,000 to 500,000 tons each. Of the remaining plants, 20 produced less than 10,000 tons each.

TABLE 1.—Salient statistics of the salt industry [1]

(Thousand short tons and thousand dollars)

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Sold or used by producers:						
Dry salt:						
Evaporated (manufactured) quantity	3,600	3,976	4,018	3,984	3,761	3,977
Rock salt do	4,492	5,293	5,623	5,341	5,407	6,160
Total do	8,092	9,269	9,641	9,325	9,168	10,137
Value	$61,637	$80,840	$88,412	$96,602	$99,484	$109,044
Average per ton	$7.62	$8.72	$9.17	$10.36	$10.85	$10.76
In brine quantity	11,464	13,424	14,565	14,519	12,743	15,023
Value	$15,146	$42,437	$47,727	$52,285	$42,002	$46,795
Total salt quantity	19,556	22,693	24,206	23,844	21,911	25,160
Value [2]	$76,783	$123,277	$136,139	$148,887	$141,486	$155,839
Imports for consumption quantity	63	186	368	651	611	1,025
Value	$300	$1,161	$2,354	$3,523	$3,368	$5,438
Exports quantity	323	407	336	391	363	424
Value	$2,830	$3,023	$2,464	$2,591	$2,273	$2,660
Apparent consumption quantity	19,296	22,472	24,238	24,104	22,159	25,761
World: Production do	62,650	71,700	75,300	78,700	82,200	88,900

[1] Includes Hawaii (1952–58).
[2] Values are f.o.b. mine or refinery and do not include cost of cooperage or containers.

---

[1] **Commodity specialist.**
[2] **Supervisory statistical assistant.**

TABLE 2.—Salt sold or used by producers in the United States[1]

(Thousand short tons and thousand dollars)

State	1958		1959	
	Quantity	Value	Quantity	Value
California	1,297	(2)	1,388	(2)
Kansas	1,073	$11,348	1,123	$13,670
Louisiana	3,442	18,960	4,807	20,918
Michigan	4,267	33,018	4,485	35,725
New Mexico	31	275	36	322
New York	3,896	30,609	4,011	30,958
Ohio	2,443	17,443	2,858	20,486
Oklahoma	4	41	(2)	(2)
Texas	3,843	15,114	4,519	17,498
Utah	184	2,275	209	2,453
West Virginia	627	2,784	811	3,305
Other States[3]	805	9,633	916	10,542
Total[1]	21,912	141,500	25,163	155,877

[1] Includes Puerto Rico as follows: 1958: 1,000 tons, $14,000; 1959: 3,000 tons, $38,000.
[2] Included with "Other States" to avoid disclosing individual company confidential data.
[3] Includes States indicated by footnote 2, and Alabama, Colorado, Hawaii (1958 only), Nevada, and Virginia.

TABLE 3.—Salt sold or used by producers[1] in the United States, by methods of recovery

(Thousand short tons and thousand dollars)

Method of recovery	1958		1959	
	Quantity	Value	Quantity	Value
Evaporated:				
Bulk:				
Open pans or grainers	327	$9,300	326	$9,476
Vacuum pans	1,982	39,965	2,088	44,612
Solar	1,173	6,695	1,278	7,112
Pressed blocks	280	6,413	288	6,763
Rock:				
Bulk	5,354	35,753	6,105	39,713
Pressed blocks	53	1,372	55	1,406
Salt in brine (sold or used as such)	12,743	42,002	15,023	46,795
Total	21,912	141,500	25,163	155,877

[1] Includes Puerto Rico as follows: 1958: 1,000 tons, $14,000; 1959: 3,000 tons, $38,000.

CONSUMPTION AND USES

Apparent consumption of salt increased 16 percent, reflecting gains in both production and imports. Chlorine manufacture continued to be the largest and fastest growing market for salt, consuming nearly 9 million tons compared with 7.7 million in 1958. Soda ash production was second, consuming 7 million tons. Chlorine, soda ash, and other chemical uses consumed 69 percent of the salt production.

Salt used by feed dealers and mixers and by State and county governments (for snow and ice removal) also increased substantially. Thirty-eight State highway departments and most major cities in the snow belt used salt to remove ice and snow from streets and highways. Since 1955 the tonnage used for this purpose has increased 2½ times.[3]

---

[3] Roads and Streets, Last Winter Saw Record Salt Use: Vol. 102, No. 1, January 1959, p. 199.

TABLE 4.—Evaporated salt sold or used by producers in the United States [1]

(Thousand short tons and thousand dollars)

State	1958		1959	
	Quantity	Value	Quantity	Value
Kansas	373	$7,963	389	$9,035
Louisiana	131	2,959	168	4,279
Michigan	826	17,145	872	18,598
Oklahoma	4	41	(2)	(2)
Texas	118	3,215	105	2,945
Utah	176	2,225	(2)	(2)
Other States [3]	2,134	28,825	2,446	33,106
Total [1]	3,762	62,373	3,980	67,963

[1] Includes Puerto Rico as follows: 1958: 1,000 tons, $14,000; 1959: 3,000 tons, $38,000.
[2] Included with "Other States" to avoid disclosing individual company confidential data.
[3] Includes States indicated by footnote 2, and California, Hawaii (1958 only), Nevada, New Mexico, New York, Ohio, and West Virginia.

TABLE 5.—Rock salt sold by producers in the United States

(Thousand short tons and thousand dollars)

Year	Quantity	Value	Year	Quantity	Value
1950–54 (average)	4,492	$23,849	1957	5,341	$36,389
1955	5,293	31,978	1958	5,407	37,125
1956	5,623	36,040	1959	6,160	41,119

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
1950–54 (average)	281	$4,160	65	$839	346	$4,999
1955	286	5,070	57	1,038	343	6,108
1956	269	4,968	52	994	321	5,962
1957	289	6,064	55	1,327	344	7,391
1958	280	6,413	53	1,372	333	7,785
1959	288	6,763	55	1,406	343	8,169

TABLE 7.—Salt sold or used by producers in the United States, by classes and consumers or uses

(Thousand short tons)

Consumer or use	1958				1959			
	Evaporated	Rock	Brine	Total	Evaporated	Rock	Brine	Total
Chlorine	469	1,226	6,034	7,729	469	1,266	7,259	8,994
Soda ash	(1)	(1)	6,164	6,180	--------	19	7,046	7,065
Textile and dyeing	68	145	--------	213	78	141	--------	219
Soap (including detergents)	32	6	--------	38	31	6	--------	37
All other chemicals	158	454	445	1,057	173	563	578	1,314
Meatpackers, tanners, and casing manufacturers	(1)	(1)	--------	799	352	448	--------	800
Fishing	25	9	--------	34	25	8	--------	33
Dairy	52	7	--------	59	56	4	--------	60
Canning	172	50	--------	222	169	40	--------	209
Baking	109	4	--------	113	118	6	--------	124
Flour processors (including cereal)	57	3	--------	60	54	5	--------	59
Other food processing	65	24	--------	89	75	10	--------	85
Ice manufacturers and cold-storage companies	(1)	(1)	--------	71	27	33	--------	60
Feed dealers	566	292	--------	858	567	335	--------	902
Feed mixers	158	55	--------	213	203	86	--------	289
Metals	(1)	(1)	--------	127	42	111	--------	153
Ceramics (including glass)	(1)	(1)	--------	24	3	11	--------	14
Rubber	(1)	54	(1)	103	(1)	(1)	(1)	116
Oil	(1)	68	(1)	124	34	66	13	113
Paper and pulp	(1)	104	(1)	141	(1)	101	(1)	142
Water-softener manufacturers and service companies	(1)	198	(1)	319	156	193	3	352
Grocery stores	572	161	--------	733	567	181	--------	748
Railroads	11	46	--------	57	12	50	--------	62
Bus and transit companies	(1)	(1)	--------	35	1	36	--------	37
States, counties, and other political subdivisions (except Federal)	(1)	(1)	--------	1,706	(1)	(1)	--------	2,022
U.S. Government	22	21	--------	43	17	19	--------	36
Miscellaneous	516	(1)	(1)	765	643	455	20	1,118
Undistributed [2]	710	2,480	100	--------	108	1,967	104	--------
Total	3,762	5,407	12,743	21,912	3,980	6,160	15,023	25,163

[1] Included with "Undistributed" to avoid disclosing individual company confidential data.

[2] Includes some exports and consumption in Territories, oversea areas administered by the United States and Puerto Rico.

TABLE 8.—Distribution (shipments) of evaporated and rock salt produced in the United States,[1] by destination

(Thousand short tons)

Destination	1958		1959	
	Evaporated	Rock	Evaporated	Rock
Alabama	22	170	23	236
Alaska	2	----------	1	----------
Arizona	14	13	13	13
Arkansas	18	27	11	44
California	648	78	630	76
Colorado	61	20	55	25
Connecticut	12	62	13	51
Delaware	7	5	7	6
District of Columbia	5	3	6	3
Florida	18	57	19	69
Georgia	35	65	39	72
Hawaii	2	----------	17	----------
Idaho	24	2	17	3
Illinois	221	287	244	383
Indiana	121	124	130	153
Iowa	115	114	129	142
Kansas	53	187	56	184
Kentucky	37	147	39	150
Louisiana	25	176	26	176
Maine	8	129	10	146
Maryland	41	89	41	89
Massachusetts	42	147	46	128
Michigan	130	229	145	365
Minnesota	118	70	130	87
Mississippi	14	51	16	63
Missouri	73	84	71	121
Montana	23	2	21	2
Nebraska	55	58	63	71
Nevada	6	137	6	149
New Hampshire	4	134	5	164
New Jersey	108	202	124	211
New Mexico	23	25	15	37
New York	184	1,035	199	1,106
North Carolina	73	101	80	114
North Dakota	16	8	16	5
Ohio	228	311	239	419
Oklahoma	26	31	26	41
Oregon	103	(2)	89	(2)
Pennsylvania	138	160	151	190
Rhode Island	9	14	10	15
South Carolina	18	22	19	27
South Dakota	25	14	27	15
Tennessee	42	86	70	85
Texas	[3] 76	192	80	208
Utah	[3] 43	5	46	(2)
Vermont	6	57	6	61
Virginia	72	68	69	58
Washington	291	(2)	295	----------
West Virginia	22	96	22	58
Wisconsin	126	89	137	134
Wyoming	13	2	14	1
Other [4]	[3] 166	222	217	204
Total	3,762	5,407	3,980	6,160

---

[1] Production from Puerto Rico included.

[2] Included with "Other" to avoid disclosing individual company confidential data.

[3] Revised figure.

[4] Includes shipments to territories, oversea areas administered by the United States, exports, and some shipments to unspecified destinations.

PRICES

Prices quoted in Oil, Paint and Drug Reporter for rock and table salt were stable throughout the year. Rock salt in paper bags, carlots, f.o.b. New York, was quoted at $1.09 per hundred pounds; table salt, vacuum, common fine, on the same basis, was $1.34.

The average value of dry salt was $10.76 per ton, and salt in brine averaged $3.11 per ton of contained salt.

FOREIGN TRADE[4]

Salt imported for consumption in the United States increased about 67 percent over 1958. Most of the increase was in imports from Canada, which supplied 61 percent of the imported salt; 17 percent came from the Bahamas and 13 percent from Mexico. The remaining imports were from the Caribbean Islands, except for a small quantity from Italy and less than 1 ton from Japan.

Exports of salt from the United States increased 17 percent in 1959; Canada received 55 percent and Japan 42 percent. Most of the increase was in exports to Japan.

TARIFF

The duty on bulk salt imported into the United States, unchanged since June 30, 1958, was $0.017 per hundred pounds. Duty on packaged salt was unchanged at $0.035 per hundred pounds. Duty on salt in brine, an unenumerated article according to paragraph 1558 of the Tariff Act of 1930, was 10 percent ad valorem.

TABLE 9.—Salt shipped to the Commonwealth of Puerto Rico and oversea areas administered by the United States

[Bureau of the Census]

Territory	1958		1959	
	Short tons	Value	Short tons	Value
American Samoa	142	$5, 426	142	$4, 675
Guam	86	9, 383	123	10, 805
Puerto Rico	12, 480	999, 899	13, 289	1, 005, 011
Virgin Islands	82	10, 906	98	10, 387
Wake	(1)	620		

[1] Less than 1 ton.

---

[4] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of Census.

TABLE 10.—Salt imported for consumption into the United States, by countries

[Bureau of the Census]

Country	1958		1959	
	Short tons	Value	Short tons	Value
North America:				
Bahamas	123,847	$481,158	178,800	$659,503
Canada	366,834	2,600,399	624,452	4,221,170
Dominican Republic	46,644	189,691	55,560	212,237
Jamaica	4,086	11,670	2,627	7,710
Leeward and Windward Islands	-----	-----	20,633	67,505
Mexico	69,631	85,389	128,382	160,934
Trinidad and Tobago	-----	-----	4,363	16,141
Total	611,042	3,368,307	1,014,817	5,345,200
Europe: Italy	-----	-----	9,812	91,991
Asia: Japan	1	152	(1)	450
Grand total	611,043	3,368,459	1,024,629	5,437,641

[1] Less than 1 ton.

TABLE 11.—Salt imported for consumption in the United States, by classes

[Bureau of the Census]

Year	In bags, sacks, barrels, or other packages (dutiable)		Bulk (dutiable)	
	Short tons	Value	Short tons	Value
1950–54 (average)	2,474	[1] $30,090	60,992	$270,373
1955	8,109	[1] 116,409	177,544	[1] 1,044,110
1956	25,255	[1] 360,864	342,957	1,992,864
1957	34,501	[1] 426,596	616,344	3,096,098
1958	43,864	558,902	567,179	2,809,557
1959	37,726	531,151	986,903	4,906,490

[1] Data known to be not comparable with other years.

TABLE 12.—Salt imported for consumption in the United States, by customs districts

[Bureau of the Census]

Customs district	1958		1959	
	Short tons	Value	Short tons	Value
Buffalo	26,068	$291,458	20,497	$209,233
Chicago	52,785	335,003	140,641	894,351
Duluth and Superior	24,059	153,013	43,673	300,362
Florida	1,450	6,677	250	1,344
Georgia	78,353	290,005	125,586	464,690
Hawaii	-----	-----	(1)	450
Maine and New Hampshire	275	6,977	744	18,848
Massachusetts	21,403	82,327	40,004	144,270
Michigan	201,215	1,426,998	319,434	2,138,123
New York	34,228	136,302	52,740	249,970
Ohio	27,109	160,319	62,139	414,968
Oregon	24,452	28,915	46,415	58,117
St. Lawrence	219	1,763	201	2,000
San Francisco	(1)	152	80	896
Vermont	801	6,500	3,187	25,958
Virginia	39,143	167,208	53,214	194,813
Washington	45,179	56,474	81,967	102,817
Wisconsin	34,304	218,368	33,857	216,431
Total	611,043	3,368,459	1,024,629	5,437,641

[1] Less than 1 ton.

TABLE 13.—Salt exported from the United States, by countries

[Bureau of the Census]

Country	1958		1959	
	Short tons	Value	Short tons	Value
North America:				
Bermuda	27	$2,270	-----	-----
Canada	235,454	1,268,704	232,286	$1,366,511
Central America:				
British Honduras	-----	-----	127	4,005
Canal Zone	152	11,098	-----	-----
Costa Rica	373	15,546	295	12,696
El Salvador	65	2,421	-----	-----
Guatemala	30	2,877	56	2,518
Honduras	456	12,483	202	6,221
Nicaragua	605	15,115	350	8,990
Panama	24	7,234	150	2,100
Mexico	3,550	142,425	4,156	152,460
West Indies:				
Bahamas	23	3,990	20	3,040
Cuba	5,681	156,639	7,455	209,515
Dominican Republic	-----	-----	102	5,676
Haiti	59	5,145	15	1,400
Netherlands Antilles	326	28,842	309	23,207
Other West Indies	12	1,104	14	1,201
Total	246,837	1,675,893	245,537	1,799,540
South America	51	8,232	180	7,620
Europe	82	17,908	90	9,270
Asia:				
Japan	115,321	494,472	177,641	755,274
Korea, Republic of	68	2,197	17	1,566
Laos	91	3,645	-----	-----
Lebanon	6	634	60	9,062
Philippines	136	13,468	330	19,023
Saudi Arabia	262	35,078	227	32,924
Other Asia	16	4,147	60	5,327
Total	115,900	553,641	178,335	823,176
Africa	4	4,618	13	620
Oceania	135	13,118	193	19,990
Grand total	363,009	2,273,410	424,348	2,660,216

WORLD REVIEW

Canada.—Two new salt mines were opened in November, one at Goderich, Ontario, and the other at Pugwash, Nova Scotia. The Goderich mine had a 16-foot diameter shaft 1,860 feet deep and a rated productive capacity of 550 tons per hour. At Pugwash a 15x6.5-foot rectangular shaft was completed at 700 feet; productive capacity of this mine was estimated at 140 tons per hour. Reserves of the two mines were estimated at 900 and 200 million tons, respectively.[5]

The Canadian Brine Co., an affiliate of Canadian Salt Co., Ltd., continued to supply brine to a chemical plant in Detroit through pipelines under the Detroit River.

Colombia.—Modern salt-processing equipment was installed at the Government-owned salt mines at Zipaquira. This new equipment replaced 72 privately owned salt-boiling and drying facilities, some of which were more than 500 years old. The plant was operated by El Banco de la Republica. The salt produced by the new equipment was iodized to combat goiter, a common malady in Colombia.[6]

---

[5] Northern Miner (Toronto), Canadian Salt Mining Stature Increases With Newest Mines: Vol. 45, No. 33, Nov. 5, 1959, pp. 17, 23.

[6] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 2, August 1959, p. 57.

TABLE 14.—World production of salt by countries,[1] in thousand short tons [2]

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country [1]	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada	944	1,254	1,599	1,772	2,361	3,234
Costa Rica	6	6	[3] 6	49	[3] 33	14
Guatemala	13	18	15	18	18	22
Honduras	8	[3] 11	15	13	[3] 11	[3] 11
Mexico	205	[3] 248	[3] 265	[3] 265	[3] 265	[3] 265
Nicaragua	14	11	11	10	11	12
Panama	7	11	9	9	7	[3] 7
Salvador	31	54	55	55	[3] 55	[3] 55
United States:						
Rock salt	4,488	5,293	5,623	5,342	5,407	6,160
Other salt	15,080	17,411	18,593	18,512	16,504	19,003
West Indies:						
British:						
Bahamas	106	60	154	192	112	233
Leeward Islands (exports)	7	6	1	1	[3] 1	----------
Turks and Caicos Islands	26	7	15	18	22	23
Cuba	61	71	71	75	75	[3] 66
Dominican Republic:						
Rock salt	12	20	36	51	49	71
Other salt	14	20	1	(4)	18	22
Haiti	[3] 31	33	50	[3] 11	[3] 11	11
Netherlands Antilles	3	[3] 3	1	1	[3] 1	[3] 1
Total	21,056	24,537	26,520	26,394	24,961	29,210
South America:						
Argentina:						
Rock salt	1	2	3	2	(4)	(4)
Other salt	456	432	413	359	622	[3] 551
Brazil	938	640	880	880	1,053	[3] 1,102
Chile	51	57	[3] 55	37	[3] 44	[3] 44
Colombia:						
Rock salt	155	193	214	228	243	235
Other salt	43	45	41	106	78	63
Ecuador	31	55	29	26	21	24
Peru	83	99	112	126	116	118
Venezuela	80	68	42	95	97	86
Total [1] [3]	1,855	1,610	1,810	1,880	2,290	2,240
Europe:						
Austria:						
Rock salt	1	1	1	1	1	1
Other salt	378	438	481	568	567	443
Bulgaria	105	36	64	82	123	[3] 123
Czechoslovakia	181	147	169	177	[3] 176	[3] 176
France:						
Rock salt and salt from springs	2,621	2,837	3,139	3,109	2,971	3,061
Other salt	629	805	625	613	908	[3] 882
Germany:						
East	1,653	1,676	1,863	1,935	1,960	[3] 1,984
West (marketable):						
Rock salt	2,793	3,361	3,591	3,598	3,556	3,659
Brine salt	321	369	356	357	370	363
Greece	96	79	103	99	105	108
Italy:						
Rock salt and brine salt	1,001	1,105	1,112	1,153	1,140	1,768
Other salt	967	948	946	488	635	521
Malta	3	1	2	1	2	2
Netherlands	503	645	690	791	876	1,087
Poland:						
Rock salt	915	424	435	417	432	[3] 441
Other salt		939	963	1,017	1,344	[3] 1,323
Portugal	[5] 218	331	149	345	343	[3] 342
Rumania	507	624	929	934	807	[3] 827
Spain:						
Rock salt	406	467	535	565	617	[3] 622
Other salt	953	874	714	926	983	[3] 992
Switzerland	125	134	131	144	138	151
U.S.S.R.[3]	6,400	7,200	7,200	7,200	7,200	7,200
United Kingdom:						
Great Britain:						
Rock salt	51	78	111	99	130	[3] 132
Other salt	4,738	5,297	5,472	5,484	5,397	[3] 5,401
Northern Ireland	13	14	10	8	7	----------

See footnotes at end of table.

TABLE 14.—World production of salt by countries,[1] in thousand short tons [2]—Con.

Country [1]	1950–54 (average)	1955	1956	1957	1958	1959
Europe—Continued						
Yugoslavia	140	150	160	163	190	[3] 195
Total [1] [3]	26,100	29,350	30,300	30,650	31,350	32,200
Asia:						
Aden	311	308	278	222	164	[3] 165
Afghanistan	30	24	25	[6] 63	[3] 66	[3] 66
Burma	67	117	96	128	123	[3] 123
Cambodia	36	96	26	33	33	[3] 33
Ceylon	58	41	121	95	20	34
China [3]	5,060	6,830	7,280	8,820	11,500	14,330
Cyprus	4	----------	6	7	6	6
India:						
Rock salt	6	6	4	4	6	4
Other salt	3,145	3,228	3,551	4,041	4,659	3,499
Indonesia	347	51	120	383	303	[3] 300
Iran [7]	218	294	309	331	[3] 330	[3] 330
Iraq [7]	22	21	[3] 22	[3] 22	[3] 22	[3] 22
Israel	17	31	29	35	37	37
Japan	478	619	693	917	1,166	1,285
Jordan	7	9	12	11	[3] 12	18
Korea, Republic of	184	390	217	407	481	430
Lebanon [3]	8	6	6	6	3	3
Pakistan:						
Rock salt	157	157	181	174	198	180
Other salt	223	290	211	333	197	141
Philippines	49	88	71	122	154	193
Portuguese India	21	[3] 17	7	11	6	3
Ryukyu Islands	3	6	6	3	4	4
Taiwan	299	496	363	427	489	474
Thailand [3]	300	330	330	220	330	390
Turkey:						
Rock salt	29	31	33	10	40	[3] 40
Other salt	345	529	386	494	498	[3] 500
United Arab Republic (Syria region)	14	15	36	37	[3] 44	[3] 22
Viet-Nam, South	114	85	66	88	68	[3] 65
Yemen	[8] 110	110	28	[3] 110	----------	----------
Total [3]	11,660	14,230	14,510	17,550	21,440	23,180
Africa:						
Algeria	91	114	117	132	150	[3] 150
Angola	57	64	89	57	76	76
Belgian Congo	1	(4)	1	(4)	(4)	1
Canary Islands	17	21	20	17	17	[3] 17
Cape Verde Islands	21	24	24	22	17	22
Eritrea	195	203	148	220	132	[3] 130
Ethiopia: Rock salt	15	17	[3] 13	[3] 13	[3] 17	[3] 17
French Equatorial Africa	4	6	[3] 6	[3] 6	[3] 6	2
French Somaliland	71	20	8	2	----------	----------
French West Africa [3]	65	11	3	3	6	6
Ghana [3]	22	24	24	24	24	24
Italian Somaliland [3]	4	6	6	4	3	3
Kenya	21	29	24	25	21	22
Libya	14	17	19	[3] 17	14	17
Mauritius	3	4	4	4	4	4
Morocco:						
Northern zone	(4)	10	[3] 11	14	[3] 13	[3] 13
Southern zone:						
Rock salt	9	18	6	57	67	37
Other salt	43	31	40			
Mozambique	12	17	13	20	24	24
South-West Africa:						
Rock salt	6	7	6	7	7	6
Other salt	36	58	83	66	89	50
Sudan	55	57	60	60	60	[3] 55
Tanganyika	20	26	31	29	40	41
Tunisia	136	147	149	165	176	94
Uganda	8	10	10	11	11	10
Union of South Africa	150	154	190	161	241	261
United Arab Republic (Egypt region)	563	443	584	569	444	[3] 440
Total [1] [3]	1,640	1,539	1,690	1,706	1,660	1,523

See footnotes at end of table.

TABLE 14.—World production of salt by countries,[1] in thousand short tons [2]—Con.

Country [1]	1950–54 (average)	1955	1956	1957	1958	1959
Oceania:						
Australia	343	413	457	478	481	[3] 485
New Zealand	(4)	3	13	9	23	[3] 23
Total	343	416	470	487	504	[3] 508
World total (estimate)[1] [2]	62,650	71,700	75,300	78,700	82,200	88,900

[1] Salt is produced in Albania, Bolivia, Hungary, Madagascar, Nigeria, and North Korea, but figures of production are not available. Estimates for these countries are included in total.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Estimate.

[4] Less than 500 tons.

[5] Average for 1952–54.

[6] Year ended Mar. 20 of year following that stated.

[7] Year ended Mar. 31 of year following that stated.

[8] Average for 1953–54.

Denmark.—Development of salt production in the Jutland area proceeded slowly. The Harboore horst on the Ronland Peninsula was the first salt horst to be exploited. The salt was used primarily for chlorine production. Other horsts, ranging in depth from 500 to 1,100 feet, have been found at Uglev, Mosted, Tostrup, Hvornum, and Suldrup.[7]

Philippines.—The Salt Industries of the Philippines, Inc., a joint Filipino-Spanish company, opened a new salt plant near San Jose in southwestern Mindoro. The plant combines solar and thermal evaporation of sea water in producing salt 98 to 99 percent pure. Annual capacity of the plant was expected to range from 39,000 to 55,000 tons. Older installations continued to produce solar salt with a purity of 75 to 85 percent, which was used mostly for curing fish.[8]

United Arab Republic (Egypt Region).—General Egyptian Salt Co., with facilities near Alexandria, and Port Said Salt Co., with facilities at Port Fouad, were consolidated to form Mediterranean Salt Co. Total annual output of the new company was expected to exceed 500,000 tons of coarse marine salt. Various refined grades of salt for industrial and food uses were produced.

United Kingdom.—New skips were installed at the Winsford mine of Imperial Chemical Industries Salt Division, the only rock salt mine in operation. The salt was mined at a depth of 500 feet and was used chiefly for agriculture and snow and ice control.[9]

TECHNOLOGY

A new method of solids separation having particular application to upgrading rock salt was the subject of U.S. Patent 2,907,456. The process is based on the fact that sodium chloride crystals are transparent to infrared radiation, whereas typical impurities (such as anhydrite, dolomite, and shale) are not. If the impure salt is sub-

---

[7] Bureau of Mines, Mineral Trade Notes: Vol. 48, No. 2, February 1959, pp. 38–39.

[8] U.S. Embassy, Manila, Philippines, State Department Dispatch 677, Mar. 30, 1959, pp. 1–2.

[9] Mining Magazine (London), Modernization of a Salt Mine: Vol. 101, No. 4, October 1959, p. 185.

jected to infrared radiation, the impurities are selectively heated while the salt crystals remain relatively cool. The irradiated salt is then spread evenly on a high-speed conveyor belt with a heat sensitive surface. The cooler rock salt particles fly off the end of the belt into a collection bin, whereas the warmer impurities stick to the belt long enough to be thrown into another container. Several thermoplastic resins, including styrenepolymers, terpene resins, and coumarone-indene resins, have proved satisfactory as separating materials. The resin surfaces must be renewed when the build-up of dust particles reduces the tackiness. The new technique for upgrading rock salt was considered more effective and economic than the widely used method of differential crushing and screening. Application of the new principle to other solids separations was contemplated.[10]

A pilot-plant unit was developed to concentrate sea water by electrodialysis. The unit, which was shipped to Japan, was designed to produce 1 ton per day of a salt brine having a concentration of 15 to 25 percent (salts in sea water average 3.5 percent). A much larger waste stream, slightly depleted in salt, also results from the process. Plans were announced to produce 50,000 to 60,000 tons of salt annually by the method, subject to approval of the Japanese Government. Lacking native salt deposits, Japan depends on the sea and on imports for its salt.

The principle used in concentrating sea water by electrodialysis is the same as that used in converting salt and brackish water to fresh water (see Water chapter). In the latter process a relatively small stream of fresh water is obtained, and a larger stream of brine slightly more concentrated than the feed is produced. Although it is theoretically possible to produce a concentrated brine and fresh water concurrently in the same unit, such a process is economically impractical.[11]

Controlled growth of salt crystals in an "Oslo" or fluidized-bed crystallizer was achieved experimentally in a semitechnical plant in England. Factors affecting the crystal growth were: Degree of supersaturation of the solution, size and orientation of the seed crystals, retention time, and temperature. Standard methods of producing large crystals of salt by direct firing or steam-coil heating in open pans are uneconomical, and attempts to grow large crystals in normal evaporators have been unsuccessful.[12]

Tests to study the possibility of disposing of nuclear wastes in natural salt formations were conducted in the Carey Salt Mines at Hutchinson, Kans. The work was part of a research effort, sponsored by the Atomic Energy Commission, to find more economical methods of disposing of highly radioactive wastes resulting from reprocessing spent nuclear fuels. Many physical and chemical properties of salt beds are well adapted to storage of hot chemical materials in liquid form. The test site at Hutchinson is 645 feet deep; the humidity is 40 percent and the temperature, 68° F. Synthetic wastes having the same physical and chemical properties as actual nuclear wastes, but

---

[10] Chemical and Engineering News, Heat Cleans Rock Salt: Vol. 37, No. 44, Nov. 2, 1959, p. 58.
Chemical Engineering, Radiant Heat Key to New Solids Separation Route: Vol. 66, No. 23, Nov. 16, 1959, pp. 108, 110.

[11] Chemical Engineering, How to Add Salt to the Ocean: Vol. 66, No. 17, Aug. 24, 1959, p. 53.

[12] Chemical Age (London), Controlled Crystallization of Sodium Chloride Using Oslo Crystallizer: Vol. 82, No. 2104, Nov. 7, 1959, p. 648.

not the radioactivity, were used in the tests. The materials were heated electrically to simulate actual conditions.[13]

Theoretical aspects of problems in storing radioactive wastes in salt formations were discussed in publications of the Engineers Joint Council. Calculations indicated that wastes stored in cavities over 30 feet in radius would produce temperatures beyond permissible limits.[14]

The first new salt mine in the United States in 25 years was opened near Painesville, Ohio. The Fairfield mine of the Morton Salt Co. began producing rock salt at a 6,000-acre property leased for 200 years. Two shafts, one 12 and the other 16 feet in diameter, were completed to the 2,000-foot level; production of 300 tons per hour was planned, with an upper limit of 500 tons. Modern machinery and handling methods have reduced production of fines to a low level. However, the fines that were produced were agglomerated by a unique process. After passing between rolls under high pressure, the fine salt emerged as a sheet which was broken into marketable flakes.[15]

A new service to the chemical industries of the Beaumont-Port Arthur area was started by a Texas concern, which began to supply brine by pipeline to customers. Previously, most brine production had been captive. Using sea water, another Texas firm produced a dry, relatively nonhygroscopic salt product containing many of the trace elements of sea water. This special salt product was obtained by treating the brine chemically, then evaporating the water by submerged combustion. The product was sold for table use and for use in food industries.

---

[13] Kansas State Board of Health, Tests Underway at Salt Mines for Possible Storage of Radioactive Wastes: Newsletter, vol. 27, No. 5, November 1959, p. 3.

[14] Schechter, R. S., and Gloyna, E. F., Thermal Considerations in the Storage of Radioactive Wastes in Salt Formation: Nuclear Eng. and Sci. Conf., Engineers Joint Council, April 1959, 25 pp.

Serata, S., and Gloyna, E. F., Development of Design Principle for Disposal of Reactor Fuel Waste into Underground Salt Cavities: Nuclear Eng. and Sci. Conf., Engineers Joint Council, April 1959, 28 pp.

[15] Chemical Engineering, Salt Users Gain New Supply from Vast Vein: Vol. 66, No. 9, May 4, 1959, pp. 46–48.

Sand and Gravel

By Wallace W. Key,[1] George H. Holmes, Jr.[1] and Annie L. Mattila[2]

◆

PRODUCTION of sand and gravel in 1959 paralleled the national construction trend and reached a new peak, surpassing the previous record year of 1958. Increased private construction, resulting from continued suburban expansion, was the principal factor contributing to the higher output of sand and gravel in 1959. Although output of aggregates for highway construction increased, compared with 1958, the anticipated usage level was not achieved, mainly due to highway-financing difficulties. Sales of industrial sands were not adversely affected by the steel strike.

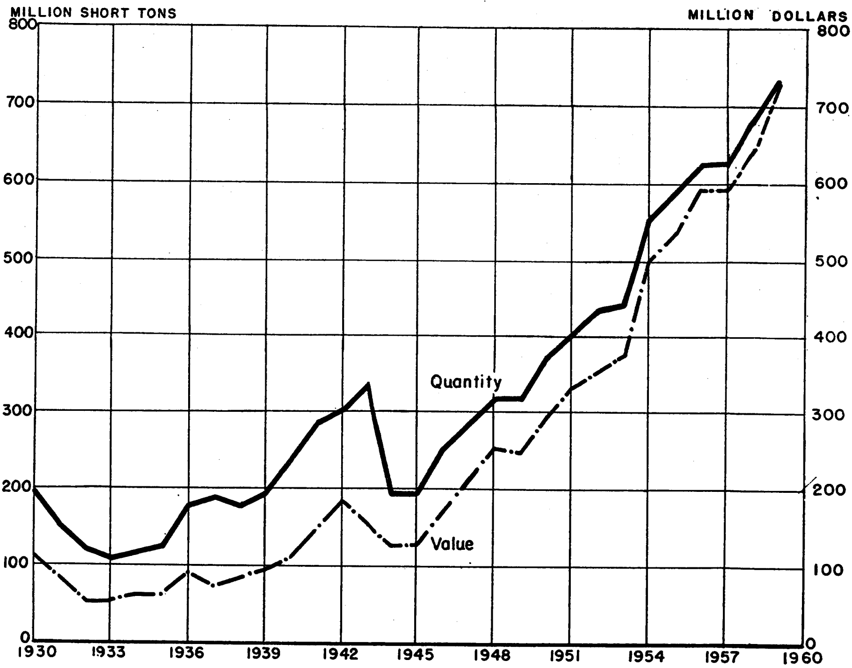

FIGURE 1.—Production and value of sand and gravel in the United States, 1930–59.

---

[1] Commodity specialist.
[2] Statistical assistant.

LEGISLATION AND GOVERNMENT PROGRAMS

Congressional action aided the construction industry. This, in turn, proved beneficial to the sand and gravel producer. For example, the Federal Airport program for fiscal year 1960 included 288 construction projects, for which the Federal Government provided about $57 million, to be matched on a 50–50 basis by local project sponsors.[3]

Congress also approved an advance of $359 million from general revenues to the Highway Trust Fund to make up a shortage in funds for fiscal year 1960, which had forced many States to delay highway contract awards.[4]

Congress passed a $1.177 billion public works appropriation bill, which allocated $868 million for the Civil Works program of the U.S. Army Corps of Engineers, $250 million for the Bureau of Reclamation, and about $15 million for TVA.[5]

DOMESTIC PRODUCTION

The sand and gravel industry continued its upward climb for the 10th consecutive year. Output reached 730 million short tons valued at $729 million, increases of 7 and 12 percent, respectively. A few States showed decreases in production, although most registered moderate gains. Greatest increases were for building sand and gravel; paving-sand production began to reflect the reduction in highway contract awards. Industrial-sand production remained high despite the extended steel strike, which affected related industries.

Increased consumption of sand and gravel was attributed to greater construction activity, particularly homebuilding. Construction volume registered an 11-percent gain over 1958, with $54.3 billion of new construction put in place. Private construction increased 14 percent to $38.3 billion, and public construction 4 percent to $16 billion. Highway construction, the largest component of public works, increased to $5.8 billion.[6]

Shortages of aggregates in several States were responsible for intensive investigations of new sources of supply and technologic improvements in processing methods and plant design.

Commercial Production.—Commercial operations supplied the greater share of production—73 percent of the total output. The average price of commercially produced sand and gravel was $1.12 a ton. A relatively higher value was attributable to the larger proportion processed. The commercial plant was the preferred source of material, as its modern processing methods could produce the various sizes and grades to meet the ever-increasing complex specifications required by the construction industry. The use of portable plants increased in many sections of the country, as these mobile plants normally operated beyond the economic transportation limits of stationary plants and utilized small deposits near special jobs.

---

[3] The Constructor, Federal Airport Program For Fiscal 1960 Provides $57 Million For 288 Projects: Vol. 16, No. 12, December 1959, p. 47.

[4] The Constructor, President Signs New Highway Act But Says Spending Must Be Limited: Vol. 16, No. 10, October 1959, p. 63.

[5] The Constructor, $1.177 Billion Public Works Bill Passed Over Presidential Veto: Vol. 16, No. 10, October 1959, p. 60.

[6] Construction Review, vol. 6, No. 3, March 1960, pp. 4–13, 20.

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

	1958		1959	
	Quantity	Value	Quantity	Value
Construction:				
Building:				
Sand	[1] 100,957	[1] $101,829	123,237	$128,122
Gravel	[1] 95,141	[1] 120,124	114,190	142,371
Paving:				
Sand	[1] 98,897	[1] 82,240	104,687	88,417
Gravel	[1] 311,533	[1] 255,903	313,178	271,307
Fill:				
Sand	(2)	(2)	15,551	8,727
Gravel	(3)	(3)	16,814	9,460
Railroad ballast:				
Sand	381	182	990	534
Gravel	4,874	3,565	4,812	3,695
Other:				
Sand	[1] 25,920	[1] 20,478	5,508	5,034
Gravel	[1] 31,292	[1] 22,126	6,956	7,697
Total construction	668,995	606,447	705,923	665,364
Industrial sand:				
Unground:				
Glass	5,575	17,858	6,251	20,122
Molding	[1] 5,632	12,827	6,246	15,144
Grinding and polishing [4]	1,547	5,136	1,874	5,654
Fire or furnace	424	952	534	1,188
Engine	893	1,347	873	1,535
Ferrosilicon			65	175
Filtration	659	973	395	934
Oil (hydrafrac)	(2)	(2)	85	360
Other	(2)	(2)	1,946	4,571
Total unground	14,730	39,093	18,269	49,683
Ground [5]	773	7,249	930	8,007
Total industrial	15,503	46,342	19,199	57,690
Miscellaneous gravel	(3)	(3)	4,773	5,473
Grand total	[1] 684,498	[1] 652,789	729,895	728,527
Commercial:				
Sand	[1] 211,578	[1] 234,113	231,554	266,457
Gravel	[1] 277,716	[1] 291,170	303,369	332,188
Government-and-contractor: [6]				
Sand	30,080	16,958	37,618	22,067
Gravel	[1] 165,124	[1] 110,548	157,354	107,815

[1] Revised figure.
[2] Included with "other sand."
[3] Included with "other gravel."
[4] Includes blast sand as follows—1958: 719,258 short tons valued at $3,282,839; 1959: 695,516 tons, $3,136,528.
[5] See table 11 for use breakdown.
[6] Approximate figures for operations by States, counties, municipalities, and other Government agencies or under lease.

TABLE 2.—Sand and gravel sold or used by producers in the United States [1]

(Thousand short tons and thousand dollars)

Year	Sand		Gravel (including railroad ballast)		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1950–54 (average)	160,047	$156,041	280,682	$216,200	440,729	$372,241
1955	221,119	222,241	371,034	313,995	592,153	536,236
1956	235,190	246,276	391,305	349,919	626,495	596,195
1957	[2] 236,020	[2] 244,640	[2] 396,235	[2] 355,110	[2] 632,255	[2] 599,750
1958	[2] 241,658	[2] 251,071	[2] 442,840	[2] 401,718	[2] 684,498	[2] 652,789
1959	269,172	288,524	460,723	440,003	729,895	728,527

[1] Includes possessions and other areas administered by the United States (1950–56).
[2] Revised figure.

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	1958						1959					
	Commercial		Government-and-contractor		Total		Commercial		Government-and-contractor		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	3,992	$4,072	136	$138	4,128	$4,210	4,271	$4,526	81	$68	4,352	$4,594
Alaska	535	729	3,720	3,142	4,255	3,871	631	1,162	5,228	4,103	5,859	5,265
Arizona	4,574	4,082	7,634	5,444	12,208	9,526	5,117	5,308	8,341	6,658	13,458	11,966
Arkansas	6,256	5,719	2,388	1,320	8,644	7,039	6,973	7,535	4,723	4,322	11,696	11,857
California	68,212	80,808	15,925	14,532	84,137	95,340	76,011	97,440	11,934	11,469	87,945	108,909
Colorado	8,148	8,820	12,478	9,022	20,626	17,842	10,302	10,857	10,595	7,960	20,897	18,817
Connecticut	4,916	5,440	103	39	5,019	5,479	4,578	4,845	171	68	4,749	4,913
Delaware	1,090	962	----------	----------	1,090	962	1,107	970	134	101	1,241	1,071
Florida	5,490	4,388	----------	----------	5,490	[1] 4,388	6,674	5,177	----------	----------	6,674	5,177
Georgia	[1] 2,631	[1] 2,693	----------	----------	[1] 2,631	[1] 2,693	2,909	2,982	----------	----------	2,909	2,982
Hawaii	437	1,110	1	2	438	1,112	454	1,235	9	18	463	1,253
Idaho	2,949	2,639	[1] 3,930	[1] 3,765	[1] 6,879	[1] 6,404	2,102	2,218	7,082	5,862	9,184	8,080
Illinois	28,380	32,361	1,486	1,092	29,866	33,453	27,538	32,289	2,703	1,428	30,241	33,717
Indiana	16,334	14,786	528	259	16,862	15,045	19,994	17,762	363	162	20,357	17,924
Iowa	10,226	9,816	2,185	1,149	12,411	10,965	11,376	10,559	2,108	1,099	13,484	11,658
Kansas	8,282	5,806	2,035	963	10,317	6,769	9,257	6,661	2,077	1,276	11,334	7,937
Kentucky	4,467	4,652	218	183	4,685	4,835	4,798	5,361	283	207	5,081	5,568
Louisiana	[1] 14,610	[1] 16,982	451	137	[1] 15,061	[1] 17,119	15,505	19,898	547	213	16,052	20,111
Maine	1,436	1,020	7,505	2,726	8,941	3,746	1,532	1,058	7,920	2,586	9,452	3,644
Maryland	[1] 8,141	[1] 11,232	372	136	[1] 8,513	[1] 11,368	9,383	12,755	651	228	10,034	12,983
Massachusetts	9,052	9,202	1,568	833	10,620	10,035	11,468	11,076	1,742	710	13,210	11,786
Michigan	30,619	28,898	9,252	5,718	39,871	34,616	35,474	34,672	12,578	6,521	48,052	41,193
Minnesota	16,392	15,118	13,242	6,562	29,634	21,680	16,366	15,012	12,120	5,714	28,486	20,726
Mississippi	5,614	5,149	931	1,091	6,545	6,240	6,921	7,199	599	544	7,520	7,743
Missouri	8,281	9,285	691	443	8,972	9,728	9,574	10,959	705	447	10,279	11,406
Montana	2,136	2,400	11,296	10,193	13,432	12,593	2,064	2,335	8,866	10,252	10,930	12,587
Nebraska	9,764	7,466	677	479	10,441	7,945	10,405	7,695	797	606	11,202	8,301
Nevada	1,663	2,145	3,840	3,166	5,503	5,311	2,180	2,804	4,256	4,719	6,436	7,523
New Hampshire	1,234	1,300	3,706	1,320	4,940	2,620	1,740	1,686	3,384	1,201	5,124	2,887
New Jersey	9,824	16,119	53	26	9,877	16,145	10,962	18,589	71	31	11,033	18,620
New Mexico	7,027	6,568	6,178	4,845	13,205	11,413	10,116	10,718	2,344	2,614	12,460	13,332
New York	21,423	26,038	3,307	1,503	24,730	27,541	23,992	29,527	3,951	1,888	27,943	31,415
North Carolina	4,167	4,245	2,877	1,635	7,044	5,880	5,727	5,935	2,853	1,491	8,580	7,426
North Dakota	2,813	2,204	8,651	4,401	11,464	6,605	4,659	3,726	5,224	2,790	9,883	6,516
Ohio	29,436	36,469	188	150	29,624	36,619	36,216	44,150	2,388	989	38,604	45,139
Oklahoma	4,245	4,417	2,987	1,442	7,232	5,859	4,376	4,988	1,626	939	6,002	5,927
Oregon	6,295	7,224	4,169	3,041	10,464	10,265	7,213	7,887	10,874	7,619	18,087	15,506

Pennsylvania	11,663	19,101	162	79	11,825	19,180	14,225	23,220	32	13	14,257	23,233
Rhode Island	1,559	1,519	479	364	2,038	1,883	1,616	1,499	124	89	1,740	1,588
South Carolina	2,912	2,844	34	14	2,946	2,858	3,059	3,056	45	21	3,104	3,077
South Dakota	2,677	2,079	12,028	7,100	14,705	9,179	5,381	3,949	12,394	7,109	17,775	11,058
Tennessee	5,069	6,317	543	354	5,612	6,671	5,695	7,187	526	383	6,221	7,570
Texas	27,015	28,703	5,856	2,105	32,871	30,808	29,520	32,098	5,775	2,628	35,295	34,726
Utah	22,465	12,897	2,839	1,482	25,304	14,379	6,018	4,769	2,825	1,667	8,843	6,436
Vermont	887	849	995	467	1,882	1,316	1,064	998	946	407	2,010	1,405
Virginia	6,930	10,661	228	173	7,158	10,834	8,148	12,058	304	311	8,452	12,369
Washington	11,702	10,866	12,687	9,220	24,389	20,086	11,325	11,170	10,035	7,406	21,360	18,576
West Virginia	5,253	11,729	------	------	5,253	11,729	4,854	10,513	------	------	4,854	10,513
Wisconsin	18,438	14,044	20,945	11,801	39,383	25,845	21,997	16,899	20,002	10,636	41,999	27,535
Wyoming	1,633	1,310	3,700	3,450	5,333	4,760	2,056	1,673	2,636	2,309	4,692	3,982
Total	[1] 489,294	[1] 525,283	[1] 195,204	[1] 127,506	[1] 684,498	[1] 652,789	534,923	598,645	194,972	129,882	729,895	728,527
Guam	------	------	9	23	9	23	------	------	28	20	28	20
Panama Canal Zone	41	35	------	------	41	35	14	21	------	------	14	21
Puerto Rico	251	242	225	521	476	763	259	269	271	619	530	888
Canton Island	------	------	------	------	------	------	------	------	(2)	(2)	(2)	(2)

[1] Revised figure.
[2] Less than 1,000.

TABLE 4.—Sand and gravel sold or used by producers in the United States in 1959, by States, uses, and classes of operations

(Commercial unless otherwise indicated)

State	Sand—Construction							
	Building				Paving			
	Commercial		Government-and-contractor		Commercial		Government-and-contractor	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	1,478,760	$1,288,274	494	$494	450,676	$400,253	11,602	$9,861
Alaska	75,813	248,276	12,661	34,818	37,500	77,500	340,303	830,775
Arizona	1,325,300	1,671,700	1,500	3,300	178,600	157,100	1,225.600	838,750
Arkansas	1,373,980	1,354,520	-------	-------	1,202,821	1,120,954	2,299.721	1,862,842
California	17,429,692	21,848,287	14,067	14,915	8,880,987	9,932,006	2,319,746	2,317,083
Colorado	1,914,300	2,127,600	25,600	14,800	321,800	281,300	258,100	166,000
Connecticut	1,123,080	985,801	-------	-------	1,255,582	1,143,221	72,763	26,705
Delaware	106,478	120,329	-------	-------	403,703	270,677	60,000	45,000
Florida	5,299,862	3,938,056	-------	-------	371,132	240,841	-------	-------
Georgia	1,981,584	1,446,211	-------	-------	326,981	225,090	-------	-------
Hawaii	443,741	1,210,556	-------	-------	6,800	17,200	2,550	5,100
Idaho	269,298	331,081	148	222	51,336	76,474	300,652	157,978
Illinois	4,615,378	4,434,536	4,420	1,637	5,214,903	5,100,964	373,506	170,273
Indiana	3,655,113	2,850,029	-------	-------	3,577,767	2,916,188	1,000	350
Iowa	2,494,368	2,226,359	-------	-------	1,376,016	1,254,096	184,592	78,306
Kansas	3,569,164	2,606,748	73,246	24,993	2,341,117	1,639,580	954,657	392,796
Kentucky	2,038,123	2,255,856	-------	-------	943,884	969,618	-------	-------
Louisiana	2,223,301	2,429,018	108,510	81,383	2,097,625	2,200,314	-------	-------
Maine	242,724	239,117	2,915	1,020	164,958	110,442	510,092	197,418
Maryland	2,375,645	3,029,827	-------	-------	1,729,610	2,274,240	1,215	425
Massachusetts	3,007,104	3,013,307	-------	-------	1,354,672	1,143,820	29,155	20,314
Michigan	4,825,157	3,751,749	4,305	2,144	4,735,520	4,187,541	2,362,163	1,039,033
Minnesota	4,028,026	3,275,064	-------	-------	1,514,252	1,127,087	3,291,970	1,637,205
Mississippi	365,246	305,324	72,643	95,855	1,722,676	1,452,346	40,650	12,745
Missouri	3,566,523	3,079,279	42,000	25,200	1,166,407	1,063,705	3,200	3,380
Montana	297,952	523,386	49,112	102,923	9,667	19,331	356,265	427,695
Nebraska	1,985,300	1,533,700	-------	-------	761,400	575,200	77,900	29,500
Nevada	252,194	420,269	30	30	146,200	139,314	107,034	129,882
New Hampshire	205,176	216,505	-------	-------	316,086	201,661	816,687	288,055
New Jersey	3,489,248	3,516,895	-------	-------	2,107,605	1,923,340	11,524	4,318
New Mexico	1,194,300	1,312,000	24,300	28,900	188,000	230,400	69,800	43,900
New York	8,859,343	11,001,221	13,167	12,202	3,629,379	4,159,738	232,935	126,297
North Carolina	1,726,292	1,284,202	-------	-------	735,689	526,343	2,511,412	1,251,834
North Dakota	310,300	376,100	-------	-------	201,900	191,700	138,300	70,500

Ohio	6,117,776	7,266,953			6,911,832	7,081,558	253,228	143,829
Oklahoma	1,781,615	1,443,778			1,121,499	961,351	979,465	473,568
Oregon	742,419	965,171	18,012	34,640	412,574	482,880	91,347	40,969
Pennsylvania	3,824,920	5,476,084	50	180	2,148,497	3,218,653		
Rhode Island	357,512	349,185			336,256	261,576	30,451	20,691
South Carolina	1,179,287	621,283			404,210	133,885	45,309	21,080
South Dakota	477,600	528,900			376,600	350,600	444,600	300,300
Tennessee	1,883,801	2,327,055			469,031	498,639		
Texas	7,618,554	7,165,697	43,300	45,000	3,994,028	3,873,062	907,074	436,082
Utah	778,400	760,600	5,000	17,200	412,000	388,600	15,400	8,900
Vermont	63,058	61,639			275,544	163,347	95,612	49,068
Virginia	2,060,716	2,643,117			1,064,636	1,218,769	90,079	42,105
Washington	2,271,450	2,391,050	741,908	781,804	290,979	252,278	223,130	126,106
West Virginia	1,348,426	1,639,914			273,583	474,545		
Wisconsin	3,079,498	2,590,702	600	210	2,362,934	1,923,635	11,844,439	5,698,126
Wyoming	151,300	220,500	94,900	94,900	225,200	137,500	98,200	101,700
Undistributed								
Total	121,884,197	126,702,810	1,352,888	1,418,770	70,602,654	68,770,462	34,083,428	19,646,844
Canton Island							70	63
Guam							28,372	19,860
Panama Canal Zone	14,392	20,500						
Puerto Rico	6,510	10,757	200,000	480,000	73,218	66,200	4,033	4,775

TABLE 4.—Sand and gravel sold or used by producers in the United States, in 1959, by States, uses, and classes of operations—Continued

State	Sand—Construction (Continued)									
	Railroad ballast		Fill				Other			
			Commercial		Government-and-contractor		Commercial		Government-and-contractor	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	(1)	(1)	7,912	$4,641						
Alaska			7,600	4,675			25,454	$86,589		
Arizona			322,400	166,500			(1)	(1)		
Arkansas			187,953	99,634			34,181	20,509		
California	(1)	(1)	2,049,060	1,360,333			2,525,436	2,422,036		
Colorado	(1)	(1)	60,200	31,000	28,000	$15,700	(1)	(1)		
Connecticut	7,445	$2,803	83,623	35,793			100,924	109,818		
Delaware			(1)	(1)			36,610	31,263		
Florida			201,872	110,876			147,177	90,762		
Georgia	(1)	(1)	16,103	17,150						
Hawaii							(1)	(1)		
Idaho			(1)	(1)			(1)	(1)		
Illinois	(1)	(1)	676,926	376,763			62,538	59,309		
Indiana	(1)	(1)	498,858	281,047			(1)	(1)		
Iowa	(1)	(1)	351,792	189,541			13,294	7,976		
Kansas	79,109	29,031	666,318	352,504			27,110	19,982		
Kentucky			194,830	182,265						
Louisiana	24,855	13,094	212,153	151,820			374,427	429,580		
Maine			98,644	31,404			17,996	8,218	12,960	$4,536
Maryland			10,710	4,341			35,786	47,594		
Massachusetts	(1)	(1)	283,543	121,246	6,903	5,113	370,381	251,761	3,000	4,500
Michigan	(1)	(1)	1,287,707	531,490	577,852	134,948	40,254	30,502		
Minnesota	(1)	(1)	339,205	165,774	42,706	10,676			10,341	2,967
Mississippi			11,926	9,589			93,299	64,312		
Missouri	17,899	11,149	175,970	154,637			1,024	1,860		
Montana	(1)	(1)	(1)	(1)			12,984	6,141		
Nebraska	(1)	(1)	132,100	81,100			(1)	(1)		
Nevada			45,146	44,742						
New Hampshire			30,371	9,629	22,950	8,032	(1)	(1)		
New Jersey			136,959	74,664			2,574	3,947	4,915	1,720
New Mexico			18,200	10,700			35,100	19,500		
New York	(1)	(1)	501,402	312,870	992,967	652,301	491,262	459,435	220,456	87,762
North Carolina	(1)	(1)	39,474	23,514						
North Dakota			95,900	66,800			1,700	1,400		
Ohio			973,455	679,983	85,981	18,725	189,366	169,255		
Oklahoma	(1)	(1)	256,369	154,591			29,500	24,736		

Oregon			52,364	44,810			24,544	16,354		
Pennsylvania			(1)	(1)			81,798	121,007		
Rhode Island			(1)	(1)			54,884	42,667		
South Carolina	(1)	(1)	(1)	(1)						
South Dakota	44,700	24,200	22,100	10,900			20,500	8,100		
Tennessee			(1)	(1)			(1)	(1)		
Texas	(1)	(1)	844,274	382,039			154,825	151,806		
Utah			145,800	62,000	8,900	3,600	42,700	63,600		
Vermont			(1)	(1)			38,737	13,984	2,250	788
Virginia	35,000	35,000	543,541	510,789			(1)	(1)		
Washington	(1)	(1)	570,982	234,804			8,987	18,192		
West Virginia			(1)	(1)			(1)	(1)		
Wisconsin	108,151	86,108	1,319,813	647,649	160,743	50,053	10,896	10,351		
Wyoming			(1)	(1)						
Undistributed [1]	673,231	332,659	150,248	93,715			147,382	119,313		
Total	990,390	534,044	13,623,803	7,828,322	1,927,002	899,148	5,253,630	4,931,859	253,922	102,273
Canton Island										
Guam										
Panama Canal Zone										
Puerto Rico							(2)	(2)		

---

[1] Figures withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[2] Figures withheld to avoid disclosing individual company confidential data.

TABLE 4.—Sand and gravel sold or used by producers in the United States, in 1959, by States, uses, and classes of operations—Continued

State	Sand—Industrial							
	Glass		Molding		Grinding and polishing [3]		Fire or furnace	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama			130,341	$214,635				
Alaska								
Arizona								
Arkansas	(1)	(1)	(1)	(1)				
California	499,114	$1,957,692	49,634	224,297	202,865	$795,671	(1)	(1)
Colorado					(1)	(1)		
Connecticut								
Delaware								
Florida	(1)	(1)			(1)	(1)	(1)	(1)
Georgia	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Hawaii								
Idaho								
Illinois	1,215,998	2,961,821	548,087	1,502,351	(1)	(1)		
Indiana	(1)	(1)	455,058	645,589			(1)	(1)
Iowa			(1)	(1)	(1)	(1)		
Kansas			(1)	(1)	34,140	24,938		
Kentucky	7,621	23,600	1,835	6,400				
Louisiana					(1)	(1)		
Maine								
Maryland	(1)	(1)			(1)	(1)	44,000	$96,800
Massachusetts			(1)	(1)	2,000	7,000		
Michigan	(1)	(1)	1,918,507	2,849,091	(1)	(1)		
Minnesota	(1)	(1)	(1)	(1)				
Mississippi			55,560	142,110				
Missouri	(1)	(1)	154,546	447,849	(1)	(1)		
Montana								
Nebraska					5,400	5,000		
Nevada	(1)	(1)	93,591	382,251			(1)	(1)
New Hampshire								
New Jersey	604,375	2,376,760	1,313,317	3,866,021	125,698	520,906	(1)	(1)
New Mexico								
New York			198,845	773,646				
North Carolina								
North Dakota								
Ohio	394,003	1,457,587	433,845	1,636,768	(1)	(1)	173,769	435,376
Oklahoma	(1)	(1)	(1)	(1)	(1)	(1)		
Oregon					(1)	(1)		
Pennsylvania	(1)	(1)	173,104	483,130	(1)	(1)	105,868	380,094
Rhode Island			(1)	(1)			10,068	7,150
South Carolina	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)

South Dakota			1, 200	5, 400				
Tennessee	(1)	(1)	266, 949	784, 440	(1)	(1)	(1)	(1)
Texas	(1)	(1)	12, 476	31, 459	5, 284	18, 672		
Utah			(1)	(1)				
Vermont					(1)	(1)		
Virginia	(1)	(1)	(1)	(1)	(1)	(1)		
Washington	14, 049	119, 440	1, 998	9, 145	(1)	(1)		
West Virginia	(1)	(1)	(1)	(1)	(1)	(1)	44, 813	64, 104
Wisconsin			66, 132	124, 410	(1)	(1)		
Wyoming								
Undistributed [1]	3, 515, 777	11, 224, 717	371, 440	1, 015, 506	1, 499, 181	4, 281, 577	155, 482	204, 714
Total	6, 250, 937	20, 121, 617	6, 246, 465	15, 144, 498	1, 874, 568	5, 653, 764	534, 000	1, 188, 238
Canton Island								
Guam								
Panama Canal Zone								
Puerto Rico	56, 108	46, 940						

---

[1] Figures withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[2] Includes 695,516 tons of blast sand valued at $3,136,528.

TABLE 4.—Sand and gravel sold or used by producers in the United States, in 1959, by States, uses, and classes of operations—Continued

State	Sand—Industrial (Continued)									
	Engine		Ferrosilicon		Filtration		Oil (hydrafrac)		Other	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	52,624	$34,206								
Alaska										
Arizona	(1)	(1)								
Arkansas									(1)	(1)
California	55,240	177,213			(1)	(1)	(1)	(1)	28,183	$140,690
Colorado	(1)	(1)			(1)	(1)			(1)	(1)
Connecticut					(1)	(1)				
Delaware	32,744	24,558							13,907	13,907
Florida					(1)	(1)			(1)	(1)
Georgia	(1)	(1)			(1)	(1)			(1)	(1)
Hawaii	(1)	(1)								
Idaho									24,336	7,301
Illinois	73,373	126,923			(1)	(1)	(1)	(1)	(1)	(1)
Indiana	83,644	93,094							17,108	13,686
Iowa	(1)	(1)			(1)	(1)			(1)	(1)
Kansas	40,583	70,273			(1)	(1)	(1)	(1)	(1)	(1)
Kentucky	(1)	(1)							(1)	(1)
Louisiana	(1)	(1)							(1)	(1)
Maine	3,191	4,628								
Maryland	(1)	(1)							(1)	(1)
Massachusetts									1,680	2,520
Michigan	63,031	72,704			1,350	$1,000			(1)	(1)
Minnesota	(1)	(1)							(1)	(1)
Mississippi	(1)	(1)	(1)	(1)						
Missouri	13,310	9,745	(1)	(1)					36,179	99,432
Montana										
Nebraska	900	500							1,100	800
Nevada									(1)	(1)
New Hampshire	(1)	(1)			(1)	(1)				
New Jersey	20,063	61,802			55,441	146,129			306,027	655,237
New Mexico										
New York	(1)	(1)			24,772	41,747			110,163	73,458
North Carolina					(1)	(1)			7,600	7,600
North Dakota										
Ohio	(1)	(1)	(1)	(1)	20,173	49,881			86,746	189,468
Oklahoma	(1)	(1)	(1)	(1)	(1)	(1)			(1)	(1)
Oregon										
Pennsylvania	77,213	192,675	(1)	(1)	(1)	(1)			198,722	475,107
Rhode Island					1,800	2,500				
South Carolina	23,040	43,858			(1)	(1)			40,416	54,155

South Dakota										
Tennessee	660	825								
Texas	(1)	(1)			(1)	(1)	(1)	(1)	(1)	(1)
Utah	(1)	(1)								
Vermont	(1)	(1)								
Virginia	(1)	(1)			18,781	27,749			(1)	(1)
Washington										
West Virginia	98,143	278,061	(1)	(1)					(1)	(1)
Wisconsin	(1)	(1)			(1)	(1)	(1)	(1)	(1)	(1)
Wyoming									(1)	(1)
Undistributed [1]	235,546	344,070	64,757	$174,793	272,401	664,734	84,719	$360,614	1,074,379	2,837,333
Total	873,305	1,535,135	64,757	174,793	394,718	933,740	84,719	360,614	1,946,546	4,570,694
Canton Island										
Guam										
Panama Canal Zone										
Puerto Rico										

---

[1] Figures withheld to avoid disclosing individual company confidential data; included with "Undistributed."

TABLE 4.—Sand and gravel sold or used by producers in the United States, in 1959, by States, uses, and classes of operations—Continued

State	Gravel—Construction							
	Building				Paving			
	Commercial		Government-and-contractor		Commercial		Government-and-contractor	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	1,207,121	$1,443,089	2,625	$3,938	716,566	$887,635	66,400	$53,155
Alaska	61,851	192,583	817,061	847,393	108,174	221,201	4,057,660	2,390,105
Arizona	1,197,400	1,453,900	1,500	3,300	1,199,800	1,309,300	7,112,600	5,813,250
Arkansas	1,630,070	1,865,910	-----	-----	2,105,110	2,232,459	2,423,161	2,459,647
California	20,090,885	29,462,627	87,120	62,786	20,061,432	24,739,034	9,512,699	9,073,924
Colorado	2,493,800	3,092,200	125,000	83,400	5,113,600	4,875,700	9,915,900	7,544,500
Connecticut	948,418	1,440,543	-----	-----	609,458	727,786	98,313	41,219
Delaware	25,240	63,979	-----	-----	419,306	365,853	73,766	55,326
Florida	(1)	(1)	-----	-----	(1)	(1)	-----	-----
Georgia	(1)	(1)	-----	-----	(1)	(1)	-----	-----
Hawaii	-----	-----	-----	-----	-----	-----	6,475	12,950
Idaho	409,374	512,641	42,623	65,419	1,152,581	1,124,183	6,738,526	5,637,987
Illinois	3,418,964	3,531,010	26,343	10,987	9,690,142	9,093,429	2,298,217	1,245,790
Indiana	4,296,998	4,369,420	-----	-----	5,881,546	5,527,452	318,281	145,069
Iowa	1,416,088	2,026,242	-----	-----	5,314,483	4,206,258	1,883,480	1,008,928
Kansas	202,729	208,767	122,585	49,368	1,737,351	1,370,146	926,893	808,565
Kentucky	851,236	1,079,210	-----	-----	666,872	782,841	282,636	207,456
Louisiana	4,050,125	5,201,954	-----	-----	5,204,733	7,100,256	438,436	131,931
Maine	175,722	213,121	455	159	563,029	333,898	7,391,954	2,381,860
Maryland	2,198,895	3,703,190	-----	-----	2,042,336	2,717,454	649,795	227,428
Massachusetts	2,556,595	3,534,708	43,000	38,500	2,436,999	1,966,655	995,425	396,895
Michigan	4,273,557	5,095,315	30,369	12,148	16,996,751	15,948,564	9,436,477	5,297,171
Minnesota	2,915,917	3,778,451	44,491	19,007	6,572,131	5,357,680	8,695,044	4,034,979
Mississippi	664,098	725,311	92,706	254,905	3,695,853	4,189,567	393,202	180,636
Missouri	1,590,786	1,849,089	-----	-----	2,011,858	1,939,006	660,191	417,990
Montana	508,567	725,583	772,652	505,873	624,401	671,618	7,687,787	9,215,507
Nebraska	2,109,600	1,756,100	-----	-----	5,182,500	3,594,000	719,300	576,400
Nevada	415,410	605,108	123,275	123,275	875,908	724,337	4,025,132	4,465,650
New Hampshire	201,121	322,676	-----	-----	819,991	844,437	2,544,512	905,587
New Jersey	1,742,315	3,214,776	-----	-----	767,741	1,054,721	49,941	22,646
New Mexico	1,358,400	1,729,700	86,400	117,200	7,217,100	7,355,100	2,163,700	2,423,800
New York	4,628,654	7,237,485	58,000	20,300	3,134,603	3,516,373	2,191,005	848,212
North Carolina	1,329,248	1,698,848	-----	-----	1,621,214	2,034,775	341,149	239,394
North Dakota	514,000	833,900	44,600	26,900	3,290,600	2,132,400	5,040,800	2,692,500
Ohio	5,773,706	7,066,461	-----	-----	11,818,735	13,673,403	930,467	671,177
Oklahoma	102,918	123,781	-----	-----	466,985	498,478	646,978	464,942
Oregon	1,617,529	1,864,160	5,266,185	1,996,711	3,956,596	4,173,837	5,497,833	5,547,195

Pennsylvania	4,037,098	5,385,540			2,200,930	3,270,382		
Rhode Island	215,794	288,333			314,234	328,437	93,936	68,654
South Carolina	(1)	(1)						
South Dakota	294,500	281,600	398,600	348,600	4,010,400	2,677,800	11,550,200	6,460,600
Tennessee	1,835,048	2,147,006			811,058	727,695	526,197	383,275
Texas	7,575,155	9,702,537	69,510	70,000	7,535,755	8,851,836	4,754,928	2,076,259
Utah	894,700	819,500	216,400	147,400	2,319,400	1,874,900	2,463,400	1,461,100
Vermont	73,718	122,441			583,660	623,150	844,332	355,397
Virginia	2,326,390	4,392,856			1,727,505	2,423,395	214,177	268,847
Washington	3,094,235	3,334,358	1,521,904	1,774,684	3,975,799	3,823,496	7,547,511	4,723,821
West Virginia	1,339,069	1,506,153			482,507	945,462		
Wisconsin	3,422,570	3,028,078			9,511,187	7,095,010	7,970,678	4,878,478
Wyoming	284,800	384,200	393,900	299,600	1,123,700	774,400	2,048,700	1,813,300
Undistributed [1]	1,432,490	2,074,555			276,951	471,172		
Total	103,802,904	135,488,995	10,387,304	6,881,853	168,949,571	171,176,971	144,228,194	100,129,502
Canton Island								
Guam								
Panama Canal Zone								
Puerto Rico	(2)	(2)	33,434	67,270	101,200	118,066	33,549	66,679

---

[1] Figures withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[2] Figures withheld to avoid disclosing individual company confidential data.

TABLE 4.—Sand and gravel sold or used by producers in the United States, in 1959, by States, uses, and classes of operations—Continued

State	Gravel—Construction (Continued)										Gravel—Miscellaneous	
	Railroad ballast		Fill				Other					
			Commercial		Government-and-contractor		Commercial		Government-and-contractor			
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	(1)	(1)	2,034	$2,179	-----	-----	(1)	(1)	-----	-----	(1)	(1)
Alaska	170,069	$132,683	96,600	99,934	-----	-----	24,657	$80,792	-----	-----	23,958	$17,747
Arizona	(1)	(1)	673,600	335,900	-----	-----	(1)	(1)	-----	-----	-----	-----
Arkansas	(1)	(1)	149,410	60,227	-----	-----	(1)	(1)	-----	-----	(1)	(1)
California	297,125	318,157	1,970,178	1,452,734	-----	-----	1,260,067	1,453,016	-----	-----	564,197	763,316
Colorado	(1)	(1)	311,500	322,000	233,900	$125,900	23,800	36,500	8,500	$9,400	21,800	31,200
Connecticut	-----	-----	207,271	140,116	-----	-----	(1)	(1)	-----	-----	55,747	84,608
Delaware	-----	-----	(1)	(1)	-----	-----	-----	-----	-----	-----	30,410	57,243
Florida	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	31	85
Georgia	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Hawaii	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Idaho	(1)	(1)	67,374	74,626	-----	-----	48,591	57,286	-----	-----	(1)	(1)
Illinois	303,994	220,804	936,121	545,706	-----	-----	24,224	28,525	-----	-----	40,429	33,019
Indiana	280,192	207,497	999,521	622,953	43,646	16,317	40,275	38,479	-----	-----	(1)	(1)
Iowa	(1)	(1)	203,543	126,633	40,534	12,187	(1)	(1)	-----	-----	(1)	(1)
Kansas	4,280	1,284	187,414	108,938	-----	-----	6,554	15,969	-----	-----	7,284	8,552
Kentucky	-----	-----	(1)	(1)	-----	-----	-----	-----	-----	-----	-----	-----
Louisiana	42,757	44,828	147,323	126,835	-----	-----	1,079,099	1,930,441	-----	-----	-----	-----
Maine	19,815	6,935	234,603	105,334	1,902	666	2,607	1,207	377	132	8,474	3,955
Maryland	-----	-----	90,814	62,351	-----	-----	(1)	(1)	-----	-----	-----	-----
Massachusetts	-----	-----	869,081	363,089	664,075	244,773	305,434	246,072	-----	-----	133,585	99,714
Michigan	(1)	(1)	361,226	252,188	164,751	33,918	51,074	54,010	1,750	1,500	57,637	54,483
Minnesota	446,622	330,145	278,203	124,522	34,707	9,405	(1)	(1)	-----	-----	35,000	55,000
Mississippi	76,592	47,907	41,703	56,117	-----	-----	126,578	155,031	-----	-----	(1)	(1)
Missouri	(1)	(1)	33,232	22,662	-----	-----	(1)	(1)	-----	-----	(1)	(1)
Montana	495,277	293,373	104,480	83,803	-----	-----	1,959	1,700	-----	-----	3,010	3,862
Nebraska	600	400	33,400	27,400	-----	-----	7,600	6,800	-----	-----	156,600	102,400
Nevada	1,000	1,250	67,710	61,643	-----	-----	78,000	58,500	-----	-----	(1)	(1)
New Hampshire	4,327	1,514	65,374	41,271	-----	-----	(1)	(1)	-----	-----	44,755	16,041
New Jersey	-----	-----	66,774	32,009	-----	-----	47,946	82,362	4,576	1,602	(1)	(1)
New Mexico	(1)	(1)	(1)	(1)	-----	-----	-----	-----	-----	-----	52,200	34,600
New York	47,935	59,187	648,653	350,329	238,364	138,873	800,001	600,440	4,742	1,660	872,902	888,746
North Carolina	26,325	19,338	(1)	(1)	-----	-----	(1)	(1)	-----	-----	178,689	285,521
North Dakota	190,100	84,600	44,500	20,900	-----	-----	1,100	1,100	-----	-----	9,500	17,200
Ohio	209,400	169,585	845,103	596,126	1,118,526	155,099	732,551	847,868	-----	-----	1,343,375	2,007,744
Oklahoma	-----	-----	17,573	9,277	-----	-----	(1)	(1)	-----	-----	(1)	(1)

Oregon	(1)	(1)	290, 214	194, 497	----------	----------	29, 120	25, 618	----------	----------	22, 860	28, 521
Pennsylvania	(1)	(1)	110, 644	98, 534	32, 336	12, 385	68, 159	60, 608	----------	----------	101, 811	62, 151
Rhode Island	----------	----------	77, 121	39, 608	----------	----------	234, 607	136, 088	----------	----------	----------	----------
South Carolina	(1)	(1)	(1)	(1)	----------	----------	(1)	(1)	----------	----------	(1)	(1)
South Dakota	51, 500	34, 500	46, 400	15, 600	----------	----------	100	100	----------	----------	35, 800	10, 800
Tennessee	109, 999	111, 623	(1)	(1)	----------	----------	----------	----------	----------	----------	(1)	(1)
Texas	315, 837	234, 780	498, 924	208, 746	----------	----------	167, 319	132, 103	----------	----------	318, 074	201, 621
Utah	(1)	(1)	1, 320, 800	668, 200	116, 500	29, 200	(1)	(1)	----------	----------	3, 200	7, 100
Vermont	----------	----------	11, 541	4, 120	4, 500	1, 575	----------	----------	----------	----------	(1)	(1)
Virginia	----------	----------	(1)	(1)	----------	----------	(1)	(1)	----------	----------	(1)	(1)
Washington	(1)	(1)	478, 452	381, 763	----------	----------	257, 724	273, 258	----------	----------	(1)	(1)
West Virginia	(1)	(1)	(1)	(1)	----------	----------	(1)	(1)	----------	----------	(1)	(1)
Wisconsin	521, 974	379, 802	1, 222, 378	637, 154	25, 268	8, 843	182, 347	93, 959	----------	----------	(1)	(1)
Wyoming	189, 100	94, 500	(1)	(1)	----------	----------	----------	----------	----------	----------	(1)	(1)
Undistributed [1]	1, 007, 337	900, 814	284, 480	194, 675	----------	----------	1, 334, 793	1, 265, 004	----------	----------	651, 356	597, 861
Total	4, 812, 157	3, 695, 506	14, 095, 272	8, 670, 699	2, 719, 009	789, 141	6, 936, 286	7, 682, 836	19, 945	14, 294	4, 772, 684	5, 473, 090
Canton Island	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------
Guam	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------
Panama Canal Zone	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------
Puerto Rico	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------

---

[1] Figures withheld to avoid disclosing individual company confidential data; included with "Undistributed".

Government-and-Contractor Production.—The volume of sand and gravel output classified as Government-and-Contractor was 27 percent of total production, a decrease of 8 percent from 1958. Its value was $130 million, an average of 67 cents a ton. This material went into Government construction projects, including Federal, State, and local public-construction programs. States reported 57 percent of Government-and-contractor production in 1959, counties 29 percent, Federal agencies 12 percent, and municipalities 2 percent. Major production was by contractors; the remainder was by maintenance crews.

Production decrease in this category was due mainly to increased open-market sales by contractors. Some contractors utilized relatively small deposits near the job sites, successfully upgraded marginal material to meet rigid specifications, and produced more than they needed.

The Government-and-contractor classification includes direct output by Federal, State, and county agencies, municipalities, and some output of private producers. The entire production of a private producer must be on contract to a Government agency to be classed under the Government-and-contractor category. If any part of the production is sold commercially, the entire output reverts to commercial classification.

Degree of Preparation.—More stringent specifications and demand for special products resulted in an increase of washed, screened, or otherwise prepared sand and gravel. Output of processed material rose to 87 percent of commercial production and averaged $1.20 a ton, compared with $0.60 a ton for the unprepared commercial production. Only 45 percent of the Government-and-contractor production was prepared; its average value was $0.90 a ton.

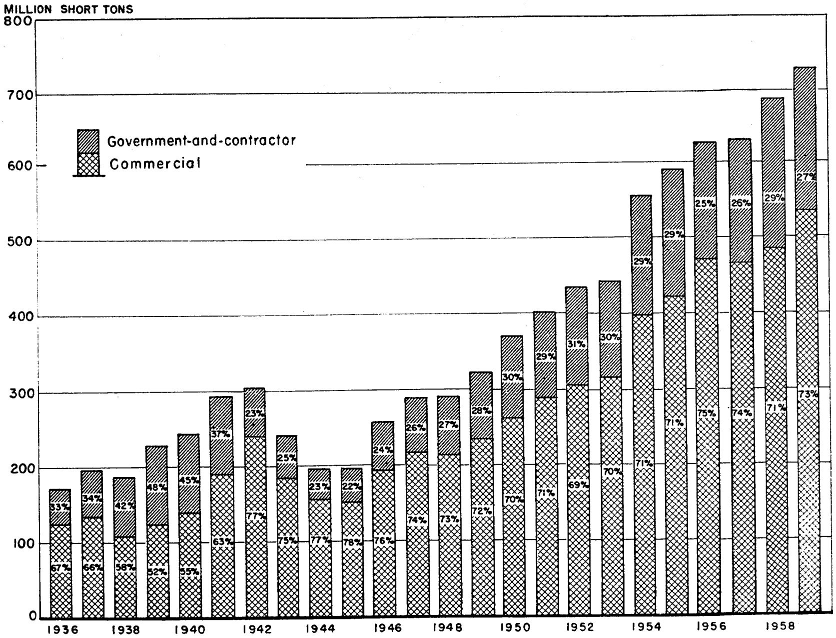

FIGURE 2.—Sand and gravel sold or used in the United States, 1936–59.

Because of its binding quality and lower unit value, unprepared or "bank-run" material was preferred for many uses, including base courses, subgrade treatment to increase stability and drainage, fill, and secondary roads.

TABLE 5.—Sand and gravel sold or used by Government-and-contractor producers in the United States,[1] by uses

(Thousand short tons and thousand dollars)

Year	Sand				Gravel				Total Government-and-contractor sand and gravel	
	Building		Paving		Building		Paving			
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1950-54 (average)	1,618	$1,462	13,899	$6,009	7,291	$5,326	107,713	$50,383	130,521	$63,180
1955	1,758	1,975	22,833	11,099	15,045	7,994	132,441	77,616	172,077	98,684
1956	2,321	2,058	19,568	9,586	5,434	3,689	127,717	77,740	155,040	93,073
1957	[2] 2,324	1,903	24,159	12,280	7,857	5,860	130,908	83,734	[2] 165,248	103,777
1958	1,584	1,807	28,496	15,151	3,814	4,116	[2] 161,310	[2] 106,432	[2] 195,204	[2] 127,506
1959	1,353	1,419	34,084	19,647	10,387	6,882	144,228	100,130	[3] 194,972	[3] 129,882

[1] Includes possessions and other areas administered by the United States (1950–56).
[2] Revised figure.
[3] Includes fill sand, 1,927,000 short tons valued at $899,000; other sand, 254,000 tons at $102,000; fill gravel, 2,719,000 tons at $789,000; and other gravel, 20,000 tons at $14,000.

TABLE 6.—Sand and gravel sold or used by Government-and-contractor producers in the United States,[1] by types of producer

(Thousand short tons and thousand dollars)

Type of producer	1950-54 (average)		1955		1956		1957		1958		1959	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Construction and maintenance crews	46,553	$16,629	46,483	$18,515	47,592	$22,582	49,646	$24,076	[2] 49,771	$26,314	49,800	$28,643
Contractors	83,968	46,551	125,594	80,169	107,448	70,491	[2] 115,602	79,701	[2] 145,434	[2] 101,192	145,172	101,239
Total	130,521	63,180	172,077	98,684	155,040	93,073	[2] 165,248	103,777	[2] 195,205	[2] 127,506	194,972	129,882
States	71,546	35,288	101,842	58,074	94,767	56,746	97,813	60,120	123,555	78,676	111,386	74,762
Counties	38,906	14,384	41,444	18,657	40,608	21,066	[2] 44,303	23,234	[2] 49,329	[2] 29,639	56,293	34,975
Municipalities	2,595	1,236	2,761	1,381	4,149	2,401	3,092	2,547	[2] 2,971	1,959	3,282	1,972
Federal agencies	17,474	12,272	26,030	20,572	15,516	12,860	20,040	17,876	19,350	17,232	24,011	18,173
Total	130,521	63,180	172,077	98,684	155,040	93,073	[2] 165,248	103,777	[2] 195,205	[2] 127,506	194,972	129,882

[1] Includes possessions and other areas administered by the United States (1950–56).
[2] Revised figure.

More diversified requirements for sand and gravel and utilization of lower grade deposits have increased the complexities of modern high-capacity operations. Processing equipment was developed to a high degree, resulting in the increased use of old and new beneficiation techniques involving a variety of mechanical and hydraulic classifying devices. Some portable plants were designed to incorporate crushing, screening, and washing equipment.

Improved processing resulted in higher production costs and higher unit values for commercial output than for Government-and-contractor production.

TABLE 7.—**Sand and gravel sold or used by producers in the United States, by classes of operation and degrees of preparation**

(Thousand short tons and thousand dollars)

	1958		1959	
	Quantity	Value	Quantity	Value
Commercial operations:				
Prepared	[1] 412, 194	[1] $479, 790	464, 896	$556, 620
Unprepared	[1] 77, 100	[1] 45, 493	70, 027	42, 025
Total	[1] 489, 294	[1] 525, 283	534, 923	598, 645
Government-and-contractor operations:				
Prepared	[1] 93, 780	[1] 81, 266	88, 282	79, 195
Unprepared	101, 424	46, 240	106, 690	50, 687
Total	[1] 195, 204	[1] 127, 506	194, 972	129, 882
Grand total	[1] 684, 498	[1] 652, 789	729, 895	728, 527

[1] Revised figure.

TABLE 8.—**Number and production of commercial sand and gravel plants by size groups** [1]

Annual production (short tons)	1958				1959			
	Plants [2]		Production		Plants [2]		Production	
	Number	Percent of total	Thousand short tons	Percent of total	Number	Percent of total	Thousand short tons	Percent of total
Less than 25,000	[3] 1, 642	[3] 37. 3	[3] 18, 328	[3] 3. 8	2, 091	41. 0	20, 421	3. 8
25,000 to 50,000	[3] 749	[3] 17. 0	[3] 26, 620	[3] 5. 5	744	14. 6	26, 477	4. 9
50,000 to 100,000	[3] 733	16. 6	[3] 51, 863	[3] 10. 6	841	16. 5	59, 331	11. 1
100,000 to 200,000	629	[3] 14. 3	88, 645	[3] 18. 2	655	12. 9	92, 398	17. 3
200,000 to 300,000	280	[3] 6. 3	[3] 67, 730	[3] 13. 9	345	6. 8	84, 389	15. 8
300,000 to 400,000	138	[3] 3. 1	[3] 47, 871	[3] 9. 8	143	2. 8	49, 336	9. 2
400,000 to 500,000	80	[3] 1. 8	35, 427	7. 3	88	1. 7	39, 028	7. 3
500,000 to 600,000	54	[3] 1. 2	29, 237	6. 0	60	1. 2	32, 854	6. 1
600,000 to 700,000	30	. 7	19, 505	4. 0	28	. 5	18, 013	3. 4
700,000 to 800,000	[3] 16	. 4	[3] 11, 936	[3] 2. 4	24	. 5	17, 886	3. 3
800,000 to 900,000	11	[3] . 2	9, 044	[3] 1. 8	12	. 2	10, 053	1. 9
900,000 to 1,000,000	8	. 2	7, 629	1. 6	15	. 3	14, 229	2. 7
1,000,000 and over	38	. 9	73, 876	[3] 15. 1	50	1. 0	70, 508	13. 2
Total	[3] 4, 408	100. 0	[3] 487, 711	100. 0	5, 096	100. 0	534, 923	100. 0

[1] Excludes operations by or for States, counties, municipalities, and Federal Government agencies as follows—1958: 2,351 operations, 195,204,525 tons (revised figure) of sand and gravel; 1959: 1,764 operations, 194,971,692 tons. Excludes operations by or for railroads in 1958 only—49 operations with an output of 1,583,265 tons of sand and gravel.

[2] Includes a few companies operating more than 1 plant but not submitting separate returns for individual plants.

[3] Revised figure.

Size of Plants.—Increased use by contractors of mobile portable and semiportable plants for exploiting small deposits made the average sand and gravel operation comparatively small. The number of plants producing less than 50,000 tons annually totaled 2,835, but their combined output was only 9 percent of total production. The capacity of 2,072 plants producing between 50,000 and 500,000 tons a year accounted for 61 percent of total output. The large operators (500,000 to over 1 million tons) increased to 189 and accounted for 30 percent of production.

Production Trends.—Many deposits of high-quality sand and gravel were lost through appropriation by Government agencies for public purposes. The true value of these deposits sometimes was not taken into consideration. One company established evidence of extent of a deposit to be appropriated and gained reversal of a lower court decision that had not properly evaluated the importance of the deposit.[7]

The domestic supply of sand and gravel continued to be adequate in most areas, although in certain sections known reserves were depleted, necessitating intensive investigations for new sources of supply. Many deposits formerly considered marginal or noncommercial were reevaluated and, by modern beneficiation methods, yielded products acceptable to industry. Expanded use of portable plants has permitted utilization of small aggregate deposits that otherwise could not have been exploited economically.

Numerous producers, desiring to obtain new aggregate deposits or to expand existing facilities and reserves located near cities and towns, especially in areas of urban expansion, felt the effects of local zoning laws and regulations. Operations were restricted, and in some areas commercial deposits were permanently lost to exploitation. This problem was of major concern to the sand and gravel industry, and several articles relating to this subject were published.

Facts were presented relating to the "mineral rights" status of sand and gravel on certain lands in Michigan.[8] Reclamation projects by a Michigan sand and gravel producer resulted in a series of man-made lakes and choice residential lots. This created good will for the producer and the unopposed rezoning of agricultural land for commercial use by the company.[9]

A new publication by the Sand and Gravel Association of Great Britain dealt with similar problems concerning planning, control, and the multiple utilization of mineral-bearing land for sand and gravel production, agriculture, industry, housing, and other purposes.[10]

Methods of Transportation.—Expanding markets, increasing distances from sources of supply, and rising transportation costs were reflected in the use of larger capacity trucks and trailers. An increase in portable-plant operations at small localized deposits reduced transportation costs. The use of high-capacity, off-the-road dump trucks was another contributing factor in reducing costs.

---

[7] Parker, Leo T., Legal Decisions on Industry Problems: Pit and Quarry, vol. 52, No. 4, October 1959, p. 138.

[8] Rockwood, Nathan C., The State Owns the Sand and Gravel: Rock Products, vol. 62, No. 9, September 1959, pp. 16, 138, 141.

[9] Godfrey, Kneeland A., Jr., Gravel Pits Are Getting New Faces: Rock Products, vol. 62, No. 6, June 1959, pp. 106–108.

[10] Boorer, H. L., Planning Practice for the Sand and Gravel Industry: Sweet and Maxwell, Ltd. (Chancery Lane, London) 1959, 89 pp.

TABLE 9.—Sand and gravel sold or used in the United States, by method of transportation

	1957		1958		1959	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Commercial:						
Truck	[1]344,613	55	[1]384,493	56	442,154	61
Rail	87,845	14	[1]65,750	10	66,983	9
Waterway	21,388	3	38,089	5	25,073	3
Unspecified	13,161	2	962	(2)	713	(2)
Total commercial	[1]467,007	74	[1]489,294	71	534,923	73
Government-and-contractor: Truck [3]	[1]165,248	26	[1]195,204	29	194,972	27
Grand total	[1]632,255	100	[1]684,498	100	729,895	100

[1] Revised figure.
[2] Less than 0.5 percent.
[3] Entire output of Government-and-contractor operations assumed to be moved by truck.

Truck shipments supplied 88 percent of the sand and gravel transported in 1959, continuing the increasing trend toward this type of haulage. Shipments by rail continued to decrease, owing principally to higher freight rates, and accounted for only 9 percent of material transported. Waterway transportation dominated a few local areas, but the percentage hauled by this method was small. Continued increase in the use of trucks was based on flexibility of operation, depletion of many large deposits near railroads, ability to transport sand and gravel directly to its point of use, and lower cost.

Diesel-powered trucks with one or more connected trailers designed for both on- and off-highway hauling were in use. One type was designed to dump a payload of 33,600 pounds from each of three bodies in 30 seconds, without bringing the train to a full stop.[11]

Conveyors.—A cross-country belt conveyor designed to follow the land contour reportedly was easily installed and could be stored in a very small area.[12] Transportation of sand and gravel by belt conveyor was an important part of a construction project. Conveyors ranged from short, portable units to systems several miles long. Data relating to design, equipment, and power requirements were outlined.[13]

Installation of a pneumatic sand-conveyor system at an Indiana operation resulted in considerable saving over the former clamshell operation. Increased efficiency of the automatic operation reduced maintenance and manpower costs and space requirements and allowed better moisture control of the dry sand.[14]

A rubber-lined pump replaced a stacker belt, loader, and bulldozer in stockpiling sand at a North Carolina plant. Continuous operation of this pump proved to be a definite economic advantage over the earlier method.[15]

---

[11] Pit and Quarry, New Machinery and Equipment: Vol. 52, No. 6, December 1959, p. 57.

[12] Pit and Quarry, The Joy Limberope Conveyor: Vol. 52, No. 6, December 1959, p. 124.

[13] Peurifoy, R. L., Design of a Belt-Conveyor System: Roads and Streets, vol. 102, No. 4, April 1959, p. 68.

[14] Foundry, Pneumatic Conveyor Speeds Sand Delivery: Vol. 87, No. 10, October 1959, p. 154.

[15] Rock Products, Larger Units Cut Labor Costs: Vol. 62, No. 9, September 1959, p. 89.

Employment and Productivity.—Improved technology and increasing plant automation for both stationary and portable plants continued to increase output in tons per man-shift and to decrease the number of men employed in the industry. Rising labor costs were the principal motivation in the trend toward greater automation.

Centrally controlled operations were increasingly important in improving productivity rates. For example, a new Southern California aggregate-producing facility featured remote control, interlocked processing equipment, and multiple surge piling, resulting in a high

TABLE 10.—Employment in the commercial sand and gravel industry and average output per man in the United States in 1959, by States[1]

State	Employment					Production (short tons)	Average output per man	
	Average number of men	Time employed					Per shift	Per hour
		Average number of days	Total man shifts	Man-hours				
				Average man per day	Total			
Alabama	455	258	117,219	8.7	1,019,801	4,270,604	36.4	4.2
Alaska	56	107	5,985	8.9	53,270	631,676	105.5	11.9
Arizona	789	232	183,320	8.2	1,503,223	5,116,400	27.9	3.4
Arkansas	748	252	188,552	8.4	1,583,833	6,973,161	37.0	4.4
California	4,491	233	1,044,894	8.1	8,509,219	76,011,341	72.7	8.9
Colorado	1,015	225	228,450	8.7	1,987,515	10,302,300	45.1	5.2
Connecticut	364	208	75,608	8.3	627,550	4,577,643	60.5	7.3
Delaware	83	251	20,874	8.0	166,988	1,106,888	53.0	6.6
Florida	384	272	104,488	8.4	877,703	6,674,048	63.9	7.6
Georgia	329	265	87,155	8.6	749,536	2,909,070	33.4	3.9
Hawaii	47	135	6,338	8.0	50,700	454,099	71.6	9.0
Idaho	192	147	28,235	8.2	231,524	2,101,884	74.4	9.1
Illinois	1,691	237	400,048	8.8	3,520,421	27,538,101	68.8	7.8
Indiana	1,140	246	280,322	8.4	2,354,702	19,994,159	71.3	8.5
Iowa	842	226	190,000	9.1	1,728,997	11,375,666	59.9	6.6
Kansas	817	218	178,141	8.7	1,549,829	9,256,747	52.0	6.0
Kentucky	411	274	112,414	9.1	1,022,969	4,798,173	42.7	4.7
Louisiana	1,315	237	311,166	8.9	2,769,376	15,505,203	49.8	5.6
Maine	188	183	34,479	8.5	293,073	1,531,763	44.4	5.2
Maryland	785	246	193,184	8.7	1,680,702	9,382,710	48.6	5.6
Massachusetts	848	241	204,728	8.2	1,678,767	11,468,312	56.0	6.8
Michigan	2,535	184	466,595	8.7	4,059,378	35,474,149	76.0	8.7
Minnesota	1,423	158	225,230	9.1	2,049,592	16,366,254	72.7	8.0
Mississippi	490	260	127,321	9.3	1,184,083	6,921,220	54.4	5.8
Missouri	696	235	163,855	8.4	1,376,384	9,574,150	58.4	7.0
Montana	295	148	43,525	8.1	352,551	2,063,869	47.4	5.9
Nebraska	750	217	162,948	9.3	1,515,416	10,405,200	63.9	6.9
Nevada	163	185	30,101	8.0	241,104	2,180,154	72.4	9.0
New Hampshire	106	214	22,694	8.8	199,711	1,739,677	76.7	8.7
New Jersey	979	251	245,342	8.3	2,036,341	10,962,232	44.7	5.4
New Mexico	524	242	126,885	8.3	1,053,145	10,115,900	79.7	9.6
New York	1,560	217	337,811	8.4	2,837,610	23,991,882	71.0	8.5
North Carolina	481	230	110,581	8.6	950,997	5,727,314	51.8	6.0
North Dakota	462	176	81,174	9.6	779,267	4,659,600	57.4	6.0
Ohio	2,703	238	643,984	8.4	5,409,463	36,215,429	56.2	6.7
Oklahoma	334	256	85,355	8.6	734,055	4,375,966	51.3	6.0
Oregon	690	211	145,415	8.0	1,163,317	7,213,274	49.6	6.2
Pennsylvania	1,388	240	332,738	8.6	2,861,543	14,224,628	42.8	5.0
Rhode Island	116	227	26,364	8.2	216,182	1,615,716	61.3	7.5
South Carolina	242	276	66,760	8.0	534,077	3,059,205	45.8	5.7
South Dakota	504	183	92,081	9.5	874,773	5,381,400	58.4	6.2
Tennessee	513	249	127,875	9.0	1,150,873	5,694,796	44.5	4.9
Texas	2,410	263	633,885	8.8	5,578,186	29,519,721	46.6	5.3
Utah	512	233	119,132	8.4	1,000,710	6,017,800	50.5	6.0
Vermont	146	203	29,655	8.5	252,071	1,063,825	35.9	4.2
Virginia	598	258	154,045	8.7	1,340,195	8,147,287	52.9	6.1
Washington	702	203	142,228	8.1	1,152,049	11,325,339	79.6	9.8
West Virginia	553	237	131,108	9.1	1,193,084	4,854,052	37.0	4.1
Wisconsin	1,462	186	271,287	8.7	2,360,198	21,997,393	81.1	9.3
Wyoming	181	156	28,254	8.0	226,028	2,056,200	72.8	9.1
Total	40,508	226	9,169,828	8.6	78,642,081	534,923,580	58.3	6.8

---

[1] Excludes operations by or for States, counties, municipalities, and Federal Government agencies.

degree of flexibility in operation and a high output per man-hour.[16] By constructing a modern processing plant at a new source of supply, instead of utilizing old equipment, a New York operator doubled capacity and decreased the number of employees required by nearly 50 percent.[17]

CONSUMPTION AND USES

Construction Uses, Including Ballast.—The higher consumption of sand and gravel in 1959 resulted mainly from increased homebuilding requirements. As in prior years, the construction industry consumed most of the sand and gravel produced for buildings and concrete and bituminous paving. Reduction in highway contract awards began to affect sales of paving sand and gravel by commercial producers and reduced production by contractors in many sections of the Country.

The National Ready-Mixed Concrete Association's eighth annual survey of 3,481 ready-mix concrete companies resulted in 1,792 replies. Information indicated that 131 million tons of sand and gravel was used in producing over 81 million cubic yards of ready-mixed concrete.[18]

Industrial Sands.—Consumption of industrial sands, including ground sand, totaled 19 million tons, an increase of nearly 4 million tons over 1958. Increase in the production of glass sand was due principally to the use of more glass in buildings, automobiles, and glass containers.

The fields of special uses of sand continued to increase during 1959. For example, several articles described the use of sand in the petroleum-cracking process of a company in West Germany. By circulating fluidized sand to deliver needed heat, the cracking unit reportedly extended cracking capabilities far beyond the boundaries imposed by conventional steam crackers.[19]

TABLE 11.—Ground sand sold or used by producers in the United States,[1] by uses

Use	1958		1959	
	Short tons	Value	Short tons	Value
Abrasives	184,941	$1,616,612	169,941	$1,605,147
Chemicals	----------	----------	15,452	147,386
Enamel	29,389	282,014	9,622	107,265
Filler	85,534	682,230	118,207	787,032
Foundry uses	131,828	1,270,084	167,166	1,211,069
Glass	21,513	204,555	40,642	365,339
Pottery, porcelain, and tile	156,541	1,590,223	186,109	1,794,288
Unspecified	163,592	1,603,202	222,878	1,989,389
Total	773,338	7,248,920	930,017	8,006,915

[1] Arkansas, California, Georgia, Illinois, Louisiana, Massachusetts, Michigan, Minnesota (1959 only), Missouri, New Jersey, Ohio, Oklahoma, Oregon (1959 only), Pennsylvania, Texas (1959 only), Virginia (1959 only), Washington (1959 only), West Virginia, and Wisconsin.

---

[16] Utley, Harry F., Output of New 500–T.P.H. Gravel Plant Used Entirely in Products: Pit and Quarry, vol. 52, No. 2, August 1959, pp. 70–73.

[17] News of Industry, Compact Sand and Gravel Plant in the Catskills: Vol. 4, No. 4, Winter 1960, pp. 3–5.

[18] Tobin, Kenneth A., Ready Mix Production for 1958: Concrete, vol. 67, No. 8, August 1959, pp. 22–29.

[19] Chemical Engineering, Sand Broadens Thermal Cracking Range: Vol. 66, No. 17, Aug. 24, 1959, pp. 66, 68.

Chemical Trade Journal and Chemical Engineer (London), Ethylene by Sand Cracking: Vol. 145, No. 3764, July 24, 1959, p. 8.

There were increased applications for many specially prepared silicas. Some of the more important uses included reinforcing natural rubber, settling high-density pigments in paints, increasing viscosity in polyester resins, preventing DDT from caking, and giving antislip properties and a higher gloss to floor wax.

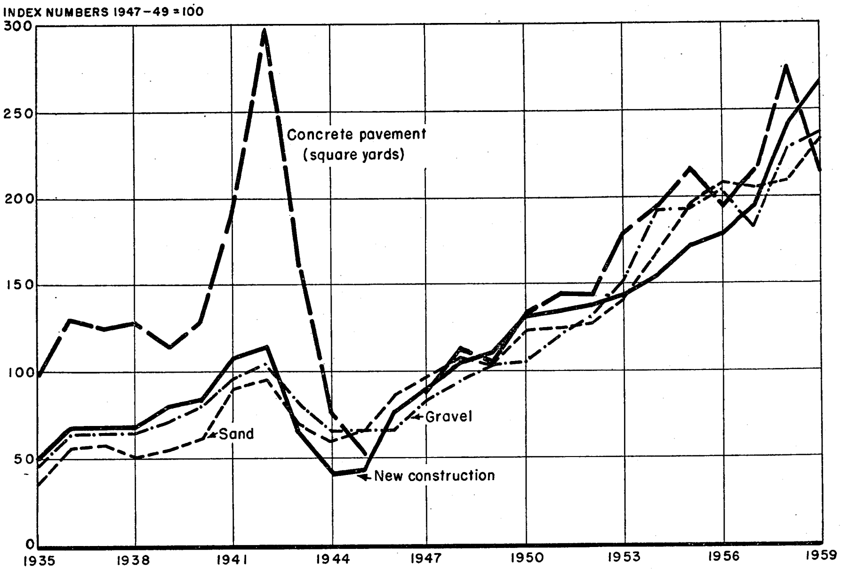

FIGURE 3.—Quantity of sand and gravel produced compared with value of total new construction, adjusted to 1947–49 prices, and total square yards of concrete pavements contracted for in the United States, 1935–59. (Data on construction from Construction Review and on pavements from Survey of Current Business.)

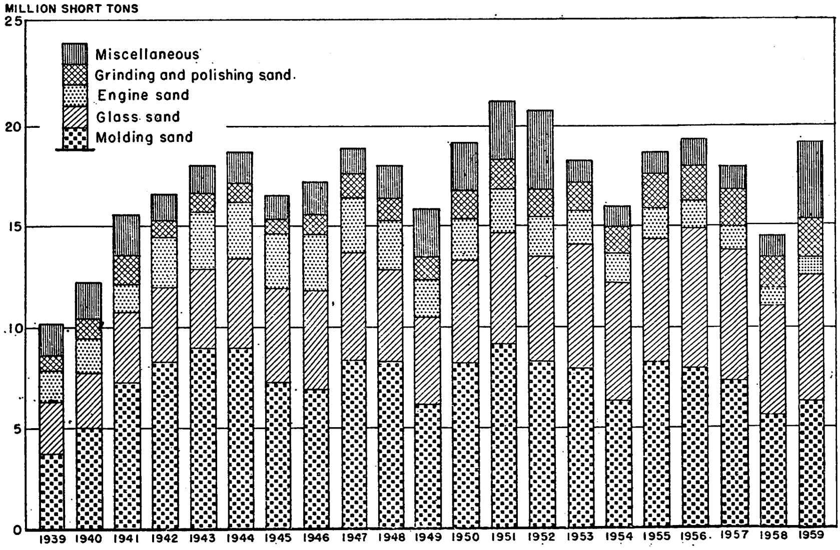

FIGURE 4.—Production of industrial sands in the United States, 1939–59.

PRICES

Average value of the total output of sand and gravel at producer plants, from both commercial and Government-and-contractor operations, was $1 per short ton, up from the 1958 price of $0.95. Unit value per ton for commercial operations was $1.12, compared with $0.67 per ton for Government-and-contractor operations. The ability of the contractors to produce their own aggregates and the use of portable plants and marginal deposits were contributing factors in maintaining stable prices.

Prepared sand and gravel and industrial sands commanded higher prices, dependent upon availability and market conditions and the amount of processing involved.

According to the U.S. Department of Commerce, average wholesale prices of sand and gravel from selected operations for December 1959 were $1.345 and $1.623, respectively, per short ton. These prices were only slightly higher than comparable December 1958 prices.

FOREIGN TRADE[20]

In 1959, foreign trade in sand and gravel comprised only a small part of the industry. Although small quantities of sand and gravel were exported to over 30 countries for specialized applications such as oil-well fracturing, shipments of ordinary sand and gravel were confined mainly to operations along the Canadian and Mexican borders. Some synthetically prepared silica continued to be imported from West Germany. Special sands were imported from Canada, United Kingdom, Australia, France, Norway, and Venezuela.

TABLE 12.—Sand and gravel imported for consumption in the United States, by classes

[Bureau of the Census]

Year	Sand				Gravel		Total	
	Glass sand[1]		Sand, n.s.p.f. crude or manufactured					
	Short tons	Value[2]	Short tons	Value	Short tons	Value	Short tons	Value
1950–54 (average)	7,097	$69,669	298,866	[3]$311,197	97,918	[3]$17,071	403,881	[3]$397,937
1955	170	171,973	317,947	[3]384,637	1,680	[3]100	319,797	[3]556,710
1956	478	393,476	332,031	[3]454,477	179	[3]405	332,688	[3]848,358
1957	683	621,065	290,280	[3]437,114	14,877	[3]21,951	305,840	[3]1,080,130
1958	6,516	223,817	317,860	485,553	7,619	7,125	331,995	716,495
1959	101	91,414	348,331	463,589	102,878	92,967	451,310	647,970

[1] Classification reads: "Sand containing 95 percent or more silica and not more than 0.6 percent oxide of iron and suitable for manufacturing glass."

[2] Consists mainly of synthetically prepared silica from West Germany for specialized uses and is not comparable in value to ordinary glass sand.

[3] Data known to be not comparable with other years.

---

[20] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

WORLD REVIEW

Canada.—The production of natural sand and gravel reached a total of 160 million short tons valued at $96 million in 1958. The 1959 estimated output was about 178 million tons valued at approximately $100 million dollars.[21]

A review of the industrial minerals of Saskatchewan was published. Extensive deposits of silica sand, suitable for manufacturing glass, were found, although their remoteness from industrial centers presented both economic and transportation problems.[22]

TECHNOLOGY

Technologic improvements in operating methods and equipment and the development and application of new processing techniques enabled many operators to meet the rigid specifications established for many sand and gravel products.

General.—The electrical resistivity method of geophysical surveying proved to be rapid and economical means of obtaining subsurface information and successfully indicating possible sand and gravel deposits. It was reportedly a valuable aid in outlining deposits in glacial drift.[23]

Research has determined that the varying characteristics of sand, in addition to size grading, can materially affect the quality of products made from it.[24]

Estimating the volume of sand and gravel stockpiles by aerial surveying and electronic computation was accomplished more rapidly and accurately than by ground surveying at an Ohio plant.[25]

A new stationary sand and gravel plant in Ohio stressed flexibility in design to facilitate adjustment to the deposit and to allow for future variations in the deposits and in materials specifications. The entire plant operated from a central control room.[26]

A report published by the Bureau of Mines described the mining and processing of a friable silica sandstone at the Simplot Silica Products, Inc., property in southern Nevada.[27]

Mining, transportation, and beneficiating methods at an English sand property were detailed. Shovel excavation, multiple conveyor-belt transportation, screening, washing, and cyclone separation, produced a high-grade silica sand for industrial use.[28]

---

[21] Canadian Mining and Metallurgical Bulletin, vol. 53, No. 573, January 1960, p. 2.

[22] Carlson, E. Y., A Review of the Industrial Minerals of Saskatchewan: Canadian Min. and Met. Bull., vol. 52, No. 564, April 1959, pp. 267–268.

[23] Johnson, Robert B., Resistivity Survey—A Good Bet in Preliminary Searches For Deposits: Rock Products, vol. 62, No. 3, March 1959, pp. 82–85.

Barnes, Howard E., Earth Resistivity for Sand and Gravel Prospecting: Pit and Quarry, vol. 51, No. 11, May 1959, pp. 92–96.

[24] Connor, Clyde C., Sand Takes on New Importance: Rock Products, vol. 62, No. 10, October 1959, pp. 128, 130, 132.

[25] Pohlman, W. E., and Jacoby, Howard, New Stockpile Measuring Method: Pit and Quarry, vol. 51, No. 10, April 1959, pp. 88–91.

[26] Trauffer, Walter E., Arrow's New Gravel Plant Eliminates Objectionable Features of Operation it Replaces: Pit and Quarry, vol. 52, No. 4, October 1959, pp. 128–131.

[27] Smith, M. Clair, Mining and Processing Silica Sands at Overton, Nev., by Simplot Silica Products, Inc.: Bureau of Mines Inf. Circ. 7897, 1959, 12 pp.

[28] Lamming, C. K. G., The Rock Common Sand Pit: Mine and Quarry Eng. (London), vol. 25, No. 11, November 1959, pp. 486–491.

A California sand producer developed a rapid method for obtaining a rough estimate of the alumina content in sand. A grab sample taken during processing was analyzed in about 10 minutes.[29]

A comprehensive article discussed the problem of sand segregation, its effect on foundry sand practice and casting quality, and recommended methods of correction.[30]

Dredging.—Dredging and processing methods at a New Jersey silica-sand deposit were described. Hydraulic dredging, transportation of dredged material through an 8-inch pipeline, and a novel screening and classifying plant produced high-purity sands.[31]

A 500-ton-per-hour bucket-ladder dredge, equipped with a dense-medium plant, impact crusher, and scrubber, operated along the Ohio River and produced sand and three grades of gravel. Four barges were loaded simultaneously from the dredge.[32]

Plant Equipment.—Use of a track-cable dragline scraper at an Ohio property produced sand and gravel from a pit 40 feet below water level at an overall cost of less than 8 cents per yard.[33]

Advances in electrical controls for modern sand-and-gravel producing equipment resulted in steadily increased output. Their application to portable and semistationary plants was described.[34]

An Illinois sand and gravel plant of 500,000 tons annual capacity incorporated several novel features in plant design, including an unusual radial stacker, water-reclaim arrangement, centralized push-button control stations, and a reclaim tunnel for quick low-cost rehandling of stacked material.[35]

Use of a side-dump bucket on a front-end loader demonstrated an operating advantage for rapid loading within a confined space. Applications considered suitable for side-dump buckets included handling and sand and gravel and other loose materials.[36]

Motorized head pulleys used on belt conveyors at a southern California semiportable crushing and screening plant eliminated many conventional conveyor accessories and cut maintenance time and costs. The drive motor and gear-reduction unit are inside the pulley, permitting conveyor galleries to be disassembled in lengths to suit highway requirements and to be easily loaded by crane.[37]

A New York operator overcame problems encountered by the depletion of more accessible deposits and the tightening of product specifications by combining bank and dredge production and by adding to its processing section a screen, crusher, gravel jig, sand cones, and a dewatering cone. This expansion and improvement program nearly

---

[29] Utley, Harry F., Quick Method For Estimating Alumina in Silica Sands: Pit and Quarry, vol. 52, No. 3, September 1959, pp. 105–106.

[30] Seaton, T. W., Sand Segregation, Causes and Effects: Foundry, vol. 87, No. 11, November 1959, pp. 86–89.

[31] Trauffer, Walter E., Silica Sand Overburden on Clay Deposit Processed for Industrial Uses by Manufacturer of Clay Brick, Lightweight Aggregates: Pit and Quarry, vol. 51, No. 8, February 1959, pp. 100–102.

[32] Rock Products, Dravo Launches 500-TPH. Ohio River Dredge: Vol. 62, No. 7, July 1959, p. 30.

[33] Rock Products, Sauerman Dragscraper Digs and Hauls from Pit to Hopper for 8 Cents Per Yard: Vol. 62, No. 12, December 1958, p. 4.

[34] Hoch, William T., Here's a Formula For More Profits: Rock Products, vol. 62, No. 7, July 1959, pp. 84–86.

[35] Godfrey, Kneeland A., Jr., Radial Stacker: Key to Two-In-One Aggregate Plant: Rock Products, vol. 62, No. 4, April 1959, pp. 90–93.

[36] Roads and Streets, Tips on Side-Dump Bucket Work: Vol. 102, No. 12, December 1959, pp. 102–103.

[37] Rock Products, Motorized Head Pulleys Prove Profitable: Vol. 62, No. 5, May 1959, pp. 152–154.

doubled the capacity of the plant and made possible a wider range of better grade products.[38]

Processing Equipment.—A series of well-illustrated articles on the theory and application of various types of classification equipment, originally developed for mineral processing and now used in fine aggregate production, were detailed.[39]

A 300-tons-per-hour rising-current classifier at a Kentucky plant effectively removed coal and debris from gravel deposits along the bottom of the Ohio River. Its use eliminated a picking belt, reduced manpower requirements, and allowed utilization of gravel deposits formerly considered unsuitable.[40]

A free-settling classifying tank, with automatic controls, that separates sands into desired size gradations and removes excess water was announced.[41]

A California operator removed cohesive clay with log washers and wet vibrating screens. Rapidly rotating paddles mixed and scoured the aggregate.[42] The flowsheet at another California sand and gravel plant was designed to effectively remove varying quantities of clay from sand and both crushed and uncrushed gravel.[43]

A western operator prevented blinding on a wet, fine screen and kept screening efficiency high by installing a set of chains along the length of the screen.[44]

An innovation in aggregate screening was a high-capacity screen that utilized harmonic principles with reaction springs storing potential energy to improve vibration. A small vibrator (exciter) reportedly powered the unit.[45]

Dense-Medium Plants.—A comprehensive evaluation of dense media as applied to aggregate beneficiation was published.[46] Beneficiation by dense media eliminated deleterious material and yielded a gravel product that met State Highway specifications in Michigan.[47] Eliminating chert, shale, and other soft particles from concrete aggregate by this method also made it possible to conform with new Ohio State Highway specifications. Compressive strength of concrete test cylinders made with the improved gravel averaged 12 percent higher than those made with untreated gravel.[48] Aggregate material for the Glen Canyon dam containing soft stone, shale, sandstone, and some clay was processed in a dense-medium separation plant, which removed deleterious types of rock and produced both sand and gravel fractions.

---

[38] Trauffer, Walter E., New York Sand-Gravel Solves Problems With Producer: Pit and Quarry, vol. 52, No. 6, December 1959, pp. 112–114, 116.

[39] Golson, C. E., Modern Classification Methods Applied to Fine Aggregates: Pit and Quarry, vol. 52, No. 2, August 1959, pp. 95–99, 114, 118; vol. 52, No. 3, September 1959, pp. 89–96; vol. 52, No. 4, October 1959, pp. 105–106, 110–111, 113–114, 116, 118.

[40] Godfrey, Kneeland A., Jr., New Classifier Cuts Labor, Shipping Costs: Rock Products, vol. 62, No. 9, September 1959, pp. 124, 125, 127, 128, 130.

[41] Pit and Quarry, New Machinery and Equipment: Vol. 51, No. 10, April 1959, p. 51.

[42] Lenhart, Walter B., Ingenuity Makes C & J a Leader: Rock Products, vol. 62, No. 6, June 1959, pp. 96–98.

[43] Lenhart, Walter B., Is Clay In Pit Run Your Problem? Rock Products, vol. 62, No. 2, February 1959, pp. 114–118.

[44] Rock Products, Fine Screening Wet Material Is Back Again: Vol. 62, No. 7, July 1959, p. 64.

[45] Rock Products, Gravel, Cement Plants in Far West Register Important Advances in Processing Techniques: Vol. 51, No. 7, January 1959, pp. 128–130.

[46] Haw, V. A., Heavy Media Separation in Aggregate Beneficiation: Mines Branch Tech. Bull. TB–5, Department of Mines and Tech. Surveys, Ottawa, Canada, September 1959. 28 pp.

[47] Godfrey, Kneeland A., Jr., Media-Treated Gravel Wins New Markets: Rock Products, vol. 62, No. 8, August 1959, pp. 77–79.

[48] Godfrey, Kneeland A., Jr., HMS System Opens Doors to New Business: Rock Products, vol. 62, No. 12, December 1959, p. 83.

Equipment, types of media used, and a flowsheet of the plant were described.[49]

Portable Plants.—A portable loading and screening plant, consisting of a vibrating screen, belt conveyor, reciprocating feeder, hopper, and gasoline engine, was mounted on the conveyor truss. The various components were hydraulically positioned so that crushed material was conveyed to the vibrating screen set at an angle over the truck.[50]

Wider application of portable plants continued; for example, a Northern California aggregate producer pioneered the use of a portable crushing and screening plant in that section of the State. It operated in a 150-mile radius outside the economic truck-hauling limits of stationary plants.[51] An Ohio contractor produced aggregate for an Interstate highway project by using portable washing and crushing plants, working in tandem and powered by a portable 190 h.p. diesel powerplant, to make 200 tons per hour of road base material.[52]

Vertical Sand Drains.—The vertical sand-drain method is often the most economical way to stabilize soft, marshy ground where the depth is 10 to 100 feet or more. Vertical sand drains are columns of sand or other granular material placed on a grid spacing over the foundation area. Compression of the ground forces water along horizontal bedding planes into and upward through the sand drains.[53] The application of this method at interchange fills and other embankments along a Utah State highway was described.[54]

Patents.—A design was patented for a skip or bucket having a classifying grid therein and adapted to receive dump loads of unclassified sand and gravel. In one motion the skip elevates, classifies, and feeds the coarse material to a crusher inlet and the fine material to a bypass inlet.[55]

According to a patent, magnetic particles can be removed from silica sand by allowing a spherical magnetized device to float in the pulp until enough magnetized material has been collected to cause the device to sink. It is then removed and cleaned by being demagnetized.[56]

A method of purifying silica sand by removing the ferruginous coating from individual grains of sand rendered it suitable for use in manufacturing colorless glass.[57]

Glass.—The first window, sheet, and plate glass plant in the Philippine Islands was to produce about 17,600 short tons a year and make the Philippines completely self-sufficient in flat glass.[58]

---

[49] Lenhart, Walter B., HMS for Sand Pioneered at Glen Canyon: Rock Products, vol. 62, No. 5, May 1959, pp. 134–135, 140–141.

[50] Engineering News-Record, Plant Screens as It Loads: Vol. 162, No. 24, June 18, 1959, p. 141.

[51] Rock Products, Portable Plant Invades, Succeeds, in Stationary Plant Area: Vol. 62, No. 3, March 1959, pp. 92–94, 118.

[52] Rock Products, Portables Prove Worth on Interstate Job: Vol. 62, No. 8, August 1959, pp. 124–126, 128.

[53] Roads and Streets, Why Vertical Sand Drains? How They Work, and How They Are Commonly Installed: Vol. 102, No. 9, September 1959, p. 63.

[54] Roads and Streets, Utah Interstate Project Puts Contractor in "Sand Drain" Business: Vol. 102, No. 9, September 1959, pp. 59–63.

[55] Robbins, F. P., Classifying Device: U.S. Patent 2,919,804, Jan. 5, 1960.

[56] McNaught, R. P., Metallic Ore-Collecting Member With a Plurality of Magnetized Surface Areas: U.S. Patent 2,918,170, Dec. 22, 1959.

[57] Adams, Frederick William, Ealing (London), (assigned to Rockware Glass Limited, Greenford, England, a British Company), Purification of Silica Sands: U.S. Patent 2,891,844, June 23, 1959.

[58] Ceramic Industry, To Open First Flat Glass Plant in Philippines: Vol. 73, No. 2, August 1959, p. 35.

A new line of industrial glass pipe manufactured from borosilicate glass reportedly possessed excellent chemical and corrosion- and heat-resistant properties; clear-view transparency; and a high degree of ruggedness.[59]

Production of pressed-glass blocks in a variety of sizes and colors by a Pennsylvania manufacturer was described. Features included ingenious weighing devices, close color and quality control, and plant automation.[60]

Foundry.—Factors and experiments relating to new molding and coremaking applications for the sodium silicate-CO_2 process were discussed. Proper selection of sands and other materials and processing techniques are necessary in high quality castings production.[61] Results in field tests of a new molding-sand binder, used in combination with oil in nonferrous foundry practice, were described.[62] The type and character of molding sands for the production of steel castings also were reviewed.[63]

Special Silicas.—The development of seven improved and new fluorosilicones for the rubber industry was outlined.[64]

An article disclosed a new process of fusing, quenching, and reforming silica for use as missile and rocket nose cones. The process may become an inexpensive method of forming intricate parts having strength to withstand temperature extremes in space application.[65]

Silica flour was produced by the Johns-Manville Co. from a pure white, high-silica, gold-bearing California quartz tailing. Desliming and flotation removed deleterious materials and produced a high-grade silica sand. A gas-fired dryer, ball mill, and superfine air separator were the principal components of the grinding plant.[66]

The vapor-phase production of colloidal silica at a 3-million pound annual capacity plant in Illinois was described. A greatly increased use for this product was forecast.[67]

New forming and bonding techniques produced fused silica shapes with good thermal shock resistance, which could be heated to 2,000° F. and rapidly cooled to room temperature without cracking. Potential uses included permanent molds for iron, steel, and other metals; one-piece furnace hearths, self-supporting sides, roofs, and removable ends for furnaces and kilns; nose cones for missiles and rockets; fixtures and containers for use in furnaces; burner rings, ladles, and crucibles for induction melting; and piping for molten metals.[68]

---

[59] Ceramic Industry, Kimble Launches Line of Industrial Glass Pipe: Vol. 73, No. 2, August 1959, p. 36.

[60] Vincent, George L., How Pittsburgh Corning Makes Improved Glass Block: Ceram. Ind., vol. 73, No. 2, August 1959, pp. 56–59.

[61] Morey, R. E., and Lange, E. A., Factors Affecting Sodium Silicate-Bonded Sands: Foundry, vol. 87, No. 4, April 1959, pp. 188–190, 193, 196, 198.

[62] Foundry, New Molding Sand Binder Used in Combination With Oil: Vol. 87, No. 10, October 1959, pp. 118, 120.

[63] Chappie, Hubert, Molding and Pouring Large Steel Castings: Foundry, vol. 87. No. 5. May 1959, pp. 96–99.

[64] Chemical and Engineering News, Seven Silicones Hit Market: Vol. 37, No. 27, July 6, 1959, pp. 46–47.

[65] Rock Products, Fused Silica Nose Cones For Missiles and Rockets: Vol. 62, No. 7, July 1959, p. 10.

[66] Rock Products, J–M Forges Ahead in Silica: Vol. 62, No. 8, August 1959, pp. 80–81.

[67] White, Laurence J., Duffy, George J., and Cabot, Godfrey L., Vapor-Phase Production of Colloidal Silica: Ind. Eng. Chem., vol. 51, No. 3, Pt. 1, March 1959, pp. 232–238.

[68] Materials in Design Engineering, Fused Silica Shapes Have Good Thermal Shock Resistance: Vol. 49, No. 6, June 1959, pp. 115–116.

A method for producing "cellulated silica" was patented. The cellulated silica reportedly was characterized by a multiplicity of uniform closed cells produced by heating silica in the presence of a carbonaceous material.[69]

---

[69] Ford, Walter D. (assigned to Pittsburgh Corning Corp., Allegheny County, Pa., a corporation of Pennsylvania), Cellulated Silica and the Production Thereof: U.S. Patent 2,890,126, Apr. 11, 1957.

Secondary Metals—Nonferrous

By Archie J. McDermid[1] [2]

⁂

RECOVERIES of all nonferrous metals from scrap increased in the United States in 1959. The production total, however, was affected by strikes, especially against primary copper producers. About a dozen primary plants used copper scrap as an addition to ore, concentrates, and in-process metal, and some operated secondary plants which also were closed by the strike. There were also shorter and less widespread strikes against other secondary plants. As a result, total copper-scrap consumption decreased from 117,000 tons in April to 79,000 tons in July. Much of the increase in February, March, and April was attributed to preparation for the strike. Monthly consumption of scrap varied greatly in the latter half of the year, but the trend was upward.

TABLE 1.—Salient statistics of nonferrous secondary metals recovered from scrap processed in the United States

Metal	From new scrap		From old scrap		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1958						
Aluminum	225, 428	$111, 407	64, 127	$31, 692	289, 555	$143, 099
Antimony	2, 675	1, 699	16, 840	10, 697	19, 515	12, 396
Copper	386, 021	203, 047	411, 367	216, 379	797, 388	419, 426
Lead	58, 518	13, 693	343, 269	80, 325	401, 787	94, 018
Magnesium	3, 933	2, 773	4, 774	3, 366	8, 707	6, 139
Nickel	3, 323	5, 216	4, 088	6, 417	7, 411	11, 633
Tin	10, 334	19, 654	15, 205	28, 917	25, 539	48, 571
Zinc	160, 406	32, 723	69, 926	14, 265	230, 332	46, 988
Total	----------	390, 212	----------	392, 058	----------	782, 270
1959						
Aluminum	[1] 281, 921	137, 916	[1] 78, 006	38, 160	[1] 359, 927	176, 076
Antimony	2, 655	1, 662	17, 388	10, 885	20, 043	12, 547
Copper	459, 563	282, 172	471, 007	289, 198	930, 570	571, 370
Lead	58, 625	13, 484	392, 762	90, 335	451, 387	103, 819
Magnesium	[1] 5, 180	3, 652	[1] 4, 973	3, 506	[1] 10, 153	7, 158
Nickel	4, 228	6, 652	5, 210	8, 196	9, 438	14, 848
Tin	11, 136	22, 720	15, 080	30, 767	26, 216	53, 487
Zinc	202, 406	46, 553	73, 848	16, 985	276, 254	63, 538
Total	----------	514, 811	----------	488, 032	----------	1, 002, 843

[1] Final figure. Supersedes figure given in commodity chapter.

---

[1] Commodity specialist.

[2] The assistance of Ivy C. Roberts, statistical assistant, is acknowledged.

Variations in consumption at aluminum, lead, and zinc scrap plants were smaller than at copper-scrap plants and reflected general industrial conditions more closely. After declining from 53,000 tons in January, the highest monthly consumption of the year, to 43,000 tons in March, lead-scrap consumption trended upward for the remainder of the year. As usual consumption for battery plates was the largest item, comprising 62 percent of the total. The quantity consumed was in proportion to the number of miles driven by automobiles, the source of most of the scrapped batteries smelted during the year.

TABLE 2.—Scrap consumption, by months, in short tons

Month	Aluminum		Copper		Lead		Zinc	
	1958	1959	1958	1959	1958	1959	1958	1959
January	35, 367	36, 295	85, 491	90, 086	46, 726	52, 964	14, 821	16, 862
February	27, 689	35, 731	75, 246	95, 289	42, 778	50, 081	11, 617	16, 363
March	30, 025	38, 681	74, 180	103, 797	37, 542	42, 883	12, 553	17, 290
April	29, 104	42, 031	83, 336	117, 295	41, 429	46, 008	13, 130	18, 841
May	27, 394	40, 568	78, 065	104, 634	41, 236	46, 297	12, 783	18, 749
June	25, 042	42, 278	75, 420	101, 170	39, 187	45, 657	12, 425	18, 607
July	25, 054	38, 090	59, 384	79, 442	34, 459	45, 184	13, 116	16, 232
August	27, 608	37, 358	73, 803	80, 574	36, 869	46, 046	14, 709	14, 931
September	30, 867	38, 199	76, 778	96, 043	42, 760	46, 307	16, 163	15, 874
October	40, 207	40, 076	93, 086	94, 342	50, 735	50, 728	16, 968	14, 275
November	32, 873	33, 923	97, 986	82, 432	46, 238	47, 125	15, 082	14, 910
December	38, 272	36, 871	100, 374	97, 001	47, 862	50, 099	15, 658	14, 611
Total	369, 502	460, 101	973, 149	1, 142, 105	507, 821	569, 379	169, 025	197, 545

Consumption of aluminum scrap apparently was affected less by strikes than by competition with primary aluminum. Consumption increased in the first half of 1959, then declined, as supply of primary metal rapidly increased. However, the ratio of reported aluminum-scrap consumption to primary aluminum production was the same in both 1958 and 1959, about 1 to 4.

An upward trend in consumption of zinc scrap, which began in the middle of 1958, continued to the middle of 1959, after which consumption decreased slightly. During the latter half of 1959, use of slab zinc in galvanizing (source of galvanizers' dross, sal skimmings, and dry skimmings) also declined because of the shortage of sheet steel to be coated.

TABLE 3.—Secondary metals recovered as unalloyed metal in alloys and in chemical compounds in the United States, in short tons

Metal	1950–54 (average)	1955	1956	1957	1958	1959
Aluminum	300, 281	335, 994	339, 768	361, 819	289, 555	[1] 359, 927
Antimony	22, 722	23, 702	24, 106	22, 565	19, 515	20, 043
Copper	922, 218	989, 004	930, 664	841, 887	797, 388	930, 570
Lead	487, 868	502, 051	506, 755	489, 229	401, 787	451, 387
Magnesium	10, 532	10, 246	10, 529	10, 658	[2] 8, 707	[1] 10, 153
Nickel	8, 367	11, 540	14, 860	12, 037	7, 411	9, 438
Tin	32, 485	31, 743	32, 973	27, 174	25, 539	26, 216
Zinc	303, 456	304, 775	281, 355	264, 104	230, 332	276, 254

[1] Final figure. Supersedes figure given in commodity chapter.
[2] Revised figure.

TABLE 4.—Number and classification of plants in the United States reporting consumption of nonferrous scrap metals, refined copper, and copper-alloy ingot in 1959[1]

Kind of plant	Type of material used			
	Aluminum	Copper	Lead and tin	Zinc
Primary producers	40	12	4	
Secondary smelters	110	72	239	[2] 52
Primary distillers				5
Chemical plants	11	42		16
Brass mills		61		
Wire mills		19		
Foundries and miscellaneous manufacturers	[3] 78	1,699	70	41

[1] Plants indicated in each column used material of the metal heading the column in products of that base; for example, 72 secondary smelters used copper materials in copper-base products.
[2] Includes 14 secondary distillers.
[3] Excludes aluminum foundries not consuming aluminum scrap.

Figure 1 indicates that consumption of copper scrap trended downward in the 10-year period shown and that of aluminum scrap upward. Apparently, consumption of copper scrap had the greatest annual variations. However, the relative percentage of variation, deter-

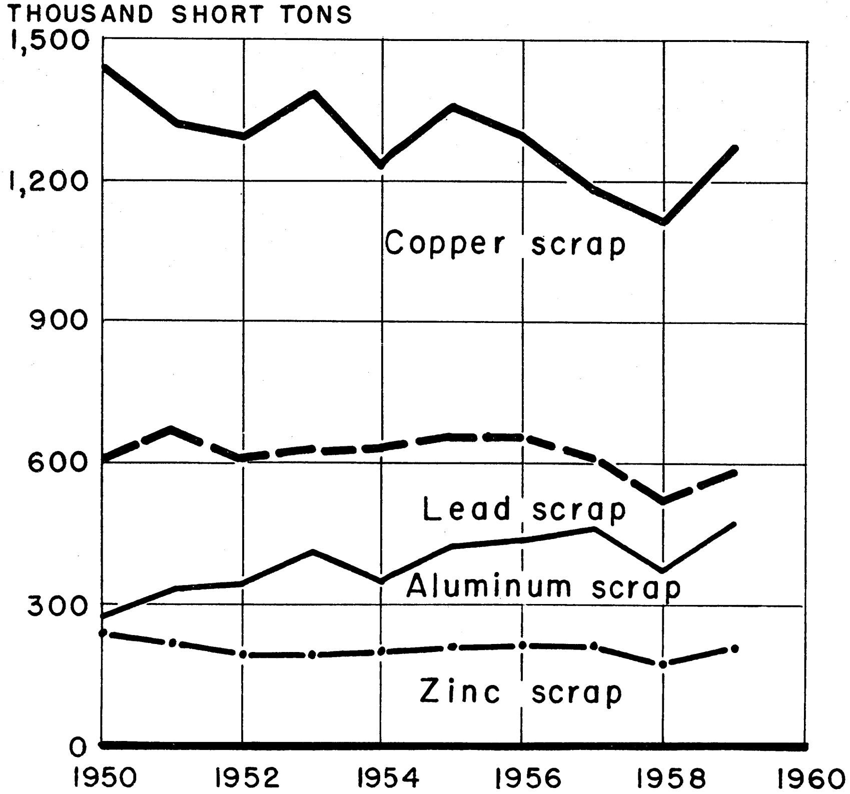

FIGURE 1.—Aluminum, copper, lead, and zinc annual scrap consumption, in thousand short tons, 1950–59.

mined by dividing the total annual changes by the total scrap consumption for each metal, was 5.9 percent for lead, 7.1 percent for zinc, 7.2 percent for copper, and 12.8 percent for aluminum.

PRICES

Except for aluminum scrap, prices of nonferrous scrap to consumers varied in 1959 with changes in the market prices of the respective primary metals. Primary producers stabilized the price of primary aluminum pig at 24.70 cents per pound until December when it was raised to 25.26 cents. Aluminum clippings in the New York market were quoted at 13.25 cents a pound in the first 4 months of 1959. The price then rose until it reached 15.25 cents in August where it remained for the rest of the year. No. 1 composition copper scrap and electrolytic refined copper were quoted at 17 and 29 cents a pound, respectively, at the beginning of 1959, rose to 20 and 31.5 cents in March, then declined to 18 and 30 cents in July. Copper scrap then rose to 19 cents in November. The price of electrolytic copper was nominally 33 cents a pound most of the final quarter of the year. The price of pig lead was 12 cents a pound at the beginning and end of the year but reached 13 cents in August, September, and October. The price of heavy lead scrap was about 4 cents less than that of pig lead.

TECHNOLOGY

Battery-lead-plate scrap is consumed in the United States in greater quantity than any other nonferrous scrap item. Most battery-lead-plate scrap is smelted in blast furnaces, then refined in kettles or in blast furnaces operated in conjunction with reverberatory furnaces and kettles. Although a blast furnace is virtually indispensable in this type of smelting, it is uneconomical to operate it on less than a 24-hour-a-day basis. Plants have therefore developed flowsheets in which the furnace is used periodically when slags have accumulated.

As supplementary equipment, a rotary steel tube for sweating plate scrap has been constructed by Eastern Smelting and Refining Company at its Los Angeles plant. (See fig. 2.) The tube is made of ¾-inch steel, is 20 feet long and 2 feet 6 inches in diameter, and is mounted on rollers with the discharge end about 1 foot lower than the charge end. A foot-long ring dam or collar, 42 inches in diameter at its larger end and 36 inches at its smaller end, is 3 feet above the lower end of the tube and tapers toward that end. Slots 1½ inches long, pointed at the ends, ¼ inch wide at the middle, and 4 inches apart are at right angles to the tube around the periphery of the collar in its larger end.

A 3-hp. motor rotates the tube at about 1 r.p.m. through a variable-speed gear mechanism and sprocket wheel connected by a drive chain to a sprocket wheel around the middle of the tube. The charge is heated by burners in each end of the tube and under the ring dam. Fuel is natural gas when available, otherwise oil, and costs about $1.50 per ton of feed scrap. Total cost of the equipment is between $6,000 and $7,000. The tube can be placed in full operation or emptied and

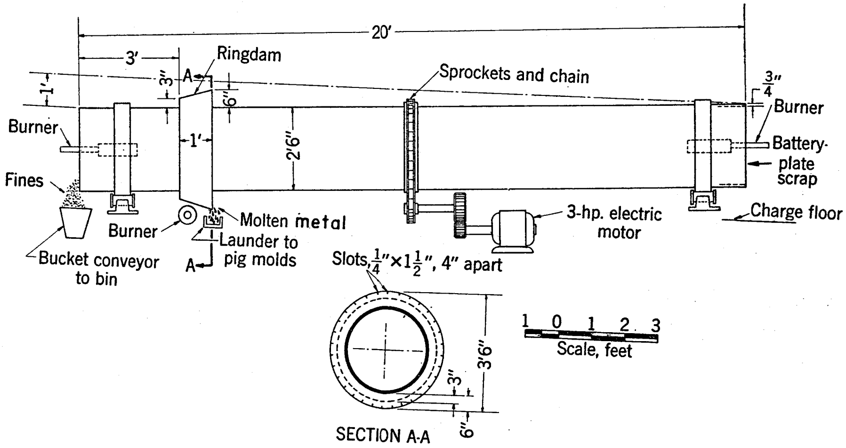

Figure 2.—Battery-plate scrap sweating tube.

shut down in 20 minutes. It is the result of 20 years of experiment and is operated whenever the plant is, except for 2-week periods when the blast furnace is in use.

The scrapped battery plates are hand shoveled into the upper end of the tube, connected together as they were when the battery casing was removed. In this form they are known as "groups." Mechanical charging has been attempted, but a satisfactory method has not been found. As the scrap gravitates down the tube the plates melt, moisture is vaporized, and some of the sulfur from the $PbSO_4$ on the plates is vaporized and burned with other flammable material such as wooden separators. In the collar, molten antimonial lead drains out through the slots into a launder, thence to pig molds. The pigs are refined in kettle or reverberatory furnaces. The fines, consisting mostly of black oxides of lead and antimony, glass from fiberglas separators, and wood ashes, work past the ring dam and are discharged to a bucket conveyor leading to a bin, from which they are sent to a reverberatory furnace. An advantage of this furnace over the blast furnace is that it may be kept in standby condition between charges if it is not allowed to cool. Matte formation is negligible because the sulfur burns off in the tube.

All battery-plate scrap is melted in the sweating furnace, except when the blast furnace is in use. The blast furnace is operated for 2-week periods, at 2- or 3-month intervals, whenever enough reverberatory furnace slag has accumulated; it is more suitable for smelting this material than any other furnace. Slag from the blast furnace, which contains about 1 percent of lead and antimony combined, is the only residue discarded in the lead-scrap operations. Generated smoke and fume is passed through a baghouse and the accumulated flue dust is returned to the reverberatory furnace. Flowsheet and recovery data are approximated in figure 3. Recovery is about 70 percent, and the recovered product is 95 percent lead and 5 percent antimony.

Some plants use tube type furnaces to burn off flammable material such as wood separators and to dry the plates without melting them.

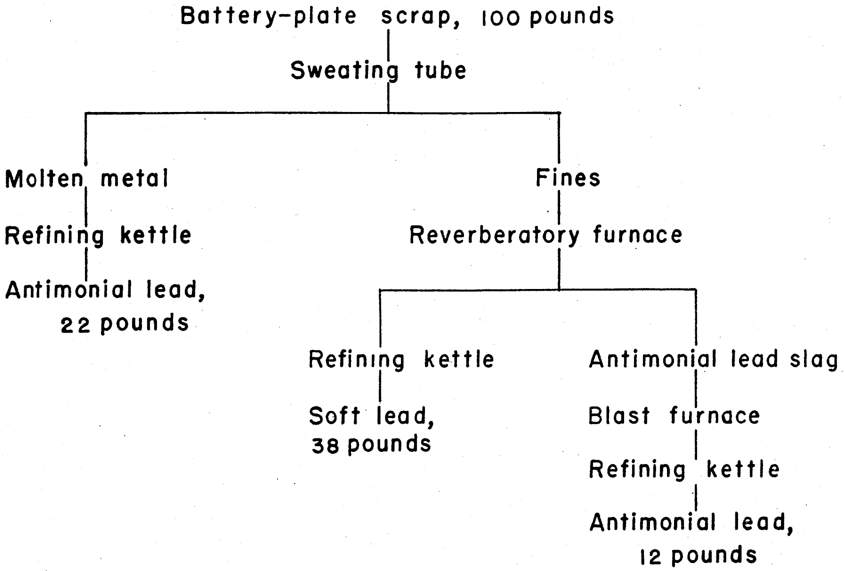

FIGURE 3.—Flowsheet for consumption of battery-plate scrap and resulting recovery.

Tubes are also used for sintering fines and flue dust and for drying aluminum turnings. Much of the equipment has been designed and constructed at the plants using it.

Silver

By J. P. Ryan[1] and Katheen M. McBreen[2]

◆

DOMESTIC production of silver dropped in 1959 for the third successive year, but consumption in the arts and industries and for coinage was substantially higher than in 1958. Mine output was 31.2 million ounces, about 3 million less than in 1958. Silver consumption—101 million ounces—represented a gain of 15.5 million over 1958. Silver imports decreased sharply; exports increased substantially. Reflecting sustained demand, the price trended steadily upward from a low 89⅞ cents an ounce at the beginning of the year to 91⅝ in August.

Free-silver stocks decreased 27.1 million ounces, when industrial consumers bought silver from the Treasury for the first time since 1957, and lend-lease returns continued to decline. Total Treasury stock declined 2 percent from the 1958 peak to 2,060 million ounces at yearend.

The upward trend in world production of silver during the preceding several years was reversed, and estimated total output dropped 9 percent to 217 million ounces, chiefly owing to reduced production

TABLE 1.—Salient silver statistics

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Mine production___thousand ounces__	39,238	37,198	38,721	38,165	34,111	31,194
Value__________________thousands__	$35,512	$33,666	$35,045	$34,541	$30,872	$28,232
Ore (dry and siliceous) produced (thousand short tons):						
Gold ore__________________________	2,595	2,234	2,255	2,359	2,411	2,289
Gold-silver ore____________________	233	120	245	116	107	137
Silver ore_________________________	571	570	687	712	639	597
Percentage derived from—						
Dry and siliceous ores____________	33	30	29	32	41	45
Base-metal ores__________________	67	70	71	68	59	55
Net consumption in industry and the arts_____________thousand ounces__	100,700	101,400	100,000	95,400	85,500	101,000
Imports [1]_______________________do____	87,397	84,519	162,832	206,119	165,966	69,088
Exports [1]_______________________do____	3,145	4,893	5,501	10,299	2,733	9,180
Treasury stocks (end of year) million ounces__	----------	1,930	1,981	2,014	2,106	2,060
Price, per troy ounce [2]_______________	$0.905+	$0.905+	$0.905+	$0.905+	$0.905+	$0.905+
World: Production_____thousand ounces__	210,900	224,000	[3]225,700	[3]230,800	[3]238,500	216,800

[1] Excludes coinage.
[2] Treasury buying price for newly mined silver.
[3] Revised figure.

---

[1] Commodity specialist.
[2] Statistical assistant.

in the United States. Free-world consumption in the arts and industries and for coinage was estimated at 296 million ounces, 18 percent more than in 1958; the United States continued to consume nearly half (including coinage).

A bill to repeal the existing silver-purchase laws, similar to those introduced in 1957, was introduced in the 86th Congress (H.R. 66). The bill was referred to the Committee on Ways and Means of the House, but no further action was taken.

DOMESTIC PRODUCTION

U.S. mine production of recoverable silver decreased 9 percent to 31.2 million ounces, chiefly because of strikes at major copper mines, smelters, and refineries, which cut off a large part of the silver output during the latter part of the year. The loss marked the third successive annual decline in silver production and dropped the United States from second to third place among silver-producing countries—surpassed by Mexico and Canada.

All leading silver-producing States, except Idaho, recorded lower production; the four leading States (Idaho, Arizona, Utah, and Montana) produced about 89 percent of the total. Except for Idaho silver ores, most of the domestic silver was recovered as a byproduct of ores mined chiefly for base metals or gold.

Only 4 of the 25 leading silver-producing mines depended chiefly on the value of silver in the ore; at the other 21 mines, copper, lead, zinc, or gold were the principal metals. The 7 leading mines, each of which produced over 1 million ounces of silver, supplied 59 percent of the domestic production; the 25 leading mines supplied 88 percent. Domestic mines supplied about 30 percent of requirements in the arts and industries.

According to preliminary data compiled by the Bureau of Mines, approximately 5,200 persons were employed in the silver and gold-silver mining industry in 1959 at 800 separate mining operations, both lode and placer.

TABLE 2.—Silver produced in the United States according to mine and mint returns, in troy ounces of recoverable metal

	1950–54 (average)	1955	1956	1957	1958	1959
Mine	39, 237, 699	37, 197, 742	38, 721, 364	38, 164, 915	34, 111, 027	31, 194, 098
Mint	39, 075, 319	36, 469, 610	38, 739, 400	38, 720, 200	36, 800, 000	23, 000, 000

TABLE 3.—Mine production of silver in the United States in 1959, by months

Month	Troy ounces	Month	Troy ounces
January	2, 901, 991	August	2, 393, 379
February	2, 948, 132	September	1, 857, 027
March	3, 018, 044	October	1, 990, 794
April	2, 999, 024	November	1, 917, 902
May	3, 090, 617	December	2, 118, 308
June	2, 970, 776		
July	2, 988, 104	Total	31, 194, 098

TABLE 4.—Twenty-five leading silver-producing mines in the United States in 1959, in order of output

Rank	Mine	District or region	State	Operator	Source of silver
1	Sunshine	Coeur d'Alene	Idaho	Sunshine Mining Co	Silver ore.
2	Galena	do	do	American Smelting & Refining Co	Do.
3	Bunker Hill	do	do	The Bunker Hill Co	Lead-zinc ore.
4	Utah Copper	West Mountain (Bingham)	Utah	Kennecott Copper Corp	Copper ore.
5	Butte Hill Zinc Mines	Summit Valley (Butte)	Montana	The Anaconda Co	Zinc ore.
6	Lucky Friday	Coeur d'Alene	Idaho	Lucky Friday Silver-Lead Mines, Inc	Lead ore.
7	United States & Lark	West Mountain (Bingham)	Utah	U.S. Smelting, Refining, & Mining Co	Gold-silver, lead, lead-zinc ores.
8	Silver Summit	Coeur d'Alene	Idaho	Polaris Mining Co	Silver ore.
9	Iron King	Big Bug	Arizona	Shattuck Denn Mining Corp	Lead-zinc ore.
10	Kelley	Summit Valley (Butte)	Montana	The Anaconda Co	Copper ore.
11	United Park City Mines	Uintah	Utah	United Park Mines Co	Lead-zinc, silver, lead ores.
12	Eagle	Red Cliff (Battle Mountain)	Colorado	The New Jersey Zinc Co	Copper, lead-zinc ores.
13	Treasury Tunnel-Black-Bear-Smuggler Union.	Upper San Miguel	do	Idarado Mining Co	Do.
14	Copper Queen-Lavender Pit	Warren	Arizona	Phelps Dodge Corp	Copper ore.
15	Butte Hill Copper Mines	Summit Valley (Butte)	Montana	The Anaconda Co	Do.
16	Knob Hill & Gold Dollar	Republic	Washington	Knob Hill Mines, Inc	Gold ore.
17	Crescent	Coeur d'Alene	Idaho	The Bunker Hill Co	Silver ore.
18	Page	do	do	American Smelting & Refining Co	Lead-zinc ore.
19	New Cornelia	Ajo	Arizona	Phelps Dodge Corp	Copper, gold-silver ores.
20	Berkeley Pit	Summit Valley (Butte)	Montana	The Anaconda Co	Copper ore.
21	Morenci	Copper Mountain	Arizona	Phelps Dodge Corp	Copper, gold-silver ores.
22	Magma	Pioneer	do	Magma Copper Co	Copper ore.
23	Star	Coeur d'Alene	Idaho	The Bunker Hill Co	Lead-zinc ore.
24	Pima	Pima	Arizona	Pima Mining Co	Copper ore.
25	San Manuel	Old Hat	do	San Manuel Copper Corp	Do.

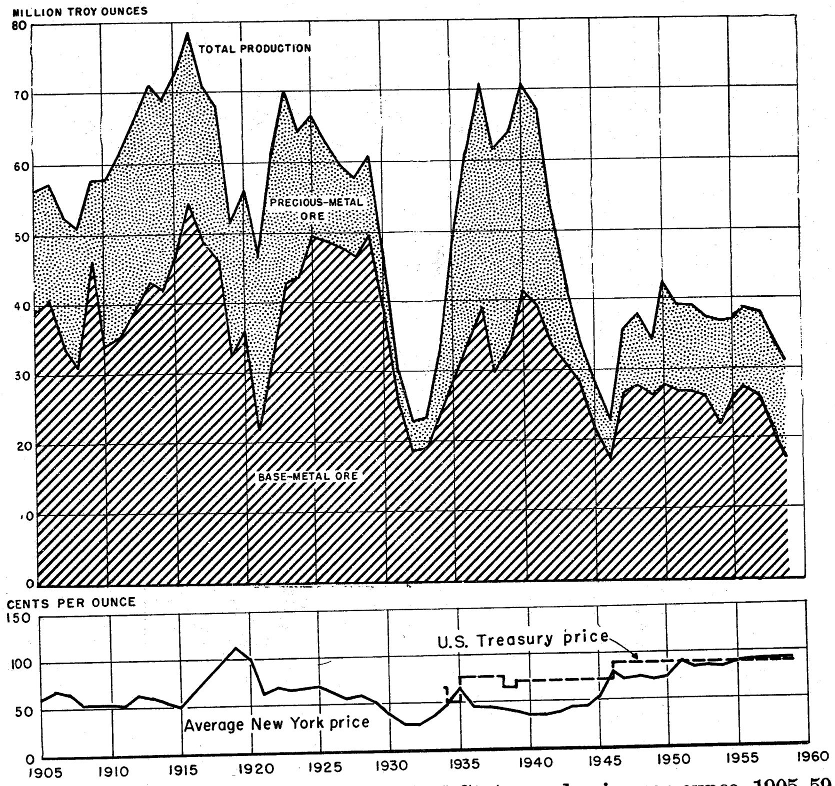

FIGURE 1.—Silver production in the United States and price per ounce, 1905–59.

TABLE 5.—Mine production of recoverable silver in the United States, by States, in troy ounces

State	1950–54 (average)	1955	1956	1957	1958	1959
Alaska	37,146	33,693	28,360	28,862	23,507	21,358
Arizona	4,759,599	4,634,179	5,179,185	5,279,323	4,684,580	3,898,336
California	932,548	954,181	938,139	522,288	188,260	172,902
Colorado	2,942,239	2,772,073	2,284,701	2,787,892	2,055,517	1,340,732
Idaho	15,255,672	13,831,458	13,471,916	15,067,420	15,952,796	16,636,486
Illinois	2,549	3,075	1,580	----------	----------	----------
Kentucky	----------	----------	31	56	99	75
Michigan	----------	478,000	379,990	430,000	----------	----------
Missouri	330,176	268,620	295,111	183,427	250,917	339,760
Montana	6,198,040	6,080,390	7,385,908	5,558,228	3,630,530	3,420,376
Nevada	943,470	845,397	993,716	958,477	932,728	611,135
New Mexico	315,122	251,072	392,967	309,385	158,758	158,925
New York	37,813	66,162	84,158	63,880	66,738	51,588
North Carolina	88	181	753	12,347	15,157	16,319
Oregon	10,083	8,815	13,542	15,924	2,728	242
Pennsylvania	9,754	10,379	(1)	(2)	(2)	(2)
South Dakota	140,761	154,092	136,118	134,737	152,995	124,425
Tennessee	50,436	66,619	64,878	54,407	44,592	59,739
Texas	1,721	126	----------	----------	----------	----------
Utah	6,898,727	6,250,565	6,572,041	6,198,464	5,277,693	3,734,297
Vermont	41,313	50,447	[1] 47,800	36,794	5,101	----------
Virginia	588	1,850	1,874	1,745	2,023	866
Washington	329,837	436,348	448,442	[2] 521,133	[2] 666,278	[2] 606,537
Wyoming	17	20	154	126	30	----------
Total	39,237,699	37,197,742	38,721,364	38,164,915	34,111,027	31,194,098

[1] Pennsylvania and Vermont combined.
[2] Pennsylvania and Washington combined.

TABLE 6.—Ore, old tailings, etc., yielding silver produced in the United States, and average recoverable content, in troy ounces of silver per ton in 1959 [1]

State	Gold ore		Gold-silver ore		Silver ore		Copper ore	
	Short tons	Average ounces of silver per ton	Short tons	Average ounces of silver per ton	Short tons	Average ounces of silver per ton	Short tons	Average ounces of silver per ton
Alaska	564	0.202	----------	----------	----------	----------	53	14.245
Arizona	11,758	.204	68,959	0.283	66,247	0.191	53,155,199	.051
California	138,599	.239	----------	----------	137	18.328	860	[2] 126.837
Colorado	71,443	.081	606	2.394	5,762	1.491	17,378	22.092
Idaho	1,133	2.456	33	9.697	435,760	28.659	379,563	.037
Montana	12,328	4.792	2,830	6.952	27,141	5.271	8,069,191	.203
Nevada	174,770	.028	47	5.128	57,792	5.412	8,547,263	.020
New Mexico	52	.231	25,543	3.225	529	8.125	4,593,458	.009
Oregon	356	.506	----------	----------	----------	----------	----------	----------
South Dakota	1,778,316	.070	----------	----------	----------	----------	----------	----------
Utah	----------	----------	38,877	.490	3,117	2.523	19,678,903	.091
Undistributed [3]	99,387	5.635	115	.339	23	116.696	235,196	.071
Total	2,288,706	.346	137,010	1.041	596,508	21.765	94,677,064	.073

State	Lead ore		Zinc ore		Zinc-lead, zinc-copper, and zinc-lead-copper ores		Total ore	
	Short tons	Average ounces of silver per ton	Short tons	Average ounces of silver per ton	Short tons	Average ounces of silver per ton	Short tons	Average ounces of silver per ton
Alaska	----------	----------	----------	----------	----------	----------	617	1.408
Arizona	4,087	6.851	16,139	0.109	442,446	[4] 2.504	53,764,835	.073
California	485	9.082	----------	----------	1,555	11.350	141,636	1.177
Colorado	13,204	4.925	67	5.776	660,863	1.324	769,323	1.742
Idaho	84,927	14.429	98,937	.505	833,352	3.427	1,833,705	9.073
Montana	17,560	2.571	648,214	2.333	[5] 1,438	[5] 1.944	8,778,702	.390
Nevada	6,713	9.118	----------	----------	1,034	20.412	8,787,619	.065
New Mexico	7,723	1.986	60,594	.058	9,735	1.186	4,697,634	.034
Oregon	----------	----------	----------	----------	----------	----------	356	.506
South Dakota	----------	----------	----------	----------	----------	----------	1,778,316	.070
Utah	2,042	8.299	33,675	.175	469,459	[4] 4.033	20,226.073	.185
Undistributed [3]	114	.140	400	.040	3,250,302	.046	[6] 3,585,537	[6] .203
Total	136,855	10.679	858,026	1.834	5,670,184	1.223	104,364,353	.295

---

[1] Missouri excluded.
[2] Includes silver recovered from tungsten ore.
[3] Includes Kentucky, New York, North Carolina, Tennessee, Virginia and Washington.
[4] Includes silver recovered from uranium ore.
[5] Includes manganese ore and silver therefrom.
[6] Excludes Pennsylvania magnetite-pyrite-chalcopyrite ore and resultant silver.

TABLE 7.—Mine and refinery production of silver in the United States in 1959, by States and sources, in troy ounces of recoverable metal

State	Placers	Dry ore	Copper ore	Lead ore	Zinc ore	Zinc-lead, zinc-copper, lead-copper, and zinc-lead-copper ores	Total	Refinery production [1]
Alaska	20,489	114	755	----	----	----	21,358	21,600
Arizona	8	34,581	2,726,008	28,000	1,757	[2] 1,107,982	3,898,336	3,600,000
California	6,146	35,622	[3] 109,080	4,405	----	17,649	172,902	106,500
Colorado	298	15,812	383,912	65,024	387	875,299	1,340,732	915,000
Idaho	158	12,491,343	14,045	1,225,404	49,926	2,855,610	16,636,486	9,000,000
Illinois	----	----	----	----	----	----	----	1,700
Kentucky	----	----	----	----	----	75	75	----
Michigan	----	----	----	----	----	----	----	2,000
Missouri	----	----	----	[4] 339,760	----	(4)	339,760	203,000
Montana	245	221,820	1,638,305	45,153	1,512,058	[5] 2,795	3,420,376	3,075,000
Nevada	37,525	317,897	173,399	61,208	----	21,106	611,135	785,900
New Mexico	----	86,677	41,876	15,339	3,487	11,546	158,925	137,800
New York	----	----	----	----	----	51,588	51,588	50,000
North Carolina	----	----	16,319	----	----	----	16,319	12,500
Oregon	62	180	----	----	----	----	242	1,160
Pennsylvania [6]	----	----	----	----	----	----	----	5,510
South Dakota	----	124,425	----	----	----	----	124,425	126,500
Tennessee	----	----	----	----	----	59,739	59,739	78,700
Utah	----	26,906	1,791,169	16,947	5,899	[2] 1,893,376	3,734,297	4,239,500
Vermont	----	----	----	----	----	----	----	1,080
Virginia	----	----	----	----	----	866	866	850
Washington [7]	----	562,779	7,150	16	16	36,576	606,537	635,700
Wyoming	----	----	----	----	----	----	----	----
Total	64,931	13,918,156	6,902,018	1,801,256	1,573,530	6,934,207	31,194,098	23,000,000
Percent	0.2	44.6	22.1	5.8	5.1	22.2	100	

[1] U.S. Bureau of the Mint.
[2] Includes silver recovered from uranium ore.
[3] Includes silver recovered from tungsten ore.
[4] Includes some silver recovered from lead-copper ore.
[5] Includes silver recovered from manganese ore.
[6] Included with Washington.
[7] Includes silver recovered from magnetite-pyrite-chalcopyrite ores in Pennsylvania.

TABLE 8.—Silver produced in the United States from ore and old tailings in 1959, by States and methods of recovery, in terms of recoverable metal [1]

State	Total ore, old tailings, etc., treated (short tons)	Ore and old tailings to mills					Crude ore to smelters	
		Short tons	Recoverable in bullion		Concentrates smelted and recoverable metal			
			Amalgamation (troy ounces)	Cyanidation (troy ounces)	Concentrates (short tons)	Troy ounces	Short tons	Troy ounces
Alaska	617	564	114	----	----	----	53	755
Arizona	53,764,835	53,200,557	3	33,366	1,668,945	3,353,435	564,278	511,524
California	141,636	138,433	4,781	25,295	1,933	109,776	3,203	26,904
Colorado	769,323	745,023	2,541	3,994	103,447	905,484	24,300	428,415
Idaho	1,833,705	1,746,726	73	----	209,571	16,574,215	86,979	62,040
Montana	8,778,702	8,685,007	2	----	338,590	3,163,381	93,695	256,748
Nevada	8,787,619	8,748,089	222	305,136	168,732	117,171	39,530	151,081
New Mexico	4,697,634	4,620,918	----	----	160,119	71,519	76,716	87,406
Oregon	356	351	28	----	10	82	5	70
South Dakota	1,778,316	1,778,316	84,886	39,539	----	----	----	----
Utah	20,226,073	20,142,679	----		592,321	3,676,340	83,394	57,957
Undistributed [2]	[3] 3,585,537	[3] 3,553,566	13	149,704	[3] 230,196	530,469	31,971	54,938
Total	104,364,353	103,360,229	92,663	557,034	3,473,864	28,501,872	1,004,124	1,637,838

[1] Missouri excluded.
[2] Includes Kentucky, New York, North Carolina, Pennsylvania, Tennessee, Virginia, and Washington.
[3] Excludes Pennsylvania magnetite-pyrite-chalcopyrite ore and resultant concentrates.

TABLE 9.—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)		Silver from all sources (percent)			
	Amalgamation	Cyanidation	Amalgamation	Cyanidation	Smelting[1]	Placers
1950–54 (average)	105,939	240,747	0.3	0.6	99.0	0.1
1955	90,647	643,983	.3	1.7	97.9	.1
1956	87,879	309,158	.2	.8	98.9	.1
1957	95,809	250,232	.2	.7	99.0	.1
1958	90,207	324,705	.3	.9	98.6	.2
1959	92,663	557,034	.3	1.8	97.7	.2

[1] Both crude ores and concentrates.

TABLE 10.—Net industrial[1] consumption of silver in the United States, in thousand troy ounces

[U.S. Bureau of the Mint]

Year	Issued for industrial use	Returned from industrial use	Net industrial consumption
1950–54 (average)	131,693	30,993	100,700
1955	123,535	22,135	101,400
1956	130,000	30,000	100,000
1957	133,742	38,342	95,400
1958	121,500	36,000	85,500
1959	142,984	41,984	101,000

[1] Including the arts.

CONSUMPTION AND USES

Consumption of silver by the arts and industries of the United States rose 18 percent to 101 million ounces, according to data compiled by the U.S. Bureau of the Mint. Of this total, about 34.5 million ounces was supplied by the Treasury under the Act of July 31, 1946, a sharp rise over 1958; the remainder came from domestic production and imports. Domestic industrial consumers used nearly half the world output of silver. Although the quantity of silver used in the arts increased moderately, the most significant gains were in the industries, reflecting expanded production of consumer durable goods—air conditioning, refrigeration, and automotive and electrical appliances.

These industries absorbed silver in many forms, especially as solders and brazing alloys, electrical contacts, and chemical products. Aircraft, missiles, and rockets used increased quantities of brazing alloys and other silver products in structural components and control mechanisms.

Photographic materials continued to absorb nearly one-third of the total industrial silver as sales of film and sensitized paper increased significantly. Solders and brazing alloys were second, and electrical and electronic materials were third as consumers of large quantities of silver.

Manufacture of sterling and plated ware continued to consume large quantities of silver. Substantial quantities also were used in ceramics, batteries, and many specialized products. In batteries, the primary and secondary silver-zinc and rechargeable silver-cadmium cells gave high output with low weight and were finding increased use in specialized applications. Other new and growing uses of silver included chemical catalysts, corrosion-resistant coatings in reaction vessels, and condensers. The use of silver to sterilize water also was increasing. A high-silver alloy was tested for control-rod material in pressurized-water reactors as a substitute for scarce hafnium; it may have potential use in the atomic energy field.

Some miscellaneous industrial uses of silver were: As silver-plated copper wire for electrical circuits in electronic devices; in survival kits for desalting sea water; in dental alloys and amalgams; in backing for mirrors and other glass coatings; in pharmaceuticals; and for medical and scientific equipment.

New industrial uses and prospects for expanding use of silver in the domestic economy were described.[3]

U.S. subsidiary coinage consumed 41.4 million ounces, 2.5 million more than in 1958. Requirements for subsidiary coins, met from free-silver stocks in the Treasury, continued to rise, principally because of the rapid growth of coin-operated merchandising machines.

The silver situation and the problems affecting future supply and demand were discussed in a trade publication.[4]

STOCK

Treasury silver stock, comprising bullion and coin inside the Treasury, aggregated 2,060 million ounces December 31, a decrease of 46 million for the year. In addition to lend-lease returns, the Treasury acquired 4.7 million ounces of newly mined domestic silver purchased under the Act of July 31, 1946, 1.5 million ounces from withdrawn coins, and 2.2 million ounces from other sources. Decreases in Treas-

TABLE 11.—U.S. monetary silver, in million ounces[1]

	1955	1956	1957	1958	1959
In Treasury:					
Securing silver certificates:					
Silver bullion	1,697.2	1,708.4	1,711.5	1,736.3	1,741.3
Silver dollars	196.1	182.8	169.4	156.8	141.1
Subsidiary coin	11.3	2.0	5.9	10.9	2.4
Free silver bullion	24.9	87.4	127.4	202.2	175.1
Total	1,929.5	1,980.6	2,014.2	2,106.2	2,059.9
Coinage in circulation:					
Silver dollars	182.0	195.1	208.3	220.8	236.2
Subsidiary coin	928.3	968.0	1,014.6	[2] 1,046.2	1,094.6
Total	1,110.3	1,163.1	1,222.9	[2] 1,267.0	1,330.8
Grand total	3,039.8	3,143.7	3,237.1	3,373.2	3,390.7

[1] Compiled from Treasury Bulletin.
[2] Revised figure.

---

[3] Wilcox, Ralph L., Recent Developments in Industrial Demand for Silver: Address at Nat. Western Min. Conf., Colorado Min. Assoc., Denver, Colo., Feb. 6, 1959.

[4] Bratter, Herbert M., Copper Strikes Bring Silver Issues to the Fore Again: Commercial and Financial Chronical, vol. 190, No. 5906, Dec. 10, 1959, pp. 1, 26–27.

ury stock included silver sold to industry and other Government agencies and silver used for coinage.

The ratio of silver to gold in the United States monetary stock was 18 percent at the yearend.

PRICES

Official prices established under U.S. silver laws for the purchase of silver from domestic producers and sales to domestic consumers remained unchanged at 90.5+ and 91.0 cents a fine-troy ounce, respectively. These fixed prices, and the buying and selling policies of the U.S. Treasury, continued to be a major factor in stabilizing the price of silver in world markets. Policies of the Bank of Mexico and the Bank of England also tended to stabilize silver markets.

Published prices in the New York market ranged from a low of 89⅞ cents an ounce, 0.999 fine, at the beginning of the year to a high of 91⅝ in August; prices declined to 91⅜ in September and remained unchanged to yearend. The higher price trend reflected increased demand from both domestic and foreign consumers; for the first time since 1957 domestic consumers bought silver from the Treasury. Sales of Treasury silver brought the New York price to 91⅜ cents, based on the delivered price of silver from the San Francisco Mint. For a week, near the end of August, the price rose to 91⅝ when supplies were cut off by a trucking strike in San Francisco and deliveries were made from the Denver Mint. The relationship of the New York silver price to the fixed Treasury price and the effect of these prices on respective buying and selling policies of consumers and producers were described in the 1957 Silver chapter. Because the New York price of silver was higher than the Treasury price during most of the year, part of the newly mined domestic silver was sold in the New York market. Prices in other centers exceeded the New York price by ½ to 1 cent an ounce during the 4-month period (August to December) when major copper refineries were closed by a strike and the domestic supply of silver was severely limited.

In the London market the price of silver per troy ounce, 0.999 fine, ranged from a low of 75⅞d. in January to a high of 80¼d. in October, equivalent to 88.64 cents and 93.92 cents, respectively—a spread of 5.28 cents, compared with 1.75 cents in New York. The higher London price was principally due to the heavy demand from industry in the United Kingdom and continental Europe and the demand for new coinage at a time when the United States was not able to alleviate the shortage.

FOREIGN TRADE [5]

U.S. imports of silver (refined and unrefined) dropped 58 percent to 69.1 million ounces valued at $61.1 million. The sharp drop was due principally to reduced lend-lease returns; very little of the original obligation remained unpaid. Deduction of the returned 5.4 million ounces of lend-lease silver left 63.7 million ounces for market con-

---

[5] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from the records of the U.S. Department of Commerce, Bureau of the Census.

sumption—about 13 percent less than in 1958. Western Hemisphere countries, chiefly Canada, Mexico, and Peru, supplied about 90 percent of total imports other than lend-lease returns.

Exports of silver from the United States (chiefly refined bullion) increased 6.4 million to 9.2 million ounces valued at $8.5 million. About three-fourths of all exports went to West Germany, the United Kingdom, and France.

TABLE 12.—Silver imported into the United States in 1959, by countries of origin

(Thousand troy ounces and thousand dollars)

[Bureau of the Census]

Country of origin	In ore and base bullion		In refined bullion		United States coin value
	Troy ounces	Value	Troy ounces	Value	
North America:					
Bermuda	-----	-----	-----	-----	$6
Canada	11,072	$9,902	12,453	$11,341	[1] 1,158
Cuba	215	187	-----	-----	453
El Salvador	188	160	-----	-----	28
Guatemala	2	2	-----	-----	-----
Honduras	2,940	2,673	-----	-----	-----
Mexico	4,326	3,836	12,483	11,227	-----
Nicaragua	223	193	-----	-----	-----
Panama	62	56	-----	-----	-----
Total	19,028	17,009	24,936	22,568	1,645
South America:					
Argentina	11	10	-----	-----	-----
Bolivia	2,443	2,173	-----	-----	-----
Chile	1,400	1,259	-----	-----	-----
Colombia	840	773	-----	-----	-----
Ecuador	107	95	-----	-----	-----
Paraguay	(2)	(2)	-----	-----	-----
Peru	6,992	6,240	3,767	3,425	-----
Total	11,793	10,550	3,767	3,425	-----
Europe:					
Malta, Gozo, and Cyprus	14	12	-----	-----	-----
Portugal	49	44	-----	-----	-----
Spain	-----	-----	225	204	-----
Sweden	(2)	(2)	-----	-----	-----
United Kingdom	65	58	401	361	19
Total	128	114	626	565	19
Asia:					
Korea, Republic of	6	5	-----	-----	-----
Lebanon	20	16	-----	-----	-----
Pakistan	4,588	3,262	-----	-----	-----
Philippines	158	141	-----	-----	-----
Saudi Arabia	144	125	-----	-----	-----
Turkey	5	5	-----	-----	-----
Total	4,921	3,554	-----	-----	-----
Africa:					
Ethiopia	976	693	-----	-----	-----
Rhodesia and Nyasaland, Federation of	540	481	-----	-----	-----
Union of South Africa	1,017	903	-----	-----	-----
Total	2,533	2,077	-----	-----	-----
Oceania: Australia	1,356	1,218	-----	-----	-----
Grand total	39,759	34,522	29,329	26,558	1,664

[1] Includes foreign coin value: Bermuda, $352; Canada, $7,734.

[2] Less than 1,000

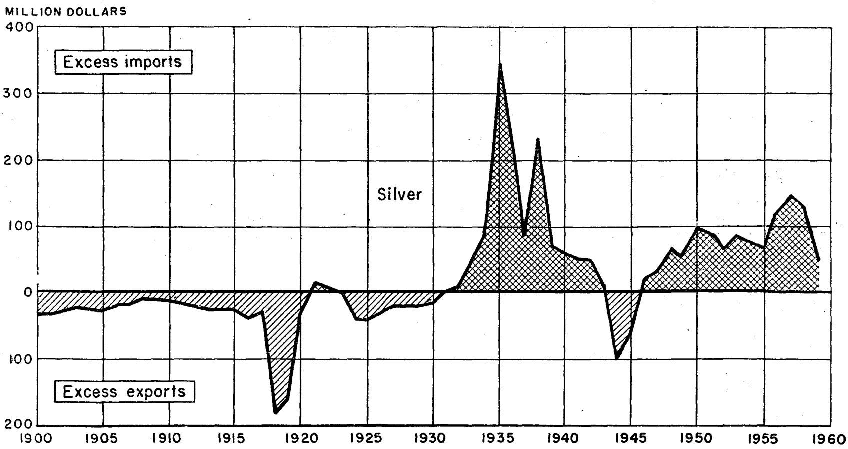

FIGURE 2.—Net imports or exports of silver, 1900–59.

TABLE 13.—Silver exported from the United States in 1959, by countries of destination

(Thousand troy ounces and thousand dollars)

[Bureau of the Census]

Country of destination	In ore and base bullion: Troy ounces	In ore and base bullion: Value	In refined bullion: Troy ounces	In refined bullion: Value	United States coin value	Foreign coin value
North America:						
Bahamas					$78	
Barbados					1	
Bermuda					13	
Canada	53	$48	950	$870	117	$1,086
Cuba			12	12		1
Mexico	5	4	1	1		
Netherlands Antilles					1	
Total	58	52	963	883	210	1,087
South America:						
Colombia			1	1		
Venezuela			32	30		
Total			33	31		
Europe:						
France			1,200	1,096		
Germany, West			3,150	2,963		
Iceland					4	
Ireland					13	
Netherlands					2	
United Kingdom	45	41	2,646	2,420	(1)	
Total	45	41	6,996	6,479	19	
Asia:						
Japan			1,085	988		
Nansei and Nanpo Islands					20	
Total			1,085	988	20	
Africa: Liberia					125	
Grand total	103	93	9,077	8,381	374	1,087

[1] Less than 1,000.

LEND-LEASE SILVER

Pakistan and Ethiopia made returns during the year against lend-lease obligations. At the end of 1959 a balance of 35.1 million ounces of silver remained unpaid of 410.8 million originally supplied to foreign countries under lend-lease agreements. Pakistan returned 4.6 million ounces, and the balance of 13.8 million ounces was to be returned in three equal annual installments; Ethiopia paid its remaining balance of 0.8 million; and Saudi Arabia has made no return of its obligation of 21.3 million ounces. (Lend-lease silver is credited to free stocks.)

WORLD REVIEW

Reversing a production trend since 1942, estimated world output of silver declined 9 percent to 217 million ounces, principally due to curtailed U.S. production caused by labor strikes. All principal silver-producing countries reported lower production, except Canada, which recorded a 2.5-percent gain. Western Hemisphere countries continued to furnish about two-thirds of world output. Consumption of silver by the arts and industries of the free world was substantially higher than in 1958, reflecting improved business conditions. Silver used for coinage also increased, especially in France and Italy, where new coinage programs were introduced. Silver coinage in free-world countries absorbed an estimated 84.2 million ounces, 21 million more than in 1958. Total estimated free-world consumption of silver was 296 million ounces, a gain of 18 percent over 1958.[6] As in several preceding years free-world silver consumption exceeded production by a wide margin, and world stocks were reduced accordingly.

TABLE 14.—World production of silver, by countries,[1] in troy ounces [2] [3]

[Compiled by Augusta W. Jann and Berenice B. Mitchell]

Country	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada	26, 197, 353	27, 984, 204	28, 431, 847	28, 823, 298	31, 163, 470	31, 927, 054
Central America and West Indies:						
Cuba	[4] 177, 888	259, 440	284, 202	[4] 252, 728	[4] 325, 278	[4] 215, 000
Guatemala	352, 638	343, 111	533, 179	528, 436	320, 621	[5] 88, 000
Honduras	3, 894, 612	1, 797, 394	2, 030, 008	2, 260, 433	2, 762, 932	2, 657, 171
Nicaragua	209, 880	268, 316	258, 521	230, 081	304, 277	274, 993
Salvador	363, 104	230, 054	161, 476	172, 305	197, 629	[4] 188, 000
Mexico	46, 212, 577	47, 957, 654	43, 078, 040	47, 149, 513	47, 592, 358	44, 075, 452
United States [6]	39, 075, 319	36, 469, 610	38, 739, 400	38, 720, 000	36, 800, 000	23, 000, 000
Total	116, 483, 000	115, 309, 800	113, 516, 700	118, 136, 800	119, 467, 700	102, 425, 700
South America:						
Argentina	1, 180, 398	1, 414, 633	1, 671, 838	1, 350, 331	1, 543, 200	1, 549, 600
Bolivia (exports)	6, 386, 012	5, 851, 107	7, 547, 304	5, 375, 089	6, 051, 284	4, 503, 772
Brazil	114, 392	140, 113	171, 524	348, 160	185, 313	225, 050
Chile	1, 337, 284	1, 714, 535	1, 821, 918	1, 555, 903	1, 504, 365	[5] 1, 500, 000
Colombia	119, 765	112, 037	110, 728	106, 494	105, 162	102, 678
Ecuador	102, 315	47, 732	29, 479	28, 694	47, 600	162, 608
Peru	17, 353, 909	22, 947, 624	22, 972, 766	24, 845, 257	25, 918, 353	24, 767, 581
Total	26, 594, 100	32, 227, 800	34, 325, 600	33, 610, 000	35, 360, 000	32, 810, 000

See footnotes at end of table.

---

[6] Handy & Harman, The Silver Market in 1959, p. 24.

TABLE 14.—World production of silver, by countries,[1] in troy ounces [2] [3]—Continued

Country	1950–54 (average)	1955	1956	1957	1958	1959
Europe:						
Austria	5, 659	3, 537	1, 286	1, 286	----------	64, 300
Czechoslovakia [5]	1, 608, 000	1, 608, 000	1, 608, 000	1, 608, 000	1, 608, 000	1, 608, 000
Finland	179, 710	224, 573	318, 453	373, 592	560, 709	522, 739
France	673, 880	628, 065	541, 869	703, 587	669, 749	745, 880
Germany:						
East [5]	3, 857, 600	4, 500, 000	4, 500, 000	4, 500, 000	4, 500, 000	4, 500, 000
West	2, 000, 200	2, 226, 375	2, 166, 446	2, 139, 407	2, 112, 304	1, 897, 730
Greece	59, 247	77, 869	79, 091	93, 462	96, 452	64, 300
Hungary [5]	57, 860	64, 300	64, 300	64, 300	64, 300	64, 300
Italy	844, 696	862, 862	1, 034, 129	956, 420	1, 334, 256	1, 060, 814
Norway	145, 321	70, 732	54, 656	64, 301	----------	----------
Poland [5]	102, 920	128, 600	128, 600	128, 600	128, 600	128, 600
Portugal	65, 247	58, 900	57, 550	62, 308	45, 783	54, 152
Rumania [5]	630, 100	643, 000	643, 000	643, 000	643, 000	643, 000
Spain	907, 654	1, 473, 404	1, 402, 801	1, 345, 734	1, 774, 850	[5] 1, 880, 000
Sweden	1, 680, 995	2, 397, 738	2, 562, 382	2, 512, 163	2, 944, 233	3, 098, 070
U.S.S.R.[5]	24, 400, 000	25, 000, 000	25, 000, 000	25, 000, 000	25, 000, 000	25, 000, 000
United Kingdom	26, 215	29, 706	27, 878	27, 337	20, 553	[5] 20, 000
Yugoslavia	2, 774, 661	2, 983, 589	2, 760, 013	2, 589, 742	3, 751, 702	2, 827, 336
Total [5]	40, 020, 000	43, 000, 000	43, 000, 000	42, 810, 000	45, 300, 000	44, 200, 000
Asia:						
Burma	477, 509	1, 537, 895	1, 500, 351	1, 526, 810	1, 961, 472	1, 969, 954
China [5]	368, 000	480, 000	480, 000	510, 000	[7] 510, 000	[7] 510, 000
India	44, 754	153, 935	104, 604	125, 838	109, 828	124, 777
Japan	5, 188, 789	5, 948, 627	6, 166, 962	6, 543, 673	6, 552, 032	6, 598, 104
Korea:						
North [5]	56, 000	160, 000	260, 000	320, 000	320, 000	320, 000
Republic of	25, 881	79, 605	196, 409	277, 346	247, 782	241, 898
Philippines	456, 719	502, 069	541, 168	479, 216	497, 987	504, 085
Saudi Arabia	112, 090	----------	----------	----------	----------	----------
Taiwan	28, 009	63, 948	53, 894	82, 965	52, 380	60, 974
Total [5]	6, 800, 000	8, 900, 000	9, 300, 000	9, 900, 000	10, 300, 000	10, 300, 000
Africa:						
Algeria (recoverable) [5] [8]	125, 000	225, 000	230, 000	235, 000	240, 000	250, 000
Bechuanaland	229	189	215	35	44	42
Belgian Congo	4, 498, 853	4, 076, 457	3, 791, 891	3, 044, 868	3, 793, 788	4, 758, 310
Ghana (exports)	46, 690	39, 284	28, 592	25, 390	45, 762	16, 839
Kenya	9, 027	1, 770	54, 689	23, 051	44, 146	46, 420
Morocco: Southern zone [8]	1, 656, 465	2, 324, 167	2, 204, 930	2, 411, 250	2, 411, 000	1, 234, 303
Nigeria	230	172	111	200	----------	----------
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	303, 887	412, 191	610, 370	569, 949	556, 523	948, 459
Southern Rhodesia	82, 572	76, 837	76, 870	74, 179	264, 630	328, 947
South-West Africa	902, 744	1, 279, 213	1, 632, 287	1, 789, 323	1, 719, 990	1, 966, 955
Tanganyika (exports) [8]	162, 419	343, 614	562, 880	521, 465	737, 802	536, 407
Tunisia	69, 831	91, 726	86, 485	113, 556	135, 194	43, 339
Uganda (exports)	41	70	52	21	36	54
Union of South Africa	1, 177, 345	1, 461, 336	1, 598, 278	1, 767, 472	1, 795, 384	2, 020, 780
Total	9, 035, 000	10, 330, 000	10, 880, 000	10, 580, 000	11, 740, 000	12, 200, 000
Oceania:						
Australia	11, 825, 072	14, 555, 412	14, 586, 197	15, 739, 400	16, 270, 181	14, 800, 000
New Guinea	50, 202	44, 459	42, 457	38, 014	24, 952	36, 796
Fiji	25, 113	20, 421	24, 302	24, 946	25, 375	23, 652
New Zealand	98, 589	27, 930	950	1, 279	2, 339	4, 873
Total	11, 999, 000	14, 648, 000	14, 654, 000	15, 804, 000	16, 323, 000	14, 865, 000
World total (estimate)	210, 900, 000	224, 000, 000	225, 700, 000	230, 800, 000	238, 500, 000	216, 800, 000

---

[1] In addition to countries listed, a negligible amount of silver is produced in Bulgaria, Cyprus, Hong Kong, Panama, Malaya, Sarawak, Turkey and Sierra Leone, for which countries no estimate has been included in total.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in detail.

[3] Data partly derived from Yearbook of American Bureau of Metal Statistics and 46th annual issue of Metal Statistics (Metallgesellschaft) Germany.

[4] Imports into United States.

[5] Estimate.

[6] Refinery production.

[7] Data represents estimate of 1957 production; however, 1958 and 1959 production were probably much greater.

[8] Includes silver content of lead and zinc concentrates.

Australia.—After rising for 9 successive years, silver output in Australia fell about 9 percent in 1959 to 14.8 million ounces. The decline reflected reduced output of silver-bearing lead-zinc ores. Mount Isa mines reported current milling ore, averaging 6.9 ounces of silver per ton, and a silver-bearing lead-zinc ore reserve of 25.2 million tons, 1 million more than in 1958. A large share of Australian silver output (bullion and in lead concentrate) was exported to the United Kingdom.

Canada.—Silver production in Canada rose 3 percent to 32.3 million ounces, marking the fourth successive annual increase and the highest level of output since 1910 (peak year of the Cobalt camp), when 32.9 million ounces were produced. Canada also became the second largest silver-producing country, surpassed only by Mexico.

British Columbia, Ontario, and the Yukon Territory supplied more than 80 percent of the total output. The United Keno Hill mines in the Yukon and the Sullivan and Torbit mines in British Columbia were again the leading producers. More than four-fifths of the total silver was recovered from base-metal ores, and virtually all of the remainder from silver, silver-cobalt, and gold ores.

The geographical distribution of Canada's silver production was as follows:

Province or territory [1]	Troy ounces	
	1958	1959
Ontario	9,815,257	9,956,316
British Columbia and Alberta	8,013,456	8,674.741
Yukon Territory	6,415,560	6,901,461
Quebec	3,908,361	4,071,377
Manitoba and Saskatchewan	1,619,836	1,548,319
Newfoundland	1,267,078	1,107,135
Northwest Territories	72,779	69,786
Nova Scotia and New Brunswick	51,143	2
Total	31,163,470	32,329,137

[1] Patterson, J. W., Silver, 1959 (Prelim.): Mineral Resources Division, Dept. Min. and Tech. Surveys, Ottawa, Canada, May 1960, 10 pages.

Total silver consumption by the arts and industries was estimated at 4.4 million ounces, an increase of 13 percent over that of 1958. Canadian coinage requirements were estimated at 5.7 million ounces, 1 million more than 1958.[7]

Exports of silver in ores and concentrates and bullion, consisting principally of shipments to the United States, totaled 21.9 million ounces, slightly more than in 1958. Imports of unmanufactured silver increased sharply to 2.8 million ounces from 2.7 thousand ounces in 1958.

Mexico.—Silver production in Mexico declined about 7 percent to 44.1 million ounces, but that country continued to rank as the world's leading silver producer by a substantial margin. Cia. Real del Monte y Pachuca, the leading silver producer, reported lower output; another major producer, La Bufa mine of Potosi Mining Co., suspended operations. Consumption in the arts and industries in Mexico

---

[7] Work cited in footnote 6.

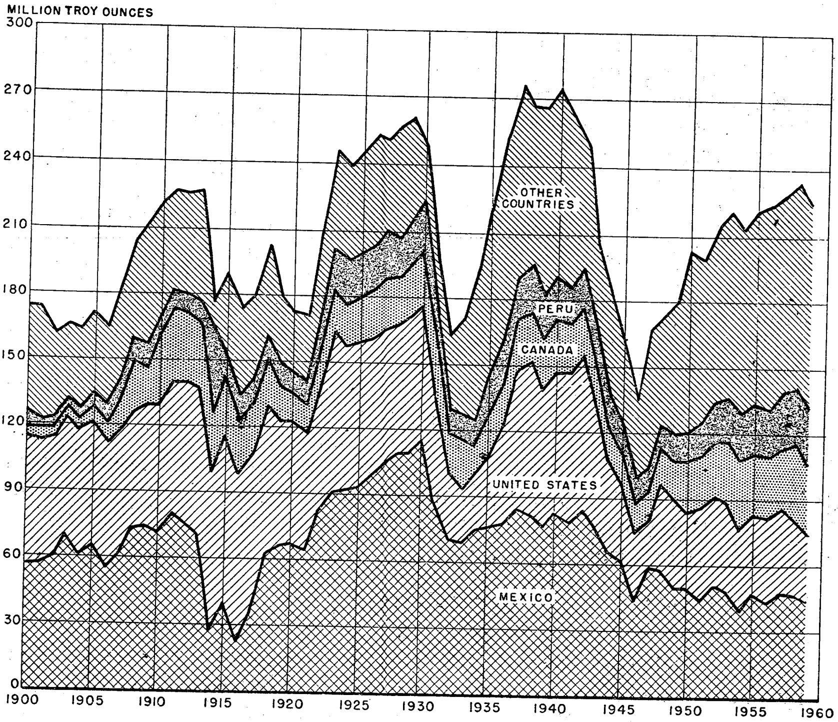

FIGURE 3.—World production of silver, 1900–59.

was estimated at 5.4 million ounces, a 23-percent increase over 1958. An additional 1.4 million ounces was used for coinage, about 0.8 million less than in 1958.

Exports of silver from Mexico were about 36.2 million ounces, of which 15.8 million ounces went to the United States and 18.6 million ounces to West Germany. According to Handy & Harman[8] demonetized coin continued to be withdrawn from circulation, and in 1959 a total of 2.5 million ounces of silver was obtained from such withdrawals. An additional 87 million ounces of silver in demonetized coin remained in the hands of the public.

A 7,500-ton flotation mill at the silver-mining center of Pachuca began to reprocess tailings accumulated over the past 50 years. This enterprize was expected to extend the life of precious-metal-mining operations in the district for several years. About 50 million tons were to be processed, with an expected recovery of about 45 grams of silver, 1 percent each of zinc and lead, and about 2 percent iron per ton.

Peru.—Output of silver from Peru, the fourth largest silver producer in the free world, declined 4 percent to 24.8 million ounces but exports increased 4.9 percent. About 43 percent of Peru's silver went to the United States, compared with 60 percent in 1958. Cerro de Pasco Corp., the largest producer, accounted for nearly 45 percent

---

[8] Work cited in footnote 6, p. 14.

of the total output; four straight-silver producers, Castrovirreyna Metal Mines Co., San Juan de Lucanas, Cia. Minera Caylloma, and Cia. Explotadora Millotengo, produced about 20 percent, and the remainder was contained in concentrates, blister copper, direct-shipping ores, and gold-silver bars.

Domestic arts and industries consumed about 3 percent of the total output.

United Kingdom.—Arts and industries of the United Kingdom consumed about 17.5 million ounces of silver, an increase of nearly 30 percent over that of 1958. Total imports were 22.8 million ounces, of which Australia supplied about 7.3 million; Western Hemisphere countries, 4.2 million; China, 2.6 million; and other Far-Eastern countries, 3.3 million.[9]

The United Kingdom exported 11.7 million ounces, principally to France, 5 million; Italy, 2.3 million; and Canada, 1 million. Other European countries received 2.5 million ounces.

About 7.5 million ounces of silver were refined from demonetized silver coin, but only 5 million ounces were released for sale to industry by the Bank of England. Part of the remainder was used to manufacture foreign coin.

TECHNOLOGY

An automatically activated 28-volt, 200-amphere, silver-zinc primary battery designed for use in space-vehicle auxiliary-power units was developed by Cook Batteries Division of Telecomputing Corp.[10] The battery is activated by a 4-amphere signal, which ignites a gas-generating material, thus forcing electrolyte into the cells. The unit weighs 13.5 pounds, is shock resistant and, in special models, is useful at temperatures ranging from −65° F. to +165° F.

A new silver anode developed by Johnson, Matthey & Co. was reported to be particularly resistant to flaking in high-speed plating baths and to have remarkable tolerance to variations in electrolyte and anode current density.[11] Allis Chalmers Manufacturing Co. reported a simplified process for silver plating aluminum, which took only three steps after routine degreasing. These were: An alkaline dip, a new mercuric compound bath, and silver plating.[12]

A patent was issued on the use of organic nitriles containing cyanide to improve the extraction of gold and silver from certain complex ores.[13] A process for polymerizing ethylene, using a silver catalyst, also was patented.[14] Other patents were issued on processes of coating silver on ceramic and other nonmetallic materials and for silver alloys in manufacturing electrical contacts.

---

[9] Annual Bullion Review 1959, Samuel Montagu & Co., Ltd., March 1960, p. 20.

[10] Electronic News, New Silver-Zinc Primary Battery Out For Space Units: Vol. 5, No. 203, May 16, 1960, p. 31.

[11] Chemistry and Industry (London), No. 9, Feb. 28, 1959, p. 304.

[12] Iron Age, Cuts Plating Time: Vol. 18, No. 21, Nov. 29, 1959, p. 9.

[13] Carpenter, Erwin L., and Hedley, Norman (assigned to American Cyanamid Co.), Process for Extracting Precious Metals From Their Ores by the Use of Alpha-Hydroxy-nitriles: Canadian Patent 592,038.

[14] Gresham, William F., and Merkling, Nicholas G. (assigned to E. I. du Pont de Nemours and Co.), Coordination Catalysts Using Silver: U.S. Patent No. 2,888,448.

A flotation process for recovering part of the silver, gold, and lead remaining in the millions of tons of cyanide tailings at Pachuca, Mexico, was developed by the Mexican Government.[15] Other significant articles pertaining to the technology of silver were published during the year.[16]

---

[15] Engineering and Mining Journal, vol. 160, No. 11, November 1959, pp. 94–96.

[16] Chaikin, Saul W., Janney, Joan, Church, Franklin M., and McClelland, Charles W., Silver Migration and Printed Wiring: Ind. and Eng. Chem., vol. 51, No. 3, pt. 1, March 1959, pp. 299–304.

Bonk, James F., and Garrett, Alfred B., A Study of Silver (1) Oxide Silver (2) Oxide Electrode: Jour. Electrochem. Soc., vol. 106, No. 7, July 1959, pp. 612–615.

Slag—Iron-Blast Furnace

By Wallace W. Key[1]

◆

OUTPUT of processed iron-blast-furnace slag decreased only slightly compared with 1958 despite a 116-day steel strike that halted slag processing at many operations. Slag processing plants continued to function at near capacity during the strike by treating material in reserve slag banks. Demand for slag products continued to increase, and output of slag per ton of pig iron declined. To counteract this condition, effort was directed toward basic research on the furnace feed and its effect on the slag produced, and examination of potential markets that offer a higher unit value for upgraded slag products.

TABLE 1.—Iron-blast-furnace slag processed in the United States, by types

(Thousand short tons and thousand dollars)

[National Slag Association]

Year	Air-cooled				Granulated		Expanded	
	Screened		Unscreened		Quantity	Value[1]	Quantity	Value
	Quantity	Value	Quantity	Value				
1950–54 (average)	22,155	$29,077	1,151	$695	2.748	$1.068	2,126	$5,001
1955	24,901	36,132	809	597	3,836	1,618	2,892	7,961
1956	25.572	38.476	2,096	1.280	4,635	1,642	2,990	8,496
1957	25,414	40.203	2,167	1,408	4,318	1.615	2,942	8,435
1958	20,499	34,027	1,411	1.170	3,536	1.373	2,985	8,638
1959	21,816	36,774	1.039	957	2,702	1,396	2.812	8.037

[1] Excludes value of slag used for hydraulic cement manufacture

DOMESTIC PRODUCTION

Slag output from the Nation's iron blast furnaces totaled about 28 million short tons in 1959, compared with 27 million tons in 1958. Pig iron output increased 5 percent over 1958. Thus the steel industry's speedup before the 116-day shutdown compensated to some degree for lost sales both in steel and slag markets. The national average of slag production at the furnaces showed slightly less than 1 ton of slag for every 2 tons of pig iron. The iron-blast-furnace slag industry utilized virtually all blast-furnace slag produced, and, in addition, drew upon

---

[1] Commodity specialist.

air-cooled slag from reserve banks. Processed slag from iron blast furnaces for commercial applications, as reported to the National Slag Association, totaled 28.4 million tons in 1959—only a few thousand tons less than in 1958. Although the steel strike shut off molten slag for granulated and expanded slag during the best part of the season, air-cooled slag, the major product, was processed and stockpiled or placed in reserve pits during the speedup measures of the steel industry before the strike. Also, many slag operations continued to process material without interruption throughout the year. Some producers, however, did not have enough reserves to supply customers and diverted activities to producing stone and sand and gravel aggregates.

Serious consideration was given to more widespread applications of open-hearth, copper, and boiler slags. These were used in limited areas, such as parking lots, where reactivity would not be harmful.

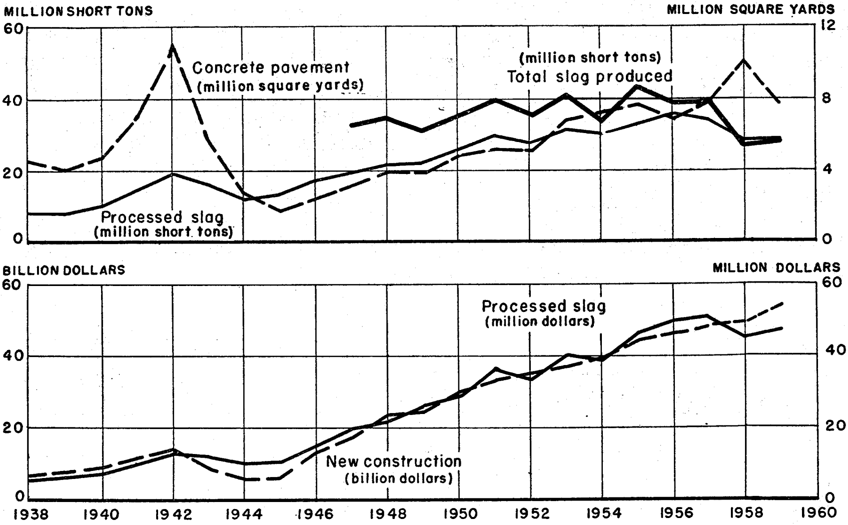

Figure 1.—Production of iron-blast-furnace slag compared with yards of concrete pavement (contract awards), monthly average, and value of new construction compared with value of processed slag, 1938–59.

Iron-blast-furnace slag was produced in 15 States; the bulk was processed in the steel centers of Pennsylvania, Ohio, and Alabama. Pennsylvania led the other States in tonnage processed and sales value. Thirty-seven companies operated 59 air-cooled plants, 14 granulating plants, and 23 expanded-slag plants.

Recovery of Iron.—An important function of the slag industry continued to be magnetic and hand recovery of iron for reuse in blast furnaces. In 1959, 335,543 tons of iron-slag (about 60 percent iron), representing more than 1 percent of the processed slag, was returned as furnace burden to the furnaces—an 8-percent decrease compared with 1958.

Employment.—In 1959, a total of 4,187,000 man-hours was expended by 2,049 plant and yard employees in producing commercial slag,

TABLE 2.—Iron-blast-furnace slag processed in the United States, by States

(Thousand short tons and thousand dollars)

[National Slag Association]

	Screened air-cooled		All types	
	Quantity	Value	Quantity	Value
1958				
Alabama	3,643	$5,555	4,428	$6,819
Ohio	4,388	8,013	5,885	10,809
Pennsylvania	5,258	9,282	7,203	11,334
Other States [1]	7,210	11,177	10,915	16,246
Total	20,499	34,027	28,431	45,208
1959				
Alabama	3,545	5,429	4,176	6,608
Ohio	4,126	7,705	5,427	10,739
Pennsylvania	5,496	9,893	7,240	11,847
Other States [1]	8,649	13,747	11,526	17,970
Total	21,816	36,774	28,369	47,164

[1] California, Colorado, Illinois, Indiana, Kentucky, Maryland, Michigan, Minnesota, New York, Tennessee, Texas, and West Virginia.

compared with the 4,538,000 man-hours of 2,050 plant and yard employees in 1958. Output at slag operations was 6.8 tons of processed slag per man-hour.

Safety competition among slag plants, sponsored by the National Slag Association, has been conducted since 1949, but an accident analysis canvass was conducted for the second time by the Bureau of Mines for 1959. Results are shown in the Employment and Injuries in the Metal and Nonmetal Industries chapter of Volume I, Minerals Yearbook.

Methods of Transportation.—As in other years, virtually the entire tonnage of processed slag was shipped by truck and rail. Waterways played a minor but locally important role. The high-volume, low-value problem continued to limit the transportation range of slag.

TABLE 3.—Shipments of iron-blast-furnace slag in the United States, by method of transportation

(Thousand short tons)

[National Slag Association]

Method of transportation	1958		1959	
	Quantity	Percent of total	Quantity	Percent of total
Rail	8,205	30	8,669	32
Truck	18,280	68	17,950	66
Waterway	583	2	544	2
Total shipments	27,068	100	27,163	100
Interplant handling [1]	1,363	-----------	1,206	-----------
Total processed	28,431	-----------	28,369	-----------

[1] Confined mainly to granulated slag used in the manufacture of cement.

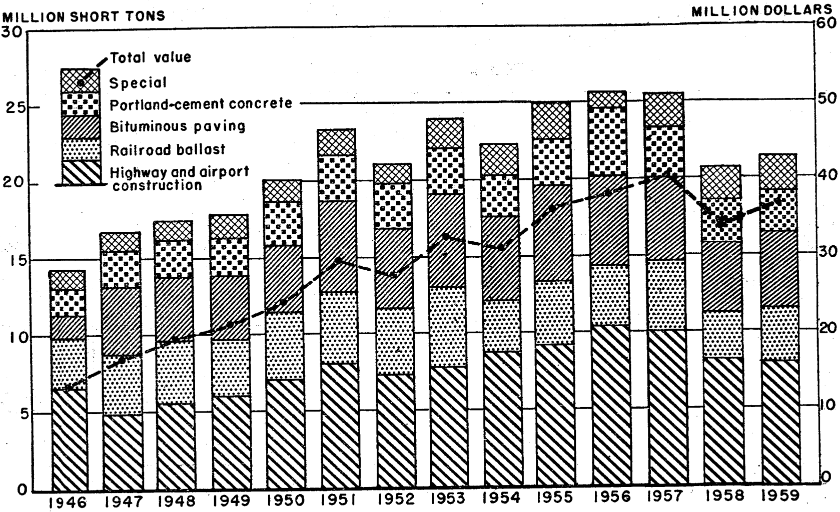

FIGURE 2.—Consumption and value of air-cooled, iron-blast-furnace slag sold or used in the United States, 1946–59.

CONSUMPTION AND USES

Screened, air-cooled slag, the major type produced by the industry, constituted 77 percent of the total output of processed slag. The remainder was divided among the other types as follows: Unscreened, air-cooled, 4 percent; granulated, 9 percent; and expanded, 10 percent.

Screened, Air-Cooled Slag.—This product results when molten slag is deposited in pits or banks for solidification under atmospheric conditions. Screened, air-cooled slag consumption increased about 6 percent; it was used mainly as aggregate in portland and bituminous concrete, for highway and airport construction, and in manufacturing concrete block, and as railroad ballast. These uses consumed about 92 percent of the total tonnage. Its use as railroad ballast and sewage trickling filter medium also increased substantially.

Consumption decreased mainly in highway and airport construction—an area of high usage for slag products. Other important applications for this material were in manufacturing mineral wool and glass and as fill for parking lots and driveways.

Unscreened, Air-Cooled Slag.—About 93 percent of the million tons of unscreened air-cooled slag (table 1) produced was used as aggregate in highway and airport construction.

Granulated Slag.—The consumption of granulated slag (water-quenched) totaled 2.7 million tons, or 24 percent under 1958. Of this quantity, 33 percent was used in highway construction as base, subgrade, and fill; 50 percent was used in manufacturing cement; and the remainder included slag for concrete-block manufacture, agricultural slag, and other purposes.

Expanded Slag.—This cellular product results from applying a limited quantity of water to molten slag in amounts less than that required for granulation. Several commercially successful methods of

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)

[National Slag Association]

Use	Screened		Unscreened	
	Quantity	Value	Quantity	Value
1958				
Aggregate in—				
Portland-cement concrete construction	2,695	$4,738		
Bituminous construction (all types)	4,627	8,168		
Highway and airport construction [1]	8,202	14,005	1,270	$1,048
Manufacture of concrete block	598	941		
Railroad ballast	2,916	3,474		
Mineral wool	448	733		
Roofing (cover material and granules)	404	997		
Sewage trickling filter medium	29	54		
Agricultural slag, liming	6	12		
Other uses	574	905	141	122
Total	20,499	34,027	1,411	1,170
1959				
Aggregate in—				
Portland-cement concrete construction	2,839	5,292		
Bituminous construction (all types)	4,966	8,994		
Highway and airport construction [1]	8,048	13,979	968	886
Manufacture of concrete block	594	933		
Railroad ballast	3,691	4,456		
Mineral wool	515	858		
Roofing (cover material and granules)	361	891		
Sewage trickling filter medium	53	192		
Agricultural slag, liming	6	10		
Other uses	743	1,169	71	71
Total	21,816	36,774	1,039	957

[1] Other than in portland-cement concrete and bituminous construction.

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)

[National Slag Association]

Use	1958				1959			
	Granulated		Expanded		Granulated		Expanded	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Highway construction (base and subgrade) Fill (road, etc.)	1,174	$1,096			883	$1,021		
Agricultural slag, liming	40	67			43	71		
Manufacture of hydraulic cement	1,994	(1)			1,338	(1)		
Aggregate for concrete-block manufacture	101	96	2,893	$8,320	125	121	2,733	$7,778
Aggregate in lightweight concrete			60	179			42	118
Other uses	227	114	32	139	313	183	37	141
Total	3,536	1,373	2,985	8,638	2,702	1,396	2,812	8,037

(1) Data not available.

expanding slag were employed. Consumption of expanded slag totaled 2.8 million tons. The bulk of this material was used for lightweight concrete block and aggregate in lightweight concrete.

Olmsted Air Force Base, east of Harrisburg, Pa., required 4.7 million cubic yards of blast-furnace slag. Because slag could be transported and placed in all types of weather, work moved along far ahead of schedule.[2]

Slags, other than iron-blast-furnace slags, were used for specialized applications. Copper slag was used for various construction purposes and investigations were being conducted toward wider application.

Lightweight aggregate was produced from boiler slag at Midland, Mich., for use in concrete block. A testing program explored all possible uses for this type slag in construction.[3]

PRICES

The average unit value of processed slag varied from $0.59 to $3.80 per short ton. For most uses, the value increased slightly because of steadily increasing costs of labor, equipment, supplies, and marketing.

A low-cost and effective program of street maintenance was established in Birmingham whereby residents could obtain durable slag paved streets for approximately 25 cents a square yard.[4]

TABLE 6.—Average value per short ton of iron-blast-furnace slag sold or used by processors in the United States, by uses

[National Slag Association]

Use	Air-cooled				Granulated		Expanded	
	Screened		Unscreened					
	1958	1959	1958	1959	1958	1959	1958	1959
Aggregate in—								
Portland-cement concrete construction	$1.76	$1.86	--------	--------	--------	--------	[1] $2.96	[1] $2.81
Bituminous construction (all types)	1.77	1.81	--------	--------	--------	--------	--------	--------
Highway and airport construction [2]	1.71	1.74	$0.83	$0.92	[3] $0.98	[3] $1.32	--------	--------
Manufacture of concrete block	1.57	1.57	--------	--------	.95	.97	2.88	2.85
Railroad ballast	1.19	1.21	--------	--------	--------	--------	--------	--------
Mineral wool	1.64	1.67	--------	--------	--------	--------	--------	--------
Roofing (cover material and granules)	2.47	2.47	--------	--------	--------	--------	--------	--------
Sewage trickling filter medium	1.84	3.61	--------	--------	--------	--------	--------	--------
Agricultural slag, liming	1.82	1.84	--------	--------	1.66	1.68	--------	--------
Fill (road, etc)	--------	--------	--------	--------	.87	1.02	--------	--------
Other uses	1.58	1.57	.86	1.00	.50	.59	4.33	3.80

[1] Lightweight concrete. [2] Other than in portland-cement and bituminous construction.
[3] Base and subgrade material.

---

[2] Roads and Streets, "All Weather" Material—Grading an Airfield With Slag: Vol. 102, No. 2, February 1959, pp. 51–56.

[3] Pit and Quarry, Lightweight Aggregate Processed From Power Plant Boiler Slag: Vol. 52, No. 2, August 1959, p. 91.

[4] McRae, Neal, Paving Most People Can Afford: American City, February 1960, pp. 114–115.

WORLD REVIEW

Canada.—Two Canadian steel plants at Hamilton, Ontario, and Sydney, Nova Scotia, produced 188,700 cubic yards of expanded slag in 1958, down slightly, compared with 1957, as a result of a steel strike. Of the slag produced, 95 percent was used in concrete block, 4 percent in insulation, and the remainder as roofing granules and refractory material.[5]

TECHNOLOGY

According to a patent description, blast-furnace slag can be used as a thermally insulating granular material to retard destruction of clay-type refractories and used as blast-furnace linings by mixing it with high-sulfur coke and placing the mixture in the space between the lining and furnace shell.[6]

A patent was granted on a method of removing sulfur from blast-furnace slag. The molten material was allowed to fall as fine spray through an oxidizing atmosphere.[7]

A process utilizing a molded mixture of blast-furnace slag, sawdust, portland cement, and an alkaline earth to produce a flooring material was patented.[8]

Expanded blast-furnace slag can be used as an absorbent of insecticide for direct seeding of plants, which normally require transplanting, according to a patent.[9]

Moist blast-furnace slag in combination with unslaked lime, dried and ground to fine particle size, constituted a patent claim for a slag-lime fertilizer.[10]

A refractory material composed of blast-furnace slag powder, silica sand, phenolic resin, and anhydrous sodium carbonate was patented.[11]

An oil-well cement, adapted for use under high temperature and pressure conditions, consisting of granulated slag and ground sand, was patented.[12]

Large flat units of molten slag may be cast by use of a patented method whereby the slag is cooled under nonoxidizing conditions.[13]

A German patent revealed a method of making paving stone by pouring molten blast-furnace slag into molds, the bottoms of which are covered with a thick layer of powdered coke and stone chips,

---

[5] Wilson, H. S., Lightweight Aggregates, 1958 (preliminary): Rev. 27, Dept. Mines and Tech. Surveys, Ottawa, 6 pp.

[6] Berry, T. F. (assigned to U.S. Steel Corp., a Corp. of N. J.), Method of Retarding Disintegration of Blast-Furnace Lining: U.S. Patent 2,912,740, Nov. 17, 1959.

[7] Perryer, E. V. (assigned to the British Oxygen Co., Ltd.), British Patent 808,788, Feb. 11, 1959.

[8] Schwarzwalder, K., and Wagner, A., Tile Composition and Product Suitable for Floors of Stables: U.S. Patent 2,877,135, Mar. 10, 1959.

[9] Dresser, H. A. (assigned to Zonolite Co., Chicago, Ill.), Direct Field Seeding: U.S. Patent 2,909,869, Oct. 27, 1959.

[10] Kippe, O. (assigned to Paul Tobeler, d.b.a. Trans-Oceanic, Los Angeles, Calif.), Method of Making Lime-Containing Fertilizers and Especially Slag Lime: U.S. Patent 2,904,425, Aug. 15, 1959.

[11] Cooper, R. H., and Corbett, G. M. (assigned to The Dow Chemical Co., Midland, Mich.), Composition Comprising Sand, Phenolic Resin and Anhydrous Sodium Carbonate, Method of Making, and Refractory Article Produced: U.S. Patent 2,869,191 and 2,869,196, Jan. 20, 1959.

[12] Matsinskii, E. K., Stafikopulo, A. N., and Bulatov, I. T., Russian Patent 111,763, June 25, 1958.

[13] Archibald, W. A. (assigned to The British Iron & Steel Research Assoc.), British Patent 801,884, Sept. 24, 1958.

underlain by a layer of gravel.[14] Another pertains to a method of controlling oxidation and viscosity of molten slag to produce a predesigned cellular product with controlled porosity.[15] A method of producing a cellular lightweight aggregate from blast-furnace slag by running the molten material continuously into a water-spray-cooled rotating drum was also patented in Germany.[16] A British patent described a method for producing porous, glasslike blast-furnace slag. Slag temperature was reduced to a point where dissolved gases were released, then cooled at reduced stages to the finished product temperature.[17]

An apparatus for frothing blast-furnace slag that allows the degree of expansion to be continually adjusted as the slag properties vary was patented. The process requires the use of a truncated cone below a revolving disk.[18]

A method of applying asphalt primer and binder to blast-furnace slag aggregate in a single operation was patented.[19]

Although various materials can be used for making rock wool, iron-blast-furnace slag was the most widely used, as it produces a white wool; copper and lead slags, on the other hand, produce a black wool.

A British patent related to a method and apparatus for producing mineral wool from blast-furnace slag whereby the molten slag was preheated in combination with silicic acid and blown through the described apparatus.[20]

Slags from several blast-furnaces that produced the same grade of pig iron were found to vary in hydraulic properties with the fineness of grind, temperature of slag withdrawal from the furnace, and composition.[21]

In England, several blast-furnace-slag cements containing 70 percent slag were ground to 2,550 and 5,500 Blaine, and their mechanical properties tested. Results indicated that controlled grinding of clinker-slag mixes would yield cements with mechanical properties equal to those made from clinker alone.[22]

In Japan, the effects of manufacturing conditions on properties of 60 different granulated blast-furnace slags and their resulting strengths in slag cements were studied.[23]

Another Japanese study of the effects of grinding method on uniformity of slag from separate plants was published.[24]

---

[14] Kliem, W. (assigned to Strassenbaustoffe G.m.b.H.), German Patent 953,055, Nov. 22, 1956.

[15] Archibald, W. A. (assigned to The British Iron & Steel Research Assoc.), British Patent 801,883, Sept, 24, 1958.

[16] Kleffel, E. O., and Kluge, H., East German Patent 14,259, Dec. 27, 1957.

[17] Energie-Versorgung Schwaben A. G., British Patent 821,741, Oct. 14. 1959.

[18] Kuzela, J., and Vavrin, F., Device for the Production of a Light Filling From Blast Furnace, Boiler and Other Slag: U.S. Patent 2,880,456, Apr. 7, 1959.

[19] Henderson, W. (assigned to Crowley Russel & Co., Ltd.), British Patent 804,599, Nov. 19, 1958.

[20] Dortmund-Horder Huttenunion A.G., British Patent 799,593, Aug. 13, 1958.

[21] Journal of the American Concrete Institute, Hydraulic Value of Slag From the Behavior of the Blast-Furnace: Vol. 30, No. 9, March 1959, p. 996.

[22] Stumper, R., and Schumacher, W., Heat of Hydration of Glassy Activated Blast-Furnace Slag: Jour. Appl. Chem. (London), vol. 9, January 1959, p. 11.

[23] Goto, Kazuo, Wada, Sadao, and Saito, Kazuyuki, [Relation Between the Apparent Properties of Slags and the Strength of Slag Cements]: Semento Gijutsu Nenpo (Tokyo), vol. 12, 1958, pp. 156–164.

[24] Ariizumi, Akira, and Yasuzawa, Shunji [Properties of Portland Blast-Furnace Slag Cements Used for a Dam and Their Uniformity]: Semento Gijutsu Nenpo (Tokyo), vol. 12, December 1958, pp. 174–180.

A Belgian patent described a blast-furnace-slag cement that had sodium sulfate and calcium hydroxide added to produce a cement with a lower heat of hydration and prevent formation of silicic acid gel.[25]

A series of comparative tests were conducted between portland cement and portland blast-furnace-slag cement. Results indicated that portland blast-furnace slag was about 25-percent stronger in mortar and 5-percent weaker in concrete than the regular cement.[26]

The usual ignition loss of portland-slag cement was prevented by oxidation of sulfide constituents. An evaluation of several methods of correcting the error produced by sulfide oxidation was published.[27]

A method of making high-early-strength cement from granulated blast-furnace slag was patented. The mixture contains 94 percent finely granulated slag, 4 percent anhydrous sodium sulfate, and 2 percent hydrated lime.[28]

A Japanese article disclosed that calcium chloride could be substituted for an insufficient quantity of gypsum in portland blast-furnace-slag cement to increase strength at an early age and also to increase the air content and slump of concrete.[29]

The cement industry in South Africa produced portland-blast-furnace cements using granulated dolomitic slag from the Pretoria steelworks. Test results showed that the high magnesia content of these slags did not cause delayed expansion in concrete.[30]

Poland increased utilization of slag and enlarged cement manufacturing facilities. Research on hydraulic properties carried out in Poland and other countries was reviewed.[31]

A rapid ASTM method of analysis by ignition in a helium atmosphere measures loss due to moisture, CO_2, and carbonaceous materials in portland blast-furnace-slag cement.[32]

Blast-furnace slag, lime, and fly ash were combined to form a masonry cement in Japan.[33]

According to a Russian article, use of electrocapillary motion of the metallic droplets in liquid slag at an approximate temperature of 1,400° C. made possible the complete extraction of sulfide inclusions.[34]

---

[25] Société Financière de Transports et d'Enterprises Industrielles S. A. [Fabrication of High Resistance Cement] (Sofina): Belgian Patent 555,216, Mar. 15, 1957 (printed Feb. 12, 1960).

[26] Bloem, Delmar L., Comparisons of Strength Development Between Portland Cement and Portland Blast-Furnace Slag Cement: NRMCA Pub. 90, October 1959, 11 pp.

[27] Chaiken, Bernard, Determination of Ignition Loss in Portland Blast-Furnace Slag Cements: ASTM Bull. 238, 1959, pp. 53–58.

[28] Société de Transports et d'Enterprises Industrielles (Sofina) Société Anonyme, British Patent 813,084, May 6, 1959.

[29] Suzuki, Setsuzo [Effect of Calcium Chloride on the Properties of Portland Blast-Furnace Slag Cement]: Semento Gijutsu Nenpo (Tokyo), vol. 12, 1958, pp. 164–171.

[30] Davies, R. J., Portland Blast-Furnace Cement: S. African Ind. Chemist, (Johannesburg), vol. 11, November 1957, pp. 232–235; Ceram. Abs., vol. 42, No. 8, August 1959, p. 201.

[31] Rogozinski, T., [Some Problems Connected With the Utilization of Blast-Furnace Slag in the Production of Cement]: Hutnik (Warsaw), vol. 25, January–February 1958, pp. 5–8.

[32] Chaiken, Bernard, Determination of Ignition Loss in Portland Blast-Furnace Slag Cement: ASTM Bull. 238, 1959, pp. 53–58.

[33] Nagai, Shoichiro, and Yoshimichi, Irokawa (assigned to Yokohama Natl. Univ.), Sekko to Sekkai (Tokyo): No. 41, 1959, pp. 19–24; Chem. Abs., vol. 53, No. 19, Oct. 10, 1959, p. 18433.

[34] Khlynov, V. V., and Esin, O. A., [Extracting Sulphide Inclusions from Molten Slags by Means of the Electric Field]: Doklady AN (Leningrad), vol. 123, February 1958, pp. 320–323.

The process of slag crystallization under natural cooling conditions was studied, and the kinetic factors in reducing the silica content of blast-furnace slags during the process of ironmaking were discussed.[35]

A rapid means for chemically analyzing slag and other materials was developed and reported by the British Coal Utilization Research Assoc.[36]

The Bureau of Mines conducted tests in an experimental blast furnace in which the charge column was quenched with nitrogen and solidified in plastic. Drilled cores showed that 65 percent of the ore and sinter were reduced just above the mantle and the greatest degree of reduction was in the smaller particles. Analysis also showed that the iron picked up sulfur and was desulfurized in the bosh and hearth; flux materials in the lower stack picked up sulfur. Flux and gangue did not combine into a common slag until just about the tuyere zone. The slag and metal in the hearth had a mixture of coke. In this test, natural gas was used to replace 30 percent coke; a reduction in the limestone charge and slag volume per ton of pig iron were correspondingly reduced.

Slag volume per ton of pig iron has been declining in recent years, owing mainly to use of higher iron content raw materials and better reduction processes. The comparative quantities of fluxes used and pig iron produced by States are shown in table 6 of the Iron and Steel chapter.

Although the aggregate industry has improved greatly in operating efficiency, a survey indicated a need for better understanding of operational improvements and pointed out available aids.[37]

The latest in a series of England's strategically located blast-furnace slag plants distributed 15,000 tons a week. In addition to slag processing, facilities were installed to utilize tar and asphalt.[38]

The importance of raw material beneficiation became evident through procedures developed at a Western blast-furnace operation. Compared with Eastern operations, the coke at this operation had weak strength, the limestone was crystalline rather than amorphous, the ore was high in sulfur, and the chemical analysis of all these materials varied widely from one sampling to the next. Nevertheless, the operation has been expanding continually.[39]

Inefficiency in open hearth slag handling was corrected by using tractor-trailer units to transport slag from the pit pouring tables to the dump site.[40]

The self-fluxing sinter process, using taconite pellets, created a demand for fine limestone and coke breeze—long a drug on the market.

---

[35] Fulton, James C., and Chipman, John, Kinetic Factors in the Reduction of Silica from Blast-Furnace Type Slags: Trans. Metallurgical Soc., vol. 215, No. 6, December 1959, pp. 888–891.

Langenberg, F. C., and Chipman, John, Activity of Silica in CaO–Al_2O_3–SiO_2 Slags at 1,600° and 1,700° C.: Trans. Metallurgical Soc., vol. 215, No. 6, December 1959, pp. 958–961, 962.

[36] Archer, K., Flint, D., and Jordan, J., Rapid Analysis of Coal Ash, Slag, and Boiler Deposits: Fuel, vol. 37, April 1958 (London), pp. 421–443.

[37] Rock Products, Aggregate Producers Invest for Profit: Vol. 62, No. 9, September 1959, pp. 75–78, 141.

[38] Green, Rowland, Tarmac's Slag, Bituminizing Operation: Pit and Quarry, vol. 51, No. 8, February 1959, pp. 86–92.

[39] Saussaman, J. D., Blast-Furnace Operation With Western Raw Materials: Iron and Steel Eng., vol. 35, No. 11, November 1958, pp. 77–82.

[40] Morgan, G. R., Open Hearth Slag Handling: Iron and Steel Eng., vol. 36, No. 20 (SIC), October 1959, pp. 129–132.

On the other hand, the relative quantity of blast-furnace slag produced by this method is less. Higher grade ores and taconite pellets reportedly will be used at the Interlake Iron Corp. self-fluxing sintering operation under construction at Chicago, Ill.[41]

Over a half-million tons of slag produced annually at a steel plant in Czechoslovakia has been a liability. A plant reportedly was being built to process the material for manufacturing building blocks.[42]

A paper presented at the annual meeting of the National Slag Association indicated that slag processing is relatively simple in terms of automation and it is possible to "overdesign" to the point where automatic controls can be impracticable and do not serve a real function in improving efficiency.[43]

---

[41] Blast-Furnace & Steel Plant, Interlake Iron Corporation to Install Sintering Plant: Vol. 47, No. 7, July 1959, p. 748.

[42] Bureau of Mines, Mineral Trade Notes, Slag-Iron Blast-Furnace: Vol. 49, No. 1, July 1959, p. 46.

[43] Herod, Buren C., National Slag Association Operators Offered Varied Program at Fifth Annual Meeting: Pit and Quarry, vol. 50, No. 10, April 1958, pp. 144–146.

Sodium and Sodium Compounds

By Robert T. MacMillan [1] and James M. Foley [2]

◆

RECORD output of both sodium carbonate and sodium sulfate from natural sources contributed to substantial increases in total production of these commodities in 1959.

DOMESTIC PRODUCTION

After a year of lower than normal demand, production of sodium and sodium compounds rebounded strongly. Compared with 1958 sodium carbonate output increased nearly 14 percent, and sodium sulfate nearly 13 percent.

Although sodium carbonate was produced largely from salt by the ammonia soda process, the proportion from natural deposits continued to gain, accounting for 15 percent of the total, compared with 13 percent in 1958.

Natural sodium carbonate was produced in California and Wyoming. In California, brine of Searles Lake was processed on the lakeshore at Trona by the American Potash and Chemical Corp., producing soda ash and other chemicals; Stauffer Chemical Co., West End Div., produced sodium carbonate from Searles Lake brine at nearby Westend; and Columbia Southern Chemical Corp. produced soda ash and sodium sesquicarbonate from Owens Lake brine near Bartlett.

In Wyoming, the Intermountain Chemical Co., a subsidiary of Food Machinery and Chemical Corp., mined trona at a depth of 1,500 feet from a large bedded deposit near Rock Springs (Sweetwater County). Most of the mine output was converted to dense soda ash in the processing plant before marketing.

Natural sodium sulfate was produced in three States by six companies. In California, American Potash and Chemical Corp. and Stauffer Chemical Co., West End Div., produced sodium sulfate from Searles Lake brines at Trona and Westend, respectively; U.S. Borax and Chemical Corp. produced sodium sulfate as a coproduct in making boric acid from borax. In Texas, natural sodium sulfate was produced from subterranean brine by Ozark Mahoning Co. In Wyoming, Wm. E. Pratt and the Sweetwater Chemical Co. (formerly Iowa Soda Products Co.) produced sodium sulfate from dry lakebeds.

---

[1] Commodity specialist.

[2] Supervisory statistical assistant.

TABLE 1.—Manufactured sodium carbonate produced[1] and natural sodium carbonates sold or used by producers in the United States

Year	Manufactured soda-ash (ammonia-soda process) [2]	Natural sodium carbonates [3]	
	Short tons (thousands)	Short tons (thousands)	Value (thousands)
1950–54 (average)	4,621	394	$9,581
1955	4,907	614	15,001
1956	4,998	653	17,400
1957	4,659	653	17,792
1958	[4] 4,324	629	17,032
1959	[5] 4,896	735	19,078

[1] U.S. 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).
[4] Revised figure.
[5] Preliminary figure.

TABLE 2.—Sodium sulfate produced and sold or used by producers in the United States

Year	Production (manufactured [1] and natural), thousand short tons			Sold or used by producers (natural only)	
	Salt cake (crude)	Glauber salt (100 percent $Na_2SO_4 \cdot 10H_2O$)	Anhydrous refined (100 percent Na_2SO_4)	Short tons (thousands) [2]	Value (thousands)
1950–54 (average)	665	187	209	237	$3,194
1955	738	149	[3] 278	285	5,381
1956	763	143	[3] 273	333	6,437
1957	709	[3] 128	[3] 280	331	6,542
1958	[3] 640	[3] 106	[3] 255	347	6,716
1959	[4] 728	[4] 110	[4] 286	403	7,689

[1] U.S. Bureau of the Census.
[2] Includes Glauber salt converted to 100-percent Na_2SO_4 basis.
[3] Revised figures.
[4] Preliminary figure.

Changes in the use pattern for rayon and technological changes in production methods for hydrochloric acid and bichromate affected the production of byproduct sodium sulfate.[3] Resurgence of rayon production in 1959, particularly for use as tire cord, led to increased recovery of sodium sulfate from this source. However, it was doubtful if the trend toward the use of nylon tire cord had been reversed. From an estimated 5 percent of the tire market in 1953, consumption of nylon cord increased to 30 percent in 1959. One major tire manufacturer announced that henceforth nylon cord would be used exclusively in its tires. In contrast with rayon, the making of nylon leaves no byproduct sodium sulfate.

Although recovery of sodium sulfate from the production of rayon is not always economical, the extent to which streams are polluted

---

[3] Oil, Paint and Drug Reporter, Sodium Sulfate Could Jump 200,000 tons in Output by '65: Vol. 176, No. 15, Oct. 5, 1959, pp. 3, 36, 39–40, 44.

by the waste material from rayon production must be considered. The need to avoid stream pollution may favor sodium sulfate recovery.

Since hydrochloric acid has become more available in recent years as a byproduct of organic chlorinations, the Mannheim furnaces as a source of salt cake are considered unlikely to expand production significantly. Bichromate sources of byproduct salt cake have remained static for several years also, and proposed new phenol plants are expected to employ the process based on cumene, instead of the benzenesulfonate process, from which salt cake is derived. However, some additional sodium sulfate is expected from expansion of cellophane production.

Following is a breakdown of estimated sodium sulfate production capacity by sources.[4]

	Yearly capacity, thousand short tons
Natural brines	454
Byproducts of—	
Rayon and cellophane plants	398
Hydrochloric acid (Mannheim and Hargreaves furnaces)	265
Bichromate plants	100
Phenol production	105
Boric acid production	21
Gulf coast petroleum refineries	20
Lithium carbonate production	12
Resorcinol production	7
Pigments production	5
Formic acid production	2
Miscellaneous	3
Total	1, 392

Metallic sodium production was 112,019 short tons, according to preliminary figures of the Bureau of the Census, U.S. Department of Commerce; it was 110,298 tons in 1958.

Metallic sodium was produced by three companies: National Distillers Chemical Co. plant at Ashtabula, Ohio; E. I. DuPont de Nemours and Co., Inc., plants at Niagara Falls, N.Y., and Memphis, Tenn.; and Ethyl Corp. plants at Baton Rouge, La., and Houston, Tex. With completion of the new Memphis plant by E. I. DuPont de Nemours and Co., metallic sodium production capacity exceeded demand in 1959 by a considerable margin.[5]

CONSUMPTION AND USES

Sodium carbonate was used in manufacturing chemicals, glass, nonferrous metals, pulp and paper, cleansers, water softeners, soap, and miscellaneous items. The use pattern was similar to that of the previous year; chemicals, including detergents, consumed the largest quantity, glassmaking was second, and nonferrous metals, third. Use of caustic soda instead of sodium carbonate in processing certain bauxites was advantageous.

Liquid detergents continued to replace soap, which formerly was an important consumer of soda ash. Although sodium compounds

---

[4] Work cited in footnote 3.

[5] Chemical Engineering, Who'll Use All That Sodium: Vol. 66, No. 22, Nov. 2, 1959, p. 36.

were used in liquid synthetic detergents, potassium compounds were reported to be advantageous in liquid detergents.[6]

As in previous years, the kraft-paper industry consumed most of the salt-cake production in 1959. Sodium sulfate was used also in making glass, detergents, stock feeds, dyes, textiles, medicines, and miscellaneous chemicals.

An estimated 75 to 80 percent of the sodium sulfate production was absorbed by the paper industry in digesting woodpulp and releasing the cellulose fiber for papermaking. The trend toward lower consumption of sodium sulfate per ton of pulp continued; average consumption dropped from 174 to an estimated 120 pounds per ton in 1959.

The principal use of metallic sodium was in manufacturing tetraethyl lead (TEL), which absorbed about three-quarters of all sodium produced. Other uses included production of high-energy fuels, metal descaling (mostly as sodium hydride), and reduction of ores of titanium, zirconium, columbium, beryllium, silicon, and other elements not readily reducible. Increased use of sodium as a reductant failed to develop as expected because titanium and zirconium output did not expand as rapidly as anticipated. One formerly important use of sodium was eliminated as a large soap and detergent manufacture converted its fatty alcohol facilities from sodium reduction to catalytic hydrogenation. Sodium was used also in making sodium peroxide, hydride, amide, cyanide, and borohydride.

A small sodium-cooled nuclear reactor in experimental operation produced 6,000 kw.[7]

PRICES

Quoted prices of sodium carbonate, sodium sulfate, and metallic sodium in Oil, Paint and Drug Reporter remained unchanged from those at the close of 1958. Soda ash dense, 58-percent Na_2O, carlots, works, was quoted at $1.60 cwt. in bulk, and $1.90 cwt. in paper bags. On the same basis light ash was quoted at $1.55 and $1.85.

Domestic salt cake, 100-percent Na_2SO_4, bulk, works, was $28 per ton. Sodium sulfate, technical, anhydrous, in bags, carlots, was quoted at $54 per ton. Rayon-grade sodium sulfate, in bags, carlots, works, was $36 per ton, and in bulk, $32 per ton.

Sodium metal fused in tanks, works, was quoted at 17 cents per pound; in bricks, lots of 18,000 pounds and over, the price was 19½ cents per pound, works.

FOREIGN TRADE[8]

Imports of sodium sulfate gained substantially for the second consecutive year, equaling 15 percent of U.S. production. The Belgium-Luxembourg area was the chief source, and Canada was the second.

---

[6] Oil, Paint and Drug Reporter, Soda Ash Volume To Be Swelled to 6.8 Million Tons During Decade: Vol. 176, No. 27, Dec. 28, 1959, p. 32.

[7] Chemical and Engineering News, Nuclear Power Growing: Vol. 37, No. 6, Feb. 9, 1959, p. 29.

[8] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

Together these nations supplied about 95 percent of the total imports of the commodity; the remainder came from West Germany.

Exports of sodium sulfate and sodium carbonate also increased. Sodium sulfate exports were 2 percent and sodium carbonate approximately 3 percent, respectively, of U.S. production.

TABLE 3.—Sodium sulfate imported for consumption in the United States

(Thousand short tons and thousand dollars)

[Bureau of the Census]

Year	Crude (salt cake)		Anhydrous		Total [1]	
	Quantity	Value	Quantity	Value	Quantity	Value
1950-54 (average)	72	$1,084	5	$127	77	$1,211
1955	121	2,412	4	117	125	2,529
1956	99	2,047	4	127	103	2,174
1957	73	1,450	2	61	75	1,511
1958	95	1,905	2	62	97	1,968
1959	118	2,478	4	97	122	2,580

[1] Includes Glauber salt, as follows: 1958, 12 tons, at $830; 1959, 227 tons, at $4,839.

TABLE 4.—Sodium carbonate and sodium sulfate exported from the United States

(Thousand short tons and thousand dollars)

[Bureau of the Census]

Year	Sodium carbonate		Sodium sulfate	
	Quantity	Value	Quantity	Value
1950-54 (average)	131	$4,891	25	$726
1955	153	4,933	25	870
1956	242	8,219	30	1,037
1957	174	6,282	24	859
1958	104	4,279	20	786
1959	153	5,644	22	805

WORLD REVIEW

Canada.—Sales of salt cake from natural deposits at Bishopric and Chaplin, Saskatchewan, increased despite a work stoppage at British Columbia papermills—the main outlet. Rising freight rates were said to be a threat to the sodium sulfate industry.[9]

Egypt.—A caustic-soda chlorine plant was under construction at Mex, the center of the salt-producing area. Said to be the first in the Middle East, the plant will have an initial capacity of 20,000 tons a year.[10]

India.—In October, a new caustic-soda plant with capacity of 30,000 tons annually was commissioned at Sahupuram, Madras. New soda ash plants were licensed at Porbandar, Moghalsarai and Bombay. The first two were to be in production in 1959. Tariff protection of the soda ash industry was extended to 1961.[11]

---

[9] Canadian Mining Journal, vol. 80, No. 4, April 1959, p. 148.

[10] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 6, December 1959, p. 53.

[11] Chemical Trade Journal and Chemical Engineer (London), vol. 144, No. 3739, Jan. 30, 1959, p. 259.

Korea.—A 40,000-ton-per-year soda ash plant was planned for the Samchok area, using Korean salt. The Development Loan Fund approved loans up to $5.6 million for the project.[12]

Pakistan.—Discovery of hot pressurized brine containing salts of sodium, potassium, calcium, and magnesium was reported in Jhelum near Dhariala. Exploitation of the deposit awaited results of experimental work.[13]

Turkey.—Exploitation of the Lake Van soda deposits was begun. A projected plant of 70,000 tons annual capacity was expected to produce soda ash mostly for export.[14]

TECHNOLOGY

Although demand for soda ash is high the investment for new ammonia soda facilities is large, and several alkali producers were investigating natural sources of soda ash near Intermountain Chemical Co. holdings in Sweetwater County, Wyo. Results of intensive drilling and sampling in the area were not made public, but the activity indicated that natural sources of soda ash were considered economically attractive, compared with the ammonia soda process.[15]

The twin problems of stream pollution and chemical recovery, which affect the pulp and paper industry, received increasing attention. Several processes were developed and achieved technical success but were questionable in process economics.[16]

A plant-scale recovery operation was started in Lynchburg, Va. In the process the spent liquor is concentrated and burned. Furnace residue containing sodium compounds is treated with flue gases containing carbon dioxide and sulfur gases to regenerate cooking chemicals.

Another plant for recovering pulping chemicals was started operating in Wisconsin. Spent liquor from the pulping process was first treated with Na_2S (sodium sulfide) and Na_2Co_3 (sodium carbonate)—to overcome a corrosion problem—then evaporated to 65 percent solids and burned. Flue gases and furnace residues were recombined in correct proportions to produce the desired cooking liquor.[17]

Production of sodium carbonate from salt by continuous anion exchange was found to be technically feasible by a Tennessee firm.[18] Still in the early stage of development the process does not produce high concentrations and quality alkali, but for certain uses it offers a high potential production rate and the ability to handle slurries.

Russian experiments in producing sodium carbonate by ion exchange indicated sulfonated coal to be the cheapest ion exchanger.[19]

---

[12] Chemical Trade Journal and Chemical Engineer (London), vol. 145, No. 3782, Nov. 27, 1959, p. 1048.

[13] Canadian Mining Journal, Brine Deposits in Pakistan: Vol. 80, No. 8, August 1959, p. 127.

[14] Mining Journal (London), vol. 253, No. 6486, Dec. 11, 1959, p. 605.

[15] Chemical Week, vol. 85, No. 9, Aug. 29, 1959, p. 40.

[16] Chemical Engineering, vol. 66, No. 6, Mar. 23, 1959, pp. 87, 90.

[17] Chemical Engineering Progress, Soda Ash Recovery Process in Operation: Vol. 55, No. 8, August 1959, pp. 86, 88.

[18] Chemical Engineering, vol. 66, No. 12, June 15, 1959, p. 76.

[19] Journal of Applied Chemistry of USSR [Preparation of Sodium Carbonate and Bicarbonate by Means of Ion Exchangers]: Vol. 32, No. 2, February 1959, pp. 273–278.

An improved process for producing tetraethyl lead using sodium hydride to split the ethylene double bond was described. Trialkyl aluminum, an intermediate in the process, was electrolized, using a cell having a lead anode. Trialkyl aluminum and metallic sodium were recovered and recycled. Economies in power consumption and lower temperatures were claimed for the process.[20]

The excellent heat-transfer properties of metallic sodium were utilized in the design of a continuous annealing furnace for annealing steel strip. The new design, requiring a fraction of the space and investment of conventional annealing lines, consisted of a deep tank of molten sodium through which the strip moves at speeds of 1,000 f.p.m. Heat economies were claimed for the design, which utilized conduction rather than radiation for heat transfer. Coefficients of heat transfer were said to range from 1,400 to 6,000 B.t.u./sq. ft./hr., depending on the strip speed.

Other advantages of the sodium annealing furnace were: More uniform heating across the width of the strip, and the fact that the strip may be stopped in the annealer without damage. In conventional annealing furnaces the motion of the strip through the furnace must be continuous to avoid overheating; hence, to permit changing coils and welding the front end of one strip to the rear of the preceding strip, expensive looping towers and pits were necessary. In the sodium annealer these were eliminated, and the motion of the strip is stopped while adjustments are made.

Although molten sodium does not attack or alloy with the steel, it removes all oxides and oil films from the metal, and the strip emerges chemically clean. Liquid sodium adhering to the strip leaving the furnace is removed by revolving nickel wire brushes. The remaining sodium film quickly oxidizes to Na_2O (sodium oxide) which is dissolved by a water spray. Residual heat in the strip quickly evaporates the water.

Problems associated with the use of a substance as highly reactive as sodium were considered in the design of the continuous annealing furnace, which was said to be ready for pilot-plant testing.[21]

A slight modification in design of the sodium graphite power reactor at Hallam, Neb., was approved by the Atomic Energy Commission to enable some of the highly radioactive sodium coolant to be removed from the core for food irradiation. Many foods such as grain, meat, potatoes, onions, and beets may be sterilized by irradiation, increasing preservation time manyfold. No toxic effects were reported from human consumption of food sterilized by radiation.[22]

---

[20] Chemical and Engineering News, vol. 37, No. 24, June 15, 1959, p. 22.

[21] Keller, J. D., Continuous Annealing in Molten Sodium: Iron and Steel Eng., vol. 36, No. 11, November 1959, pp. 125–133.

[22] Chemical Engineering, vol. 66, No. 9, May 14, 1959, p. 56.

Stone

By Wallace W. Key,[1] George H. Holmes, Jr.,[1] and Nan C. Jensen[2]

❖

Contents

CONTINUED expansion of the domestic construction industry resulted in another stone production record in 1959. However, the unprecedented Federal Highway Program, begun in 1956 and first felt by crushed stone producers in 1958, encountered financial difficulties in 1959. These caused a reduction in the anticipated output of crushed stone products.

Despite a reduced level of new highway contract awards, caused by a temporary deficiency in the Interstate Highway Program trust fund, a reduction in military construction, and the July–November steel strike, there was a spectacular rise in total construction activity. Private housing construction provided the main stimulus for this increased activity, as higher interest rates stimulated financing and lower minimum downpayments improved sales. Although national crushed-stone sales were at a record level, output dropped in many localized areas. An increase in use of portable plants, use of inferior aggregates close to the jobsite, competition from substitute and synthetic materials, and price cutting were problems of immediate concern throughout the industry.

TABLE 1.—Salient statistics of the stone industry in the United States[1]

(Thousand short tons and thousand dollars)

	1950–54 (average)	1955	1956	1957	1958	1959
Dimension stone:						
Quantity	2,142	2,674	2,640	2,456	2,522	2,442
Value	$66,934	$82,575	$83,473	$83,688	$80,254	$87,571
Crushed stone:						
Quantity	320,039	468,577	504,871	530,967	[2] 533,401	581,721
Value	$436,441	$638,634	$694,972	$741,714	[2] $746,431	$824,411
Total sold or used by producers:						
Quantity	322,181	471,251	507,511	533,423	[2] 535,923	584,163
Value	$503,375	$721,209	$778,445	$825,402	[2] $826,685	$911,982
Imported for consumption: Value[3]	$4,153	$5,728	$7,857	$8,792	$8,312	$11,064
Exported: Value	[4] $1,076	$5,491	$5,602	$6,013	$6,756	$7,292

[1] Includes slate; 1950–56 includes Territories of the United States, possessions, and other areas administered by the United States; 1957–59 includes Alaska and Hawaii.
[2] Revised figure.
[3] Includes whiting.
[4] Excludes crushed, ground, or broken stone not classified separately before Jan. 1, 1952.

---

[1] Commodity specialist.
[2] Supervisory statistical assistant.

TABLE 2.—Stone sold or used by producers in the United States, by States[1]

(Thousand short tons and thousand dollars)

State	1958		1959	
	Quantity	Value	Quantity	Value
Alabama	[2] 11,080	[2] $17,068	[2] 11,886	[2] $18,728
Alaska	615	2,065	89	377
Arizona	1,528	2,731	2,468	3,998
Arkansas	8,461	10,178	8,824	10,424
California	32,423	48,345	32,134	49,090
Colorado	2,930	4,943	2,824	5,537
Connecticut	4,223	6,863	4,462	7,088
Delaware	(3)	(3)	(3)	(3)
Florida	[2] 23,549	[2] 30,983	[2] 26,917	[2] 35,940
Georgia	12,129	31,108	13,771	35,973
Hawaii	2,377	4,446	3,034	5,480
Idaho	[4] 1,391	[4] 1,794	1,079	1,931
Illinois	35,016	44,245	35,294	45,081
Indiana	15,394	31,974	18,544	37,682
Iowa	21,045	26,138	20,501	25,759
Kansas	[2] 12,424	[2] 15,036	[2] 13,999	[2] 17,108
Kentucky	12,597	17,360	[2] 16,063	[2] 22,215
Louisiana	5,453	9,532	5,670	10,874
Maine	880	2,760	819	2,766
Maryland	6,721	14,387	7,445	15,476
Massachusetts	4,649	12,354	5,102	12,375
Michigan	27,188	26,846	30,095	30,379
Minnesota	3,519	9,560	3,639	9,461
Mississippi	[2] 102	[2] 92	[2] 126	[2] 114
Missouri	24,276	32,878	26,939	36,435
Montana	[4] 1,786	[4] 2,468	1,186	1,691
Nebraska	3,555	4,747	3,236	5,235
Nevada	813	1,335	840	1,587
New Hampshire	(3)	(3)	82	488
New Jersey	8,229	19,193	10,079	22,133
New Mexico	1,730	1,507	461	542
New York	22,598	38,219	28,640	46,556
North Carolina	12,385	19,132	12,859	20,302
North Dakota	23	35	48	84
Ohio	29,122	49,782	[2] 36,155	[2] 59,326
Oklahoma	10,794	12,232	12,683	14,980
Oregon	[4] 15,077	[4] 15,621	13,341	16,126
Pennsylvania	40,049	69,694	43,682	77,421
Rhode Island	[2] 3	[2] 8	(3)	(3)
South Carolina	[2] 3,637	[2] 5,229	[2] 6,247	[2] 8,647
South Dakota	1,395	4,095	2,721	7,243
Tennessee	[2] 16,850	[2] 26,814	18,767	29,094
Texas	36,076	40,912	42,172	47,787
Utah	13,126	13,949	3,338	4,048
Vermont	808	15,789	944	17,372
Virginia	15,413	27,504	17,787	31,447
Washington	7,837	9,991	12,278	13,587
West Virginia	[2] 5,599	[2] 9,990	[2] 5,923	[2] 10,482
Wisconsin	13,722	23,334	13,522	23,782
Wyoming	1,099	1,472	1,317	1,791
Undistributed	4,227	9,947	4,131	9,940
Total	535,923	826,685	584,163	911,982
American Samoa	30	59	178	219
Canton Island			(5)	1
Guam	684	751	568	1,109
Midway Island	175	476		
Panama Canal Zone	140	237	223	270
Puerto Rico	1,986	2,768	2,063	2,878
Virgin Islands	25	81	14	51
Wake Island	10	37	32	34

---

[1] Includes slate.

[2] To avoid disclosing individual company confidential 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 State tables in the Statistical Summary chapter of this volume.

[3] Figures withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[4] Revised figure.

[5] Less than 500 tons.

TABLE 3.—Stone sold or used by producers in the United States, by kinds[1]

(Thousand short tons and thousand dollars)

Year	Granite		Basalt and related rocks (traprock)		Marble		Limestone and dolomite		Shell	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1950–54 (average)	22,287	$52,690	28,593	$43,960	351	$11,689	229,026	$318,054	[2] 12,358	[2] $15,320
1955	26,079	59,581	35,851	56,141	1,092	19,786	[3] 361,524	[3] 489,002	15,131	22,630
1956	29,640	65,995	38,052	63,021	947	18,380	[3] 381,001	[3] 516,687	19,852	28,368
1957	41,636	75,985	43,798	72,869	1,423	23,707	383,022	532,863	19,098	27,563
1958	[4] 31,958	[4] 69,491	[4] 44,605	[4] 69,496	1,405	27,656	391,447	535,522	18,916	31,876
1959	37,571	78,416	51,779	80,454	1,895	32,269	433,955	600,497	20,180	34,810

Year	Calcareous marl		Sandstone		Slate		Other stone[5]		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1950–54 (average)	(6)	(6)	9,463	$27,472	790	$13,578	19,313	$20,612	322,181	$503,375
1955	(6)	(6)	13,108	38,624	760	12,914	17,706	22,531	471,251	721,209
1956	(6)	(6)	13,447	46,389	645	11,666	23,927	27,939	507,511	778,445
1957	1,916	$1,804	16,294	49,102	632	11,029	25,604	30,480	533,423	825,402
1958	1,803	1,660	24,973	53,677	638	11,459	20,178	25,848	[4] 535,923	[4] 826,685
1959	2,043	1,926	17,553	46,467	656	11,288	18,531	25,855	584,163	911,982

---

[1] 1950–56 includes Territories of the United States, possessions, and other areas administered by the United States; 1957–59 includes Alaska and Hawaii.

[2] 1954 only; data not available 1950–53.

[3] Includes calcareous marl used in making cement.

[4] Revised figure.

[5] Includes mica schist, conglomerate, argillite, various light-colored volcanic rocks, serpentine not used as marble, soapstone sold as dimension stone, etc.

[6] Calcareous marl for agriculture not included in stone; marl used in making cement, 1954–56, included with limestone.

Legislation and Government Programs—The Federal-Aid Highway Act of 1956 was designed to provide a long-range program for a 41,000-mile network of interstate highways to handle traffic predicted for the system in 1975 and to improve the Federal-aid primary and secondary systems and urban extensions. According to Bureau of Public Roads figures, 815,000 miles or about one-fourth of the Nation's mileage was under some form of Federal aid in 1959.

The 1956 Act authorized nearly $25 billion of Federal funds for improvements to the interstate system over a period of 13 years (1957–69). The matching basis for these funds is 90 percent Federal and 10 percent State. The 1956 Act and later legislation also increased regular authorization for primary and secondary roads (usually termed ABC Federal aid, matched on a 50–50 basis by the States). Authorizations under this program from 1957 to 1961 were to be $4.4 billion, and the aid was expected to continue at the 1959 level for at least 10 additional years.

According to estimates,[3] about 114,000 tons of aggregates (crushed stone, gravel, sand, and slag) is used for every million dollars' worth of construction in the Federal highway program. Of this quantity, the contractors were expected to produce 65,000 tons. The remainder was to be purchased.

Between July 1956 and December 1959, construction contracts were completed on nearly 6,000 miles of road under the Federal Aid Program at a cost of $2.4 billion. About 4,700 bridges had been completed, and nearly as many were under construction at the end of 1959. Work under the ABC construction contracts had been completed on 95,700 miles of road and 15,800 bridges since July 1, 1956, at a cost of $5.75 billion.

Congress approved an advance of $359 million for fiscal year 1960 from general revenues to the Highway Trust Fund to overcome a shortage in funds, which had forced many States to delay highway contract awards.[4]

The Federal Airport Program for fiscal 1960 included 288 construction projects for which the Federal Government will provide about $57 million, to be matched on a 50–50 basis by local project sponsors.[5] Congress also passed a $1.177 billion public-works appropriation bill, which allocated $868 million for the Civil Works Program of The Corps of Engineers, $250 million for the Bureau of Reclamation, and about $15 million for the Tennessee Valley Authority (TVA).[6]

---

[3] Armstrong, Ellis L., Highways and the National Economy: Crushed Stone Jour., vol. 35, No. 1, March 1960, pp. 12–15, 17.

[4] The Constructor, President Signs New Highway Act But Says Spending Must Be Limited: Vol. 16, No. 10, October 1959, p. 63.

[5] The Constructor, Federal Airport Program in Fiscal 1960 Provides $57 Million for 288 Projects: Vol. 16, No. 12, December 1959, p. 47.

[6] The Constructor, $1.177 Billion Public Works Bill Passed Over Presidential Veto: Vol. 16, No. 10, October 1959, p. 60.

DIMENSION STONE

Production of dimension stone totaled 2.4 million short tons valued at $87.6 million, a slight decrease in tonnage but an increase of 9 percent in value. Although there were 583 plants operating in 43 States in 1959, most of the tonnage came from certain districts of Indiana, Pennsylvania, Georgia, Ohio, Massachusetts, Vermont, Tennessee, Wisconsin, New York, and Minnesota.

Dimension stone was a term applied to stone sold in blocks and slabs of specified shapes and usually specified sizes, including cut stone, rough building stone, rubble, monumental stone, paving blocks, curbing, flagging, and various ornaments and novelties carved from stone. Many types of stone were used for dimension-stone applications, but they have been grouped under the categories: granite, traprock, sandstone, limestone, marble, slate, and miscellaneous stone.

Statistics of the stone industries of the United States are based on production during the year. Stocks of finished products are small and nearly constant from year to year; therefore, production and consumption may be considered synonymous. A considerable quantity of dimension stone was used as thin slabs, 7/8 to 4 inches thick, as a facing in building lobbies and on building exteriors.

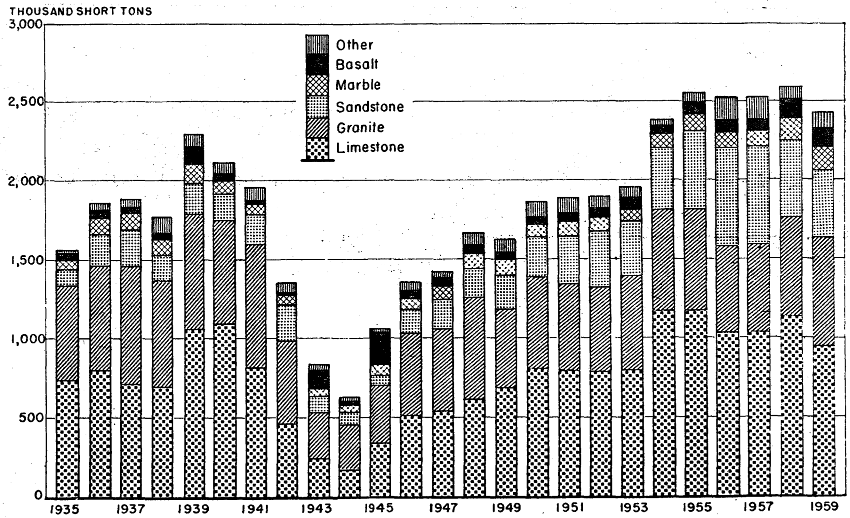

Figure 1.—Sales of dimension stone, except slate, in the United States and Puerto Rico, by kinds, 1935–59.

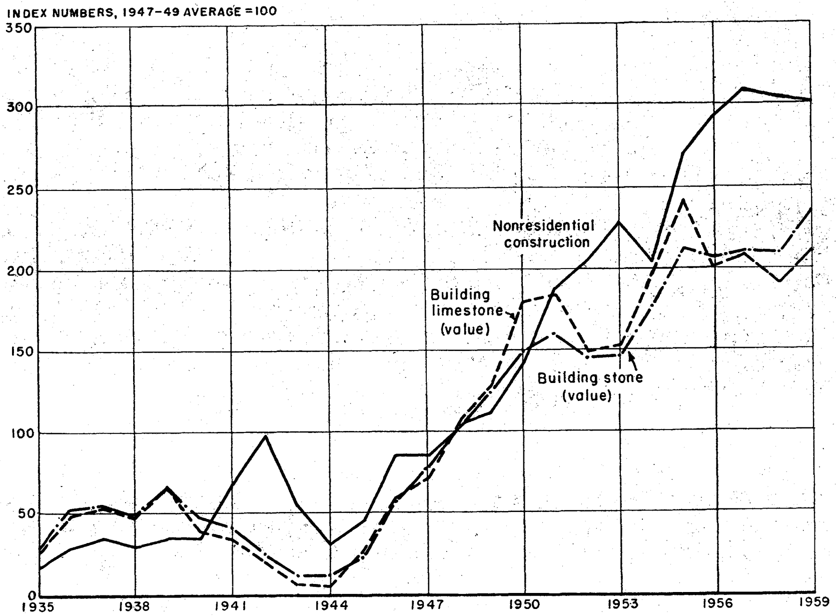

FIGURE 2.—Sales of all building stone, compared with sales of building limestone and value of all nonresidential construction, 1935–59.

(Data on nonresidential-building construction from Survey of Current Business, U.S. Department of Commerce.)

TABLE 4.—Dimension stone sold or used by producers in the United States, by uses

(In thousands)

Use	1958			1959		
	Short tons	Cubic feet	Value	Short tons	Cubic feet	Value
Building:						
Rough:						
Construction	353	----------	$2,048	245	----------	$1,805
Architectural [1]	396	5,283	6,615	354	4,744	6,303
Dressed:						
Sawed [1]	604	7,889	20,226	611	8,063	21,405
Cut	198	2,527	21,170	233	2,968	26,485
Rubble	303	----------	1,139	360	----------	1,606
Roofing (slate)	33	----------	2,020	29	----------	1,810
Millstock (slate)	24	----------	3,113	21	----------	3,095
Monumental (rough and dressed)[2]	236	2,843	17,257	236	2,840	17,862
Paving blocks [3]	101	----------	475	29	----------	144
Curbing	128	1,555	3,095	155	1,860	3,811
Flagging [4]	146	1,760	3,096	169	2,050	3,245
Total	2,522	----------	80,254	2,442	----------	87,571

[1] Includes stone for refractory use to avoid disclosing individual company confidential data.
[2] Includes stone for precision surface plates.
[3] Includes a substantial quantity of blocks for other uses.
[4] Includes a small quantity of slate for miscellaneous uses.

GRANITE

Dimension granite sales and value increased; there were seven additional active plants.

Dimension granite was produced chiefly in the Appalachian district of the eastern United States, from Maine to Georgia, and in the Middle Western States, particularly Minnesota, South Dakota, Texas, and Oklahoma. Relatively small quantities were produced in the Rocky Mountain and Pacific Coast States.

The granite industry depended upon large building contracts and the monument trade for most of its income. A tentative specification for structural granite (C–422–59T), promulgated in 1958 by Committee C–18 of American Society for Testing Materials, was held in abeyance for a year to allow wider participation in evaluating requirements.

TABLE 5.—Granite (dimension stone) sold or used by producers in the United States, by uses

(In thousands)

Use	1958			1959		
	Short tons	Cubic feet	Value	Short tons	Cubic feet	Value
Building:						
Rough:						
Construction	48	----------	$315	81	----------	$638
Architectural	15	181	588	14	173	500
Dressed:						
Construction	36	434	1,531	21	248	1,245
Architectural	32	382	4,129	35	415	4,854
Rubble	50	----------	166	104	----------	390
Monumental: [1]						
Rough	168	2,036	8,350	174	2,091	8,046
Dressed	46	556	5,539	48	589	7,153
Paving blocks [2]	101	----------	475	29	----------	144
Curbing and flagging	125	1,512	2,966	148	1,773	3,618
Total	621	----------	24,059	654	----------	26,588

[1] Includes stone for precision surface plates.
[2] Includes substantial quantity of blocks for other uses.

TABLE 6.—Granite (dimension stone) sold or used by producers in the United States in 1959, by States

State	Active plants	Short tons	Value	State	Active plants	Short tons	Value
California	14	7,662	$634,286	South Dakota	9	18,568	$3,065,502
Colorado	4	1,307	56,400	Texas	4	33,932	966,946
Georgia	23	161,510	3,717,610	Washington	5	2,102	29,634
Minnesota	22	25,903	3,093,828	Wisconsin	10	8,208	1,529,636
Missouri	1	2,852	275,230	Wyoming	1	300	4,000
Oklahoma	8	4,838	547,816	Other States [1]	50	347,755	12,035,286
Pennsylvania	4	24,720	254,007				
South Carolina	3	13,940	377,599	Total	158	653,597	26,587,780

[1] Includes Connecticut, 7 plants; Maine, 6; Maryland, 3; Massachusetts, 9; New Hampshire, 2; New York, 3; North Carolina, 10; Oregon, 1; Rhode Island, 2; and Vermont, 7.

BASALT AND RELATED ROCKS (TRAPROCK)

Demand for dark-colored building stones remained low in 1959. Output of dressed architectural stone and precision surface plates totaled 1,379 short tons valued at $323,306, about the same as in 1958. Rough-construction and rubble-stone output (13,047 tons) and value ($53,516) declined.

Stone generally known commercially as "black granite" is included in this group.

MARBLE

Dimension marble used for construction and memorial work increased in quantity and value, compared with 1958. The average value of marble per cubic foot increased $1.46; most of this increase was attributed to memorial stone.

Stone classified as commercial marble in 1959 included four groups: (1) High-calcium (accounting for nearly all production) or dolomitic marbles derived from limestone by recrystallization resulting from the heat and pressure of mountain-building forces; (2) limestone, which is usually sufficiently dense to take a good polish and exhibits an attractive pattern on its surface, caused by alternating bedding or brecciation; (3) onyx marbles (Mexican onyx, cave onyx, travertine); and (4) verd antique or serpentine marbles. A tentatively considered American Society for Testing Materials (ASTM) proposed specification for exterior marble may omit the last two groups and "dolomitic marble."

TABLE 7.—Marble (dimension stone) sold or used by producers in the United States[1]

(In thousands)

Use	1958			1959		
	Short tons	Cubic feet	Value	Short tons	Cubic feet	Value
Building:[2]						
Rough: Architectural	21	251	$895	20	241	$760
Dressed:						
Sawed	54	633	3,085	48	563	3,456
Cut	39	461	8,283	56	652	11,368
Monumental (rough and finished)	22	251	3,368	13	151	2,501
Total	136		15,631	137		18,085

[1] Produced by the following States in 1959 in order of value and with number of plants: Vermont, 9; Georgia, 2; Tennessee, 12; Missouri, 4; Alabama, 2; North Carolina, 1; Arkansas, 1; Maryland, 1; and Colorado, 2.

[2] Includes: 1958—755,000 cu. ft. of building stone, valued at $5,567,000, for exterior use, and 590,000 cu. ft. $6,696,000, for interior use; 1959—748,000 cu. ft., $7,439,000, for exterior use, and 708,000 cu. ft., $8,145,000, for interior use.

LIMESTONE

Limestone blocks cut to definite shapes and sizes were used mainly for building purposes. Small quantities were used for curbing and flagging and a negligible quantity for memorials. A few more plants produced dimension limestone, but sales decreased 3 percent. Average value increased $2.10 a ton to $21.26 in 1959.

The Bedford-Bloomington (Ind.) area continued to produce most (76 percent) of the rough-block and finished-dimension limestone in the United States. Sales by firms operating quarries in the district, as shown in table 10, include also a minor quantity of byproduct crushed stone. Some dimension limestone producers utilized the scrap resulting from the block and slab production to supply local crushed-stone markets.

Although limestone occurs in nearly every State, only a few deposits were suitable for dimension stone or favorably situated for quarrying or marketing.

ASTM Committee C–18 initiated action to formulate specifications for exterior limestone.

TABLE 8.—Limestone (dimension stone) sold or used by producers in the United States, by uses

(In thousands)

Use	1958			1959		
	Short tons	Cubic feet	Value	Short tons	Cubic feet	Value
Building:						
Rough:						
Construction	102		$263	67		$248
Architectural	256	3,510	3,456	223	3,099	3,150
Dressed:						
Sawed	331	4,452	7,682	354	4,809	8,868
Cut	86	1,154	6,582	100	1,351	7,695
Rubble	184		520	172		518
Curbing and flagging	20	260	254	36	476	214
Total	979		18,757	952		20,693

TABLE 9.—Limestone (dimension stone) sold or used by producers in the United States in 1959, by States

State	Active plants	Short tons	Value	State	Active plants	Short tons	Value
Indiana	19	587,059	$14,412,800	Oklahoma	4	2,627	24,712
Iowa	5	8,012	74,072	Tennessee	1	625	5,000
Kansas	9	39,004	502,863	Texas	9	49,801	1,105,880
Michigan	4	6,503	58,120	Wisconsin	29	89,706	1,458,070
Minnesota	9	44,262	1,573,312	Other States [1]	16	83,854	1,340,660
Missouri	9	32,500	105,827				
Nebraska	3	4,300	19,500	Total	119	952,428	20,693,196
Ohio	2	4,175	12,380	Puerto Rico	8	10,322	23,424

[1] Includes Alabama 1 plant, California 4, Connecticut 1, Florida 1, Illinois 5, New York 2, and Pennsylvania 2.

TABLE 10.—Limestone sold by producers in the Indiana oolitic limestone district, by classes

(In thousands)

Year	Construction					
	Rough blocks		Sawed and semifinished		Cut	
	Cubic feet	Value	Cubic feet	Value	Cubic feet	Value
1950-54 (average)	2,316	$2,568	3,276	$5,036	901	$4,857
1955	3,260	3,878	4,405	7,777	1,142	6,512
1956	2,969	3,378	2,801	5,626	812	4,921
1957	2,937	2,928	3,289	6,044	1,007	6,106
1958	2,941	2,967	3,007	5,104	725	4,273
1959	2,719	2,731	3,380	6,037	951	5,443

Year	Construction—Continued			Other uses		Total	
	Total						
	Cubic feet	Short tons	Value	Short tons	Value	Short tons	Value
1950-54 (average)	6,493	471	$12,461	180	$348	651	$12,809
1955	8,807	639	18,167	201	575	840	18,742
1956	6,582	477	13,925	163	452	640	14,377
1957	7,233	524	15,078	161	388	685	15,466
1958	6,673	484	12,344	168	449	652	12,793
1959	7,050	511	14,211	155	432	666	14,643

SANDSTONE

Sandstone (including quartzite) used as dimension stone decreased 3 percent in quantity but increased 4 percent in value. Slight increases in sales were reported for sandstone sold for rough construction and curbing and as cut stone. Total unit value increased slightly. One hundred seventy-five plants, an increase of 17, operated in 1959. Ohio continued as the leading State in the production of sandstone; Pennsylvania, Tennessee, and New York followed.

TABLE 11.—Sandstone (dimension stone) sold or used by producers in the United States, by uses

(In thousands)

Use	1958			1959		
	Short tons	Cubic feet	Value	Short tons	Cubic feet	Value
Building:						
Rough:						
Construction	81	----------	$899	88	----------	$878
Architectural [1]	104	1,341	1,676	97	1,231	1,893
Dressed:						
Sawed [1]	139	1,852	4,686	138	1,855	4,705
Cut	41	530	2,176	42	543	2,407
Rubble	59	----------	303	45	----------	237
Curbing	3	43	129	4	49	149
Flagging	62	769	1,444	59	718	1,476
Total	489	----------	11,313	473	----------	11,745

[1] Includes stone for refractory use to avoid disclosing individual company confidential data.

Bluestone of Pennsylvania and New York accounted for 600,000 cubic feet, valued at $1,342,000. Tennessee Crab Orchard quartzite continued in high demand, particularly for building fronts. The ASTM C–18 Committee renewed efforts to develop sandstone specifications.

TABLE 12.—Sandstone (dimension stone) sold or used by producers in the United States in 1959, by States

State	Active plants	Short tons	Value	State	Active plants	Short tons	Value
Alabama	1	500	$3,140	New Mexico	2	458	$10,850
Arizona	14	17,401	230,346	New York	14	44,161	1,228,466
Arkansas	13	22,722	296,051	Ohio	16	146,709	5,857,391
California	10	4,545	69,798	Pennsylvania	25	84,189	744,054
Colorado	17	13,164	212,305	Tennessee	12	53,290	1,414,405
Georgia	3	3,056	63,300	Utah	3	1,186	29,808
Kentucky	4	2,405	40,984	Wisconsin	8	3,129	50,994
Massachusetts	1	122	9,168	Wyoming	1	413	31,490
Michigan	4	21,779	154,510	Other States [1]	19	46,625	1,166,288
Missouri	4	5,209	83,125				
Nevada	4	1,924	48,646	Total	175	472.987	11,745,119

[1] Includes Indiana 5 plants, Kansas 1, Maryland 1, Oklahoma 2, Texas 2, Virginia 2, Washington 4, and West Virginia 2.

SLATE

Four States—Pennsylvania, Vermont, Virginia, and New York—produced over 95 percent of the total slate output. Total production increased 3 percent to 119,000 short tons valued at $6,365,000. Average value a ton decreased from $55.92 to $53.49.

Roofing slate ranged from 7 by 9 to 16 by 24 inches and was commonly $\frac{3}{16}$-inch thick. Architectural grades were much thicker and heavier. "Millstock" slate was produced for interior features such as mantels, floor tiles, steps, risers, baseboard, window sills, wainscoting, lavatory slabs, laboratory sinks and hoods, billiard tabletops, vaults, blackboards, electrical panels, and switchboards. Irregular slabs of slate were used for flagging or stepping stones.

Waste slate, which accounted for as much as 80 percent of gross production at some operations, remained a major problem in the industry. Some progress was made in increasing its utilization as granules, flour, lightweight aggregate and miscellaneous materials. Another matter of some concern to the industry was the reduced tariff rate on structural slate under General Agreements on Tariff and Trade (GATT) concessions that reportedly encouraged serious competition from foreign materials.

Slabs of Vermont slate were quarried selectively and processed into required dimensions for use in multidimensional sculpture.[7]

---

[7] Stone, Vermont Slate Used in Multidimensional Sculpture: Vol. 79, No. 8, August 1959, pp. 17, 28.

TABLE 13.—Slate (dimension stone) sold or used by producers in the United States[1]

(In thousands)

Use	1958			1959		
	Quantity		Value	Quantity		Value
	Unit of measurement	Approximate short tons		Unit of measurement	Approximate short tons	
Roofing slate	*Squares* 86	33	$2,020	*Squares* 75	29	$1,810
Millstock:						
Electrical, structural, and sanitary slate [2]	*Sq. ft.* 2,325	20	2,024	*Sq. ft.* 2,065	17	2,016
Blackboards and bulletin boards [3]	1,323	3	1,042	1,246	3	1,029
Billiard tabletops	60	1	47	67	1	50
Total millstock	3,708	24	3,113	3,378	21	3,095
Flagstones [4]	9,982	55	1,190	10,933	60	1,232
Miscellaneous uses [5]	----------	3	108	----------	9	228
Grand total	----------	115	6,431	----------	119	6,365

[1] Produced by the following States in 1959 in order of value of output and with number of plants: Pennsylvania 12, Vermont 16, Virginia 3, Maine 1, New York 10, North Carolina 3, California 2, and Arkansas 1.
[2] Includes small quantity of slate used for grave vaults and covers.
[3] Includes small quantity of school slates.
[4] Includes slate used for walkways and stepping stones.
[5] Includes slate for aquarium bottoms, buildings, fireplaces, flooring, headstones, shims, and unspecified uses.

MISCELLANEOUS STONE

Various types of stone such as mica schist, argillite, light-colored volcanic rocks (rhyolite), soapstone, tuffs, mylonite, and greenstone, which cannot be classified with any of the groups already considered, are used to some extent. The combined tonnage of these types increased, but the unit value decreased.

TABLE 14.—Miscellaneous varieties of dimension stone sold or used by producers in the United States[1]

(In thousands)

Use	1958			1959		
	Short tons	Cubic feet	Value	Short tons	Cubic feet	Value
Building:						
Sawed [2]	44	518	$3,242	50	588	$3,131
Rubble	10	----------	150	35	----------	448
Flagging	6	71	100	8	94	139
Total	60	----------	3,492	93	----------	3,718

[1] Produced by the following States in 1959 in order of value of output and with number of plants: Virginia 2, California 31, Pennsylvania 4, Maryland 1, New Jersey 2, Hawaii 2, and New Mexico 1.
[2] Includes rough and cut stone and stone for refractory use to avoid disclosing individual company confidential data.

FOREIGN TRADE[8]

Building- and ornamental-stone imports increased in total value, but the quantity of the various types used fluctuated, compared with 1958. Most of the imports were marbles from Italy, Spain, France, Belgium, Portugal, and England. Granite, chiefly for memorials, was imported from Finland, Sweden, Norway, and Canada. Travertine was imported from Italy and onyx marble from Mexico.

Exportation of building and monumental stone increased 22 percent in quantity and 2 percent in value.

Tariff regulations were unchanged from those reported in the 1958 Stone chapter.

Tables on exports and imports of the various types of stone are given under Foreign Trade in the Crushed Stone section of this chapter.

WORLD REVIEW

Canada.—Although production of dimension stone declined over 6 percent in 1958, its value of $7.5 million established a record. Value of imports in 1958 remained about the same. Marble ($1.1 million) accounted for the highest value of all imported stone; about 80 percent of imported stone was in sawed or unfinished blocks.[9]

In Manitoba, building and ornamental stone were produced from several quarries. Canadian output of 33 million short tons of limestone in 1958 was an increase of 4 million tons over the 1957 figure. Dimension stone accounted for only 84,300 of the 33 million short tons, a slight decline compared with 1957.[10]

Union of South Africa.—The combined output of marble blocks by two South African producers declined from 15,000 to 10,000 cubic feet in 1958.[11]

Yugoslavia.—Production of limestone totaled 600,500 short tons in 1957; 1,100 short tons of limestone and 12,300 short tons of marble blocks were exported.[12]

TECHNOLOGY

A new technique for stone preparation—one of the oldest jobs in mining—was derived from rocket research. The patented and developed process known as "stone shaping," which utilizes the rocket jet principle that generates tremendous energy, undoubtedly will have a considerable effect on the dimension-stone industry. The method reportedly can cut and carve five times as fast as mechanical methods and has far-reaching economic aspects.[13]

---

[8] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U. S. Department of Commerce, Bureau of the Census.

[9] Hanes, F. E., Stone, Building and Ornamental, 1958 (Prelim.): Canadian Min. Ind., Dept. Min. and Tech. Surveys, Ottawa, Rev. 52, 1958, pp. 1–10.

[10] Ross, J. S., Limestone, 1958 (Prelim.): Canadian Min. Ind., Dept. Min. and Tech. Surveys, Ottawa, Rev. 39, 1958, pp. 1–4.

[11] Bureau of Mines, Mineral Trade Notes, Marble: Vol. 49, No. 6, December 1959, p. 45.

[12] Bureau of Mines, Mineral Trade Notes, Stone: Vol. 48, No. 6, June 1959, pp. 44–45.

[13] Mining Engineering, Annual Review, Jet Flames Carve Stone: Vol. 12, No. 2, February 1960, p. 150.

A paper outlined new methods of quarrying and fabricating natural stone, which enabled the dimension stone industry to more readily meet requirements of contemporary architecture.[14]

The largest individual wire-sawing unit reportedly contained a nine-strand wire saw. Its use, and a five-station single wire saw, at a Georgia granite plant opened new avenues for producing stone.[15]

An implement was developed to thread new wire through long-strand wire saws and used wire onto a spool for easy disposal.[16]

Development of new processes to improve slate-quarrying technology included a circular saw with diamond or other inserts to produce smaller sizes of stone and a chain saw with insert cutting teeth to produce larger dimension stone.[17]

Data pertaining to the marble industry in Georgia were published. Several active quarries produced a wide variety of marble.[18]

The new trend to marble furniture was exemplified by the increased utilization of marble cleaners and polishes; these reportedly reached sales of $500,000 to $750,000 annually.[19]

An informative article on methods of removing various stains from marble was published.[20] Also, a newly developed cleaner for exterior marble, granite, slate, and other stones was reported to effectively remove dirt and stains.[21]

Results of tests were reported for moisture absorption of 21 limestones and sandstones from quarries in Poland. The absorption of these stones was compared with that of brick.[22]

A series of articles contained data on the history, geology, and production of Indiana limestone.[23]

Information on formation, operation, and objectives of the ASTM Committee C–18 on natural building stones was published.[24] Standard definitions of terms relating to natural building stones formulated by this Committee also were published.[25]

A patented Japanese process to color natural slate an attractive green required that the material be coated with a chemical solution and heated.[26] A dimension-stone chipping machine was patented.

---

[14] Krueger, Arland R., Quarried Stone Meets the Challenges of Contemporary Architecture: Min. Eng., vol. 11, No. 12, December 1959, p. 1227.

[15] Coggins, Frank A., Jr., Sawing Stone With a Wire: Stone, vol. 79, No. 5, May 1959, p. 25.

[16] Stone, Products and Publications, New Wire Puller: Vol. 79, No. 4, April 1959, p. 27.

[17] Hoyt, Frank D., and Hartman, Howard L., Developments and Research in the Sawing of Dimension Stone: Min. Eng., vol. 11, No. 12, December 1959, p. 1227.

[18] Stone, The Georgia Marble Story: Vol. 79, No. 10, October 1959, pp. 14–15, 17.

[19] Chemical Week, Putting New Shine on Marble-Cleaner Sales: Vol. 84, No. 23, June 6, 1959, pp. 55–56.

[20] Shawhan, Romer, Practical Methods of Maintaining Marble: Stone, vol. 79, No. 4, April 1959, pp. 14–15, 25, 30.

[21] Stone, New Stone Cleaner Offers Advantages: Vol. 79, No. 6, June 1959, p. 22.

[22] Penkala, B., [Study of the Moisture Absorption of Building Stones]: Biuletyn Informacii Naukowo-Technicznef 1959 (Warsaw), January-February, pp. 34–38; Building Sciences Abs., September 1959, p. 1.

[23] Donaldson, L. E., and Pierson, S. B., Indiana Limestone: Stone, vol. 79, November 1959, pp. 7–8.

[24] Stone, ASTM Committee C–18 on Stone—What It Does and Why: Vol. 79, No. 6, June 1959, p. 18.

[25] Stone, Standard Definitions of Terms Relating to Natural Building Stones: Vol. 79, No. 4, April 1959, pp. 21, 23, 26.

[26] Tajima, E., Japanese Patent 10,482 (1958): Chem. Abs., vol. 53, No. 9, May 10, 1959, p. 8573.

The process is carried out automatically as the stones are moved by conveyor through a series of chisels.[27] Another machine for breaking rough, stratified dimension stone to produce relatively long, narrow pieces was patented.[28]

A block of granite with a volume of 180 cubic yards was reportedly quarried in Czechoslovakia.[29]

Scientific techniques used as an aid in selecting building stone included inspection of quarries, sampling, microscopic examination, and physical and chemical tests.[30]

CRUSHED AND BROKEN STONE

Production of crushed and broken stone increased 9 percent to a record 582 million tons valued at $824 million.

New construction, the Nation's largest single activity, reached the greatest annual increase in a decade, climbing to a record $54.3 billion. This was 11 percent above the 1958 figures and exceeded most forecasts made early in the year. Private residential construction increased 24 percent, and highway construction 5 percent.[31] Total construction accounted for about 15 percent of the gross national product.

TABLE 15.—Crushed and broken stone sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1958		1959	
	Quantity	Value	Quantity	Value
Agriculture	20,545	$34,551	20,819	$36,038
Cement	80,757	85,748	91,010	96,901
Concrete and roadstone	[1] 322,451	[1] 427,414	356,751	477,663
Fill	14,415	13,762	4,895	4,971
Filtration	178	404	316	665
Flux	26,045	37,491	28,633	41,682
Glass	1,178	3,443	1,636	4,798
Lime and dead-burned dolomite	[1] 15,834	[1] 24,435	20,517	31,834
Mineral food	635	3,664	658	3,601
Poultry grit	767	7,117	1,059	8,586
Railroad ballast	[1] 10,803	[1] 12,060	11,314	12,739
Refractory	920	7,810	955	7,192
Riprap	15,374	18,887	17,251	21,261
Roofing granules, aggregates, and chips	1,775	10,583	1,863	11,088
Stone sand	2,619	3,215	3,973	5,163
Terrazzo	370	4,588	620	6,170
Other uses [2] and unspecified	[1] 18,735	[1] 51,259	19,451	54,059
Total	[1] 533,401	[1] 746,431	581,721	824,411

[1] Revised figure.
[2] Includes some uses listed separately in the Limestone and Sandstone sections.

---

[27] Arvay, J., Stone Facers: U.S. Patent 2,867,204, Jan. 6, 1959.
[28] Saloga, W. J., Stone Breaker: U.S. Patent 2,882,888, Apr. 21, 1959.
[29] Pit and Quarry, vol. 52, No. 4, October 1959, p. 24.
[30] Schaffer, R. J., Testing Building Stone: Building Science Abs. (London), vol. 32, No. 7, July 1959, p. 193.
[31] U.S. Department of Commerce, Construction Review: Vol. 6, No. 3, March 1960, p. 20.

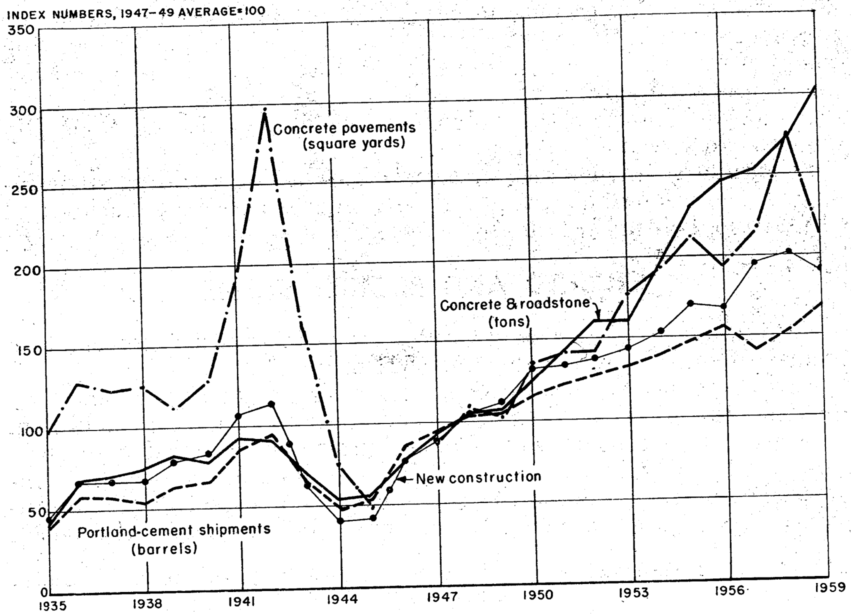

FIGURE 3.—Crushed-stone aggregates (concrete and roadstone) sold or used in the United States, compared with shipments of portland cement, total new construction (value), and concrete pavements (contract awards, square yards), 1935–59.

(Data on construction from Construction and Costs and on pavements from Survey of Current Business, U.S. Department of Commerce. Construction value adjusted to 1947–49 prices.)

TABLE 16.—Crushed stone sold or used by noncommercial producers in the United States, by uses[1]

(Thousand short tons and thousand dollars)

Use	1958		1959	
	Quantity	Value	Quantity	Value
Concrete and roadstone	[2] 39,779	[2] $40,517	38,999	$40,581
Riprap	7,960	8,991	8,745	10,192
Agricultural (limestone)	456	656	401	569
Other uses	1,572	1,466	1,604	2,578
Total	[2] 49,767	[2] 51,630	49,749	53,920

[1] Figures for "noncommercial operations" represent tonnages reported by States, counties, municipalities, and other Government agencies, produced either by themselves or by contractors expressly for their consumption, often with publicly owned equipment; they do not include purchases from commercial producers.

[2] Revised figure.

Trends in Use.—Over 61 percent of all crushed and broken stone was used in concrete and roadstone applications in 1959. Large tonnages were also used as base course material, fill, and for a variety of chemical and industrial applications. For example, cement production, which increased 9 percent to 339 million barrels and which was valued at $1.1 billion, required 91 million tons ($97 million in value) of limestone, cement rock, shell, marl, and sandstone.

Despite estimates by agricultural specialists which indicated that the Nation's soils require a minimum of 80 million tons of calcium-bearing materials, less than 22 million tons of agricultural limestone, shell, marl, lime, and blast-furnace slag (accounting for virtually all lime-bearing materials) were used for this purpose in 1959.

TABLE 17.—Crushed stone for concrete and roadstone sold or used by producers in the United States, by States

State	1958		1959	
	Short tons	Value	Short tons	Value
Alabama	4, 934, 529	$6, 218, 586	[1] 4, 929, 833	[1] $6, 395, 036
Alaska	290, 999	1, 100, 399	11, 696	292, 400
Arizona	97, 231	107, 873	400, 668	420, 362
Arkansas	[1] 4, 817, 300	[1] 5, 943, 235	4, 682, 253	4, 906, 748
California	9, 204, 846	11, 481, 260	10, 508, 699	13, 458, 238
Colorado	796, 800	1, 426, 800	366, 127	871, 205
Connecticut	[1] 3, 567, 395	[1] 5, 240, 448	4, 084, 999	5, 916, 239
Florida	19, 806, 047	25, 147, 629	[1] 20, 878, 385	[1] 26, 923, 292
Georgia	[1] 7, 940, 721	[1] 12, 716, 689	[1] 8, 863, 689	[1] 13, 201, 148
Hawaii	2, 185, 992	4, 120, 396	2, 635, 954	4, 968, 134
Idaho	[1][2] 1, 028, 559	[1][2] 1, 074, 023	618, 250	836, 553
Illinois	26, 314, 679	33, 358, 831	27, 257, 011	34, 811, 045
Indiana	9, 915, 528	12, 559, 314	13, 012, 591	16, 673, 598
Iowa	15, 562, 603	18, 973, 904	15, 083, 388	18, 801, 718
Kansas	[1] 7, 909, 338	[1] 9, 999, 601	9, 600, 138	12, 219, 100
Kentucky	10, 419, 609	14, 530, 797	[1] 13, 780, 571	[1] 19, 166, 557
Louisiana	4, 048, 313	7, 539, 563	4, 227, 039	8, 599, 909
Maine	[1] 42, 000	[1] 120, 000	210, 933	605, 771
Maryland	[1] 4, 353, 224	[1] 7, 211, 301	5, 062, 275	8, 583, 909
Massachusetts	[1] 3, 266, 993	[1] 5, 442, 559	3, 730, 886	6, 015, 495
Michigan	6, 220, 260	6, 980, 800	5, 936, 669	6, 862, 917
Minnesota	[1] 2, 524, 187	[1] 3, 019, 889	2, 455, 172	2, 955, 816
Missouri	13, 872, 461	18, 186, 027	14. 492, 463	19, 442, 320
Montana	629, 194	858, 923	210, 857	267, 283
Nebraska	1, 470, 600	2, 173, 900	1, 384, 600	2, 268, 200
Nevada	90, 248	111, 360	262, 500	322, 062
New Jersey	6, 987, 442	15, 052, 815	8, 935, 080	17, 954, 793
New Mexico	1, 633, 977	1, 366, 927	233, 728	217, 010
New York	15, 300, 339	25, 219, 867	19, 712, 623	31, 271, 235
North Carolina	[1] 11, 804, 554	[1] 16, 797, 898	12, 610, 509	17, 609, 970
North Dakota	------------	------------	4, 628	4, 628
Ohio	[1] 13, 332, 065	[1] 17, 462, 523	[1] 16, 742, 509	[1] 21, 904, 098
Oklahoma	8, 690, 694	8, 938, 215	9, 126, 750	10, 054, 725
Oregon	[2] 11, 793, 477	[2] 12, 380, 234	9, 017, 530	11, 859, 948
Pennsylvania	18, 537, 260	28, 025, 216	20, 096, 643	30, 867, 795
Rhode Island	[1] 2, 641	[1] 7, 923	(3)	(3)
South Carolina	[1] 2, 922, 265	[1] 4, 229, 973	[1] 5, 346, 058	[1] 7, 555, 243
South Dakota	831, 900	1, 274, 800	1, 537, 385	2, 441, 085
Tennessee	[1] 13, 153, 136	[1] 16, 805, 879	14, 414, 894	18, 201, 753
Texas	[1] 23, 832, 761	[1] 23, 023, 560	27, 590, 188	25, 477, 828
Utah	[1] 78, 900	[1] 78, 900	10, 000	13, 700
Vermont	(3)	(3)	423, 502	1, 000, 169
Virginia	[1] 9, 311, 588	[1] 13, 745, 473	11, 221, 064	16, 709, 561
Washington	[1] 5, 694, 531	[1] 6, 617, 739	8, 458, 126	8, 600, 333
West Virginia	[1] 1, 717, 434	[1] 3, 053, 291	2, 327, 733	3, 951, 001
Wisconsin	[1] 10, 064, 498	[1] 10, 095, 449	9, 798, 627	10, 200, 637
Wyoming	246, 600	154, 500	361, 100	393, 300
Undistributed [4]	5, 205, 627	7, 438, 621	4, 094, 754	5, 588, 919
Total	[2] 322, 451, 345	[2] 427, 413, 910	356, 751, 077	477, 662, 786

[1] To avoid disclosing confidential information, total is somewhat incomplete, the portion not included being combined as "Undistributed."

[2] Revised figure.

[3] Included with "Undistributed."

[4] Includes data indicated by footnote 3 and Delaware and New Hampshire.

Crushed-stone-aggregate producers encountered increased competition not only from sand and gravel but from blast-furnace slag, manufactured and natural lightweight aggregates, and ore gangues (chats). Indications were that several copper operations planned to market large quantities of copper slag as aggregate. Barite, steel scrap, and iron ore were used to a limited extent as a heavy aggregate in concrete for greater protection against nuclear radiation. The tremendous volume of crushed stone that can be produced at one operation was exemplified by the output during the year for use in constructing Washington, D.C.'s $75 million Dulles International Airport.[32]

A series of articles relating to percentage depletion, pending legislation, and their effect on the rock industries was published.[33]

Prices.—Unit values of crushed stone ranged from $1.02 a ton for use as fill to $10.29 a ton for limestone whiting. The average value for all types was $1.42, only slightly higher than in 1958. The relatively low value of crushed stone resulted from the constant pressure applied by competition and from increased production efficiency. The wholesale price for crushed stone reported by selected companies to the Department of Labor for December 1959 was $1.672 a short ton f.o.b. plant, compared with $1.676 for December 1958.[34]

Size of Plants.—Over 2,650 commercial crushed-stone plants operated in 1959. Although most of the plants were small or medium size, plants producing over 900,000 tons constituted 4 percent of the operating plants and produced 28 percent of the output. Plant arrangements and size were usually tailored to meet requirements of the deposit, extent of the market, and specifications for the product. Automation of new and existing plants continued to offset rising labor costs.

Portable plants continued to gain in popularity primarily as facilities for producing crushed stone from temporary locations near the jobsite. Because of this increased tendency of contractors to produce their own aggregates rather than purchase them from distant permanently established plants, more permanent-plant operators provided subsidary portable operations to serve markets beyond the economic transport radius of the main plant.

---

[32] Trauffer, Walter E., Plant Design for Eventual Commercial Production: Pit and Quarry, vol. 52, No. 6, December 1959, pp. 96–101, 111.

[33] Bell, Joseph N., Where Do We Stand on Depreciation and Percentage Depletion: Rock Products, vol. 62, October 1959, pp. 85–88; What's Ahead in Percentage Depletion: Rock Products, vol. 62, No. 11, November 1959, pp. 93–95, 136, 138.

[34] U.S. Department of Commerce, Construction Review: Vol. 6, No. 3, March 1960, p. 39.

TABLE 18.—Number and production of commercial crushed-stone plants in the United States, by size groups

Annual production (short tons)	1958				1959			
	Number of plants	Production		Cumulative total, short tons (thousands)	Number of plants	Production		Cumulative total, short tons (thousands)
		Short tons (thousands)	Percent of total			Short tons (thousands)	Percent of total	
Less than 1,000 tons	101	47	0.01	47	110	58	0.01	58
1,000 to 25,000	656	6,585	1.36	6,632	655	6,434	1.21	6,492
25,000 to 50,000	[1] 309	[1] 11,884	2.46	18,516	299	10,432	1.96	16,924
50,000 to 75,000	205	12,795	2.64	31,311	196	12,118	2.28	29,042
75,000 to 100,000	162	14,348	2.96	45,659	180	15,599	2.93	44,641
100,000 to 200,000	424	60,976	12.61	106,635	458	65,265	12.27	109,906
200,000 to 300,000	[1] 201	[1] 48,810	10.09	155,445	215	52,529	9.88	162,435
300,000 to 400,000	142	48,903	10.11	204,348	155	53,463	10.05	215,898
400,000 to 500,000	104	46,805	9.68	251,153	109	48,439	9.11	264,337
500,000 to 600,000	55	30,189	6.24	281,342	69	37,580	7.06	301,917
600,000 to 700,000	49	30,747	6.36	312,089	65	41,766	7.85	343,683
700,000 to 800,000	24	17,984	3.72	330,073	31	22,981	4.32	366,664
800,000 to 900,000	21	17,871	3.70	347,944	18	15,376	2.89	382,040
900,000 tons and over	79	135,690	28.06	483,634	95	149,932	28.18	531,972
Total	[1] 2,532	[1] 483,634	100.00	483,634	2,655	531,972	100.00	531,972

[1] Revised figure.

Transportation.—Costs remained the major consideration by contractors in purchasing crushed stone. In some areas transportation to the jobsite exceeded the f.o.b. plant cost of the material.

Trucks continued to be the dominant means of transporting crushed stone from the quarry to the plant and the jobsite. Off-the-road trucks were improved further in operating efficiency and load capacity. Although the location of water and rail facilities was not a prime consideration in establishing most new plants in 1959, it continued to be important.

TABLE 19.—Crushed stone sold or used in the United States in 1959, by method of transportation

Method of transportation	Commercial operations		Commercial and noncommercial [1] operations	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Truck	330,904	62	380,653	66
Rail	81,695	16	81,695	14
Waterway	54,611	10	54,611	9
Unspecified	64,762	12	64,762	11
Total	531,972	100	581,721	100

[1] Entire output of noncommercial operations assumed to be moved by truck.

GRANITE

Crushed-granite production of 37 million tons represented an increase of 18 percent, but the average value of $1.40 a ton was 5 cents less than in 1958. Georgia and North Carolina continued to lead the 30 other granite-producing States in output. Poultry grit had the highest average value per ton. Crushed-granite screenings were competitive with industrial sands for some applications; for example, a South Carolina operation was established to process granite screenings for use in glass manufacture.

Some novel uses of granite-type stone were reported. For example, by adding hot, liquid radioactive wastes containing fission products to an unheated mixture of 85 percent syenite and 15 percent lime, a gelled slurry that fuses upon heating to 1,350° C. could be produced. The glassy mass reportedly could then be buried without unusual precautions.[35]

TABLE 20.—Granite (crushed and broken stone) sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1958		1959	
	Quantity	Value	Quantity	Value
Concrete and roadstone	[1]26,314	[1]$39,019	31,318	$44,691
Railroad ballast	1,876	2,154	1,769	2,197
Riprap	1,023	2,067	1,282	1,479
Fill	916	614	911	1,203
Stone sand	1,128	844	1,474	982
Poultry grit	50	611	136	1,131
Other uses [2]	30	123	27	145
Total	[1]31,337	[1]45,432	36,917	51,828

[1] Revised figure.

[2] Includes stone used for agriculture, filtration, roofing granules, and unspecified uses.

TABLE 21.—Granite (crushed and broken stone) sold or used by producers in the United States in 1959, by States

State	Short tons	Value	State	Short tons	Value
Alaska	66,188	$356,930	Oklahoma	128,337	$171,750
Arizona	87,968	58,762	Oregon	440,289	673,221
Arkansas	167,914	112,424	South Carolina	6,232,929	8,269,875
California	4,335,439	4,798,616	Tennessee	40,000	60,000
Colorado	135,132	173,060	Utah	1,500	1,500
Georgia	10,089,297	14,715,984	Virginia	2,779,833	4,273,567
Idaho	14,504	10,360	Washington	577,079	453,185
Massachusetts	1,126,068	1,940,372	Wisconsin	19,050	16,500
Minnesota	655,572	1,001,878	Wyoming	228,800	249,300
Missouri	259	481	Other States [1]	1,134,099	2,366,463
Nevada	153,000	132,500			
North Carolina	8,460,497	11,911,554	Total	36,917,154	51,827,682
North Dakota	43,400	79,400			

[1] Includes Connecticut, Delaware, Maine, Montana, New Hampshire, New Jersey, New York, Rhode Island, Texas, and Vermont.

---

[35] Chemical and Engineering News, Fission Wastes Trapped in Glass: Vol. 37, No. 23, June 8, 1959, p. 38.

BASALT AND RELATED ROCKS (TRAPROCK)

Dark-colored igneous rocks (traprock), including basalt, gabbro, diorite, and diabase, were used widely for concrete and roadstone and railroad ballast. Traprock was also valued for riprap and roofing granules because of its blocky fracture and high resistance to abrasion. Output increased 16 percent, and the average value of $1.56 a ton was slightly higher than the average value of combined crushed stone. Production costs were substantially higher than for limestone because of greater resistance to drilling and processing. Oregon was the leading producer, then New Jersey, and Washington.

A contractor-operated large-tonnage traprock plant produced material for runway base courses and concrete aggregate at the new Dulles International Airport near Washington, D.C.

TABLE 22.—Basalt (crushed and broken stone) sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

	1958		1959	
	Quantity	Value	Quantity	Value
Concrete and roadstone	[1] 39,484	[1] $59,871	43,394	$66,871
Railroad ballast	[1] 1,657	[1] 2,420	1,835	2,604
Riprap	2,177	3,002	5,591	6,497
Fill	433	267	309	191
Stone sand	22	60	110	216
Other uses [2]	[1] 710	[1] 3,305	526	3,698
Total	[1] 44,483	[1] 68,925	51,765	80,077

[1] Revised figure.
[2] Includes stone used for concrete blocks, filtration, filler, roofing granules, and unspecified uses.

TABLE 23.—Basalt and related rocks (traprock) (crushed and broken stone) sold or used by producers in the United States in 1959, by States

State	Short tons	Value
Alaska	22,800	$20,000
California	1,772,035	2,727,699
Connecticut	4,198,996	6,019,001
Hawaii	1,918,219	3,872,341
Idaho	599,692	825,400
Maryland	720,130	1,234,248
Massachusetts	3,191,296	4,970,060
Michigan	86,038	63,732
Minnesota	30,322	43,879
Nevada	93,063	170,522
New Jersey	8,735,610	17,876,332
New Mexico	1,000	5,200
North Carolina	2,065,929	$2,750,753
Oregon	10,535,021	12,897,474
Pennsylvania	3,615,310	7,372,937
Virginia	2,231,859	3,761,551
Washington	8,477,577	8,526,300
Other States [1]	3,470,547	6,939,889
Total	51,765,444	80,077,318
American Samoa	60,141	76,188
Panama Canal Zone	209,578	253,765
Virgin Islands	14,429	50,616

[1] Includes Arizona, Colorado, Maine, Montana, New York, Texas, and Wisconsin.

MARBLE

In some instances defective marble blocks at dimension-stone plants were crushed and sold for various purposes. In addition, plants that formerly produced dimension stone now produce crushed marble exclusively. Forty-five plants reported output of crushed and broken marble in 1959. Marble of relatively high purity was interchangeable with limestone in many industrial applications. Because the characteristic fracture along crystal planes tended to reduce the cohesive bond, marble was considered by some to be inferior as a concrete aggregate. Others did not consider coarse-grained marbles suitable as fluxstone because of their tendency to decrepitate in the furnace. Marbles were highly prized as terrazzo and roofing granules where they commanded a relatively high price.

TABLE 24.—Marble (crushed and broken stone) sold or used by producers in the United States [1]

(Thousand short tons and thousand dollars)

Use	1958		1959	
	Quantity	Value	Quantity	Value
Terrazzo	359	$4,487	611	$6,019
Other uses [2]	910	7,538	1,147	8,165
Total	1,269	12,025	1,758	14,184

[1] Produced by the following States in 1959, in order of tonnage: Georgia, Alabama, Missouri, Texas, New York, Tennessee, Virginia, Washington, Arkansas, Maryland, California, Vermont, Arizona, New Jersey, North Carolina, Colorado, Nevada, and New Mexico.

[2] Includes stone used for agriculture, asphalt filler, concrete and roadstone, poultry grit, roofing, stone sand, stucco, whiting (excluding marble whiting made by companies that purchase marble), and unspecified uses.

LIMESTONE

Production of crushed and broken limestone established another record in 1959. Output from over 1,800 plants throughout the Nation was used in virtually every phase of construction and as an essential raw material in many industrial applications.

Concrete and roadstone accounted for most of the 433 million tons of crushed and broken limestone produced. Production of cement and lime required over 100 million tons of limestone. Some shell, marl, and marble refuse also used for these purposes were included under these separate heading. Limestone and dolomite for use in smelting iron and other metals required 7 percent of the total output in 1959. Lime, also used as a flux, is reported in the Lime chapter of this volume.

Agricultural applications totaled 5 percent of the 1959 production of limestone and dolomite. Shell, marl, lime, marble, and slags also were used in soil treatment.

Many industrial applications for limestone, such as for glass, alkali, paper, and sugar manufacture, required that the material be calcined. Therefore, manufacturers of these products required lime-producing equipment.

The value of limestone as a soil conditioner and its contribution toward higher crop yields were emphasized by the use of roadside billboards.[36] A report from the National Limestone Institute indicated that farmers used 22.8 million tons of agricultural limestone in 1958, a slight increase over the 1957 consumption. Estimated requirements, however, approached 30 million tons annually.[37]

---

[36] Pit and Quarry, Billboard Posters Highlight Agstone: Vol. 52, No. 4, October 1959, pp. 94–95.

[37] Rock Products, Ag-Lime Use Increases: Vol. 62, No. 12, December 1959, p. 60.

TABLE 25.—Limestone and dolomite (crushed and broken stone) sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1958		1959	
	Quantity	Value	Quantity	Value
Concrete and roadstone	226,693	$288,956	251,787	$325,411
Flux	25,616	36,537	28,206	40,442
Agriculture	19,922	33,901	20,503	35,665
Railroad ballast	4,307	5,290	4,589	5,693
Riprap	4,763	5,131	5,449	6,561
Alkali manufacture	5,420	7,811	3,483	3,954
Calcium carbide manufacture	742	727	834	176
Cement-portland and natural	73,976	78,240	84,354	89,947
Coal-mine dusting	479	1,921	526	1,899
Fill material	1,500	1,500	581	560
Filler (not whiting substitute):				
Asphalt	2,333	5,672	2,829	6,905
Fertilizer	424	895	464	1,046
Other	384	590	326	1,645
Filtration	125	217	255	445
Glass manufacture	964	2,864	1,317	3,979
Lime and dead-burned dolomite	[1] 14,634	[1] 22,485	19,286	30,034
Limestone sand	1,431	2,272	2,293	3,818
Limestone whiting [2]	712	6,379	698	7,184
Magnesia [3]	[1] 22	[1] 33	18	22
Mineral food	623	3,551	654	3,578
Mineral (rock) wool	3	6	2	4
Paper manufacture	417	1,210	434	1,190
Poultry grit	180	906	146	1,096
Refractory (dolomite)	369	558	242	441
Sugar refining	850	2,004	856	2,098
Other uses [4]	[1] 1,977	[1] 5,356	1,441	4,168
Use unspecified	1,602	1,753	1,430	1,843
Total	390,468	516,765	433,003	579,804

[1] Revised figure.

[2] Includes stone for filler for calcimine, calking compounds, ceramics, chewing gum, explosives, floor coverings, foundry compounds, glue, grease, insecticides, leather goods, paint, paper, phonograph records, picture-frame moldings, plastics, pottery, putty, roofing, rubber, toothpaste, wire coating, and unspecified uses. Excludes limestone whiting made by companies from purchased stone.

[3] Includes stone for refractory magnesia.

[4] Includes stone for acid neutralization, carbon dioxide, chemicals (unspecified), concrete products, disinfectant and animal sanitation, dyes, electrical products, oil-well drilling, patching plaster, rayons, rice milling, roofing granules, stucco, terrazzo, artificial stone, and water treatment.

Finely ground limestone was used at a Michigan steel plant to replace traditional large-lump fluxstone normally required when raw ore was used in the blast furnace. Plans were underway to use these "fluxing fines" at another operation.[38]

Most uses of dolomite were the same as for limestone, but some uses for dolomite and dolomitic lime were quite distinct from those of high-calcium limestone and lime. Dolomite of comparatively high quality was used as a refractory material, for patching furnace floors, and as a source of magnesium compounds and metal. Statistical data on dead-burned dolomite are in the Lime and Magnesium Compounds chapters of this volume.

An article described the use of dolomite and sea water for manufacturing magnesia at a California operation.[39]

Soft-coal binder for use with limestone aggregate in highway construction instead of the usual asphalt binder was announced.[40]

---

[38] Blast Furnace and Steel Plant, Calcite Plant Enlarged: Vol. 48, No. 1, January 1960, p. 98.

[39] Utley, Harry F., Basic Refractories Plant of Kaiser Chemical Division: Pit and Quarry, vol. 51, No. 10, April 1959, pp. 84–85.

[40] Engineering News Record, Roads From Coal: Vol. 162, No. 24, June 18, 1959, p. 137.

TABLE 26.—Limestone (crushed and broken stone) sold or used by producers in the United States in 1959, by States and uses

State	Riprap		Fluxing stone		Concrete and roadstone		Railroad ballast		Agriculture		Miscellaneous		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	(1)	(1)	1,267,422	$1,788,673	4,929,833	$6,395,036	(1)	(1)	604,757	$918,015	4,643,711	$4,815,247	11,578,293	$14,092,812
Arizona	(1)	(1)	104,000	146,600	80,000	127,100	-----	-----	(1)	(1)	1,153,400	1,392,100	1,345,200	1,678,900
Arkansas	(1)	(1)	740,328	883,437	1,792,391	2,552,744	-----	-----	258,715	390,263	(1)	(1)	3,920,949	5,293,395
California	370,157	$926,129	(1)	(1)	809,678	930,645	-----	-----	(1)	(1)	13,526,731	20,776,808	15,081,174	23,377,183
Colorado	(1)	(1)	212,500	443,300	320,500	637,000	-----	-----	-----	-----	(1)	(1)	2,482,700	4,344,000
Connecticut	-----	-----	(1)	(1)	(1)	(1)	-----	-----	(1)	(1)	(1)	(1)	161,510	576,533
Florida	19,000	11,970	-----	-----	20,878,385	26,923,292	(1)	(1)	564,099	1,614,607	(1)	(1)	25,049,516	33,093,835
Georgia	-----	-----	-----	-----	348,376	622,509	7,988	$11,583	(1)	(1)	(1)	(1)	1,145,696	1,962,745
Hawaii	-----	-----	-----	-----	506,384	709,373	-----	-----	(1)	(1)	(1)	(1)	525,647	732,067
Illinois	246,154	329,047	(1)	(1)	27,257,011	34,811,045	200,965	243,410	2,757,743	3,877,392	(1)	(1)	35,186,495	44,710,435
Indiana	41,720	50,496	(1)	(1)	13,012,591	16,673,598	293,298	366,426	1,916,865	2,664,658	(1)	(1)	17,827,022	22,348,221
Iowa	158,366	203,572	33,714	52,000	15,083,388	18,801,718	(1)	(1)	1,359,252	1,877,686	(1)	(1)	20,492,847	25,685,132
Kansas	(1)	(1)	-----	-----	9,250,215	11,847,532	(1)	(1)	352,759	545,766	3,311,533	3,611,912	13,328,243	16,380,477
Kentucky	(1)	(1)	(1)	(1)	13,780,571	19,166,557	346,963	379,326	1,297,678	1,690,223	(1)	(1)	16,060,408	22,173,610
Maryland	(1)	(1)	(1)	(1)	4,222,404	7,110,161	(1)	(1)	45,990	131,161	1,930,038	4,162,372	6,389,828	11,707,998
Massachusetts	-----	-----	(1)	(1)	(1)	(1)	-----	-----	143,884	425,782	(1)	(1)	556,367	1,717,260
Michigan	(1)	(1)	10,805,705	11,478,863	5,850,631	6,799,185	(1)	(1)	434,116	749,590	(1)	(1)	29,779,492	29,984,534
Minnesota	(1)	(1)	100	250	2,265,285	2,591,691	-----	-----	457,938	684,487	(1)	(1)	2,808,058	3,572,640
Mississippi	-----	-----	-----	-----	-----	-----	-----	-----	126,209	113,588	-----	-----	126,209	113,588
Missouri	2,079,773	1,899,681	(1)	(1)	14,190,618	19,225,844	(1)	(1)	2,675,050	4,144,529	6,958,826	8,488,772	25,947,897	33,838,275
Montana	(1)	(1)	(1)	(1)	(1)	(1)	-----	-----	-----	-----	652,757	927,889	721,809	1,031,366
Nebraska	731,600	929,400	-----	-----	1,384,600	2,268,200	-----	-----	54,100	87,400	1,061,000	1,930,500	3,231,300	5,215,500
Nevada	-----	-----	(1)	(1)	37,100	52,700	(1)	(1)	-----	-----	(1)	(1)	(1)	(1)
New Mexico	(1)	(1)	(1)	(1)	1,079	1,268	-----	-----	-----	-----	(1)	(1)	224,501	298,648
New York	108,721	158,954	78,107	145,144	17,197,623	26,734,922	431,266	632,944	463,110	2,288,383	7,421,336	9,133,674	25,700,163	39,094,021
North Carolina	-----	-----	-----	-----	2,212,090	3,221,467	-----	-----	985	1,970	-----	-----	2,213,075	3,223,437
Ohio	156,694	132,217	4,947,164	7,560,302	16,742,509	21,904,098	992,521	1,191,701	1,871,609	3,145,579	10,720,823	16,897,269	35,431,320	50,831,166
Oklahoma	566,941	746,403	-----	-----	8,631,564	9,618,888	(1)	(1)	120,527	158,914	(1)	(1)	11,239,816	13,430,546
Oregon	(1)	(1)	(1)	(1)	(1)	(1)	-----	-----	6,090	19,361	1,046,193	1,364,766	1,070,842	1,423,912
Pennsylvania	(1)	(1)	5,076,505	9,393,129	16,414,077	24,911,753	(1)	(1)	888,123	2,518,380	15,665,841	21,679,974	38,151,105	58,662,081
South Dakota	(1)	(1)	-----	-----	1,063,785	1,525,785	(1)	(1)	-----	-----	525,936	795,000	1,599,521	2,331,485
Tennessee	(1)	(1)	(1)	(1)	14,360,894	18,109,353	243,019	311,574	1,118,476	1,617,692	2,719,939	3,306,098	18,536,674	23,472,494
Texas	180,997	271,832	467,799	535,736	20,165,057	17,781,324	752,303	652,148	98,842	101,229	7,426,416	9,615,526	29,091,414	28,957,795
Utah	(1)	(1)	(1)	(1)	(1)	(1)	-----	-----	-----	-----	1,169,300	1,600,500	1,547,600	2,196,400
Vermont	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	417,084	2,737,419
Virginia	5,389	7,398	621,255	1,051,566	6,065,427	8,453,678	217,598	273,229	818,035	1,580,293	4,277,843	6,728,281	12,005,547	18,094,445
Washington	-----	-----	(1)	(1)	(1)	(1)	-----	-----	(1)	(1)	1,231,160	1,902,252	1,394,990	2,068,241
West Virginia	(1)	(1)	2,091,241	3,926,152	1,867,723	3,005,417	115,959	177,315	(1)	(1)	1,323,142	2,253,103	5,462,983	9,536,275
Wisconsin	40,093	30,854	(1)	(1)	9,703,977	9,986,637	(1)	(1)	1,292,065	1,793,363	(1)	(1)	11,370,253	12,274,951
Wyoming	(1)	(1)	(1)	(1)	308,200	328,400	(1)	(1)	-----	-----	(1)	(1)	1,074,100	1,486,200
Undistributed [2]	743,789	862,950	1,760,349	3,037,249	1,052,790	1,581,989	987,482	1,452,918	776,082	2,524,418	35,702,346	44,650,571	2,725,423	6,054,108
Total	5,449,394	6,560,903	28,206,189	40,442,401	251,786,756	325,410,909	4,589,362	5,692,574	20,503,099	35,664,729	122,468,271	166,032,614	433,003,071	579,804,130
Canton Island	-----	-----	-----	-----	154	305	-----	-----	-----	-----	280	280	434	585
Guam	105	320	-----	-----	567,552	1,109,176	-----	-----	-----	-----	-----	-----	567,657	1,109,496
Puerto Rico	-----	-----	-----	-----	524,675	1,182,773	-----	-----	23,015	74,369	1,433,150	1,435,763	1,980,840	2,692,905
Wake Island	-----	-----	-----	-----	18,750	25,312	-----	-----	-----	-----	-----	-----	18,750	25,312

---

[1] Included with "Undistributed" to avoid disclosing individual company confidential data.

[2] Includes data indicated by footnote 1 and Idaho, Maine, New Jersey, Rhode Island, and South Carolina.

TABLE 27.—Sales of fluxing limestone, by uses

(Thousand short tons and thousand dollars)

Year	Blast furnace		Open-hearth plants		Other smelters[1]		Other metallurgical[2]		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1950–54 (average)	29, 538	$34, 194	6, 365	$8, 223	853	$1, 046	214	$267	36, 970	$43, 730
1955	31, 674	40, 380	6, 578	9, 933	1, 423	2, 018	393	575	40, 068	52, 906
1956	28, 914	38, 939	7, 494	11, 488	1, 006	1, 329	375	730	37, 789	52, 486
1957	29, 352	41, 733	9, 012	12, 924	809	1, 086	211	370	39, 384	56, 113
1958	19, 427	28, 153	4, 777	6, 641	866	975	546	768	25, 616	36, 537
1959	19, 752	28, 683	6, 439	8, 963	965	1, 223	1, 050	1, 573	28, 206	40, 442

[1] Includes flux for copper, gold, lead, zinc, and unspecified smelters.
[2] Includes flux for foundries and for cupola and electric furnaces.

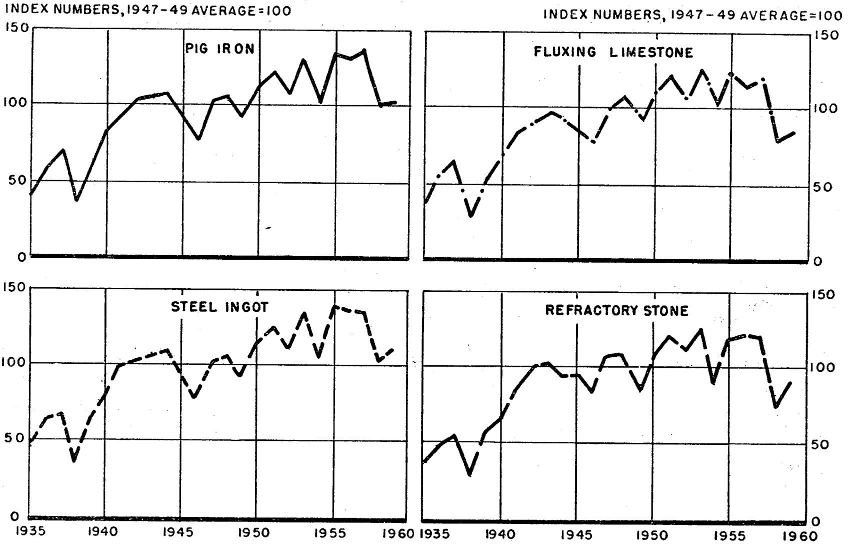

FIGURE 4.—Sales (tons) of fluxing limestone and refractory stone (including that used in making dead-burned dolomite), compared with production of steel ingot and pig iron, 1935–59.

(Statistics of steel-ingot production compiled by American Iron and Steel Institute.)

Shell.—Oystershell is nearly pure calcium carbonate, and contaminants are usually easier to remove than from limestone. Various types of shell substituted for limestone in 1959, especially in areas where the supply of limestone was limited. Some material classified as coquina was included under the shell category.

An agreement was reportedly reached between a contractor and the State of Maryland to dredge shell from the Chesapeake Bay. Some shell would be returned as oysterbed material and some sold commercially. Oystershell commanded a relatively high price as poultry grit and contributed substantial tonnages for a variety of other uses, particularly in the Gulf Coast States. Shell was at a premium in Louisiana for use as concrete aggregate and for cement and lime because of the inadequate limestone deposits. Florida oystershell was dredged from fossil beds offshore on the Atlantic and Gulf Coasts.

TABLE 28.—**Shell sold or used by producers in the United States, by uses**

(Thousand short tons and thousand dollars)

Use	1958		1959	
	Quantity	Value	Quantity	Value
Concrete and roadstone	11,216	$17,094	11,121	$17,320
Cement	5,058	5,609	4,695	4,941
Lime	1,200	1,950	1,231	1,800
Poultry grit	537	5,600	777	6,359
Mineral food	12	113	4	23
Other uses [1]	893	1,510	2,352	4,367
Total	18,916	31,876	20,180	34,810

[1] Includes agriculture, alkali, asphalt filler, filtration, magnesium metal, paper, whiting, and unspecified uses.

TABLE 29.—**Shell sold or used by producers in the United States in 1959, by States**

	Short tons	Value		Short tons	Value
Florida	1,867,590	$2,845,978	Other States [1]	2,312,521	$6,670,526
Louisiana	5,669,931	10,874,368	Total	20,180,378	34,809,682
Texas	10,309,950	14,418,810			
Virginia	20,386	(2)			

[1] Includes Alabama, California, Maryland, New Jersey, Pennsylvania, and Washington.
[2] Figure withheld to avoid disclosing individual company confidential data; included with "Other States."

Calcareous Marl.—A statistical grouping of unconsolidated calcium carbonate materials that have high percentages of impurities, mainly clay, is included in this category. Actually the material classified as marl resulting from deposition in fresh water lakes such as in Indiana and Michigan was somewhat different from the material classified as marl along the Coastal Plain of the Eastern Shore. The lake-deposited material had 25 to 50 percent moisture as dredged but was comparatively light and porous when dry. This material accounted for about 23 percent of the tonnage reported under this category. Both types of material were dredged and shipped by barge. Some dry-lake "caliche-type" materials were excavated mainly for cement manufacture.

TABLE 30.—**Calcareous marl sold or used by producers in the United States** [1]

(Thousand short tons and thousand dollars)

Use	1958		1959	
	Quantity	Value	Quantity	Value
Agriculture [2]	316	$224	299	$220
Cement	1,487	1,436	1,744	1,706
Total	1,803	1,660	2,043	1,926

[1] Produced by the following States in 1959, in order of tonnage: South Carolina, Mississippi, Virginia, Michigan, Ohio, Indiana, Minnesota, Wisconsin, West Virginia, Nevada, and Washington.
[2] Includes marl used in mineral food.

SANDSTONE, QUARTZ, AND QUARTZITE

Sales of crushed and broken sandstone, quartz, and quartzite decreased in quantity and value during 1959. Sandstone, quartz, and quartzite were used interchangeably for many applications of industrial sands. Other materials such as aplite and granite screenings were competitive in some market areas.

A quartz-lined lamp developed by General Electric utilized a quartz tube filled with an inert gas plus traces of iodine. Advantages were more light from a smaller package, no blackening of the bulb, high efficiency, and more rugged operation.[41]

Pilot-plant production of synthetic quartz crystal by the Western Electric Company was described.[42]

Several million tons of quartz tailing from an abandoned gold-milling operation was utilized by Johns-Manville in manufacturing asbestos-silica (transite) pipe.[43]

TABLE 31.—Sandstone, quartz, and quartzite (crushed and broken stone) [1] sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1958		1959	
	Quantity	Value	Quantity	Value
Concrete and roadstone	8,862	$11,820	9,882	$12,910
Railroad ballast	706	796	615	675
Riprap	1,657	2,606	1,319	2,075
Refractory stone (ganister)	551	7,252	713	6,751
Abrasives	50	270	65	320
Ferrosilicon	115	455	152	702
Filtration	45	113	49	145
Flux	429	954	427	1,240
Foundry	293	691	430	976
Glass	214	579	319	819
Other uses [2]	11,562	16,828	3,109	8,109
Total	24,484	42,364	17,080	34,722

[1] Includes ground sandstone, quartz, and quartzite. Friable sandstone is reported in the chapter on Sand and Gravel.

[2] Includes cement, enamel, fill, filler, porcelain, pottery, roofing granules, stone sand, tile, and unspecified uses.

TABLE 32.—Sandstone, quartz, and quartzite (crushed and broken stone) sold or used by producers in the United States in 1959, by States

State	Short tons	Value	State	Short tons	Value
Arizona	220,700	$589,800	Tennessee	70,532	$157,244
Arkansas	1,698,638	2,017,945	Texas	2,404,465	1,186,164
California	2,753,772	4,436,505	Utah	1,785,000	1,805,000
Colorado	30,217	81,710	Virginia	314,585	572,258
Montana	66,971	170,678	West Virginia	460,010	945,584
New Hampshire	1,861	18,610	Wyoming	12,800	19,200
New Mexico	174,857	169,146	Other States [1]	4,187,354	12,738,158
Ohio	572,805	2,625,118			
Pennsylvania	1,410,314	5,531,030	Total	17,079,681	34,722,050
South Dakota	914,800	1,657,900			

[1] Includes Alabama, Connecticut, Georgia, Idaho, Illinois, Indiana, Kansas, Kentucky, Maine, Maryland, Minnesota, Nevada, New York, North Carolina, Oklahoma, Oregon, South Carolina, Washington, and Wisconsin.

---

[41] Chemical and Engineering News, Iodine Used in Lamp: Vol. 37, No. 25, June 22, 1959, pp. 48–51.
Roads and Streets, New Lamps Do Not Blacken: Vol. 102, No. 7, July 1959, p. 169.

[42] Laudise, R. A., and Sullivan, R. A., Pilot Plant Production, Synthetic Quartz: Chem. Eng. Prog., vol. 55, No. 5, May 1959, pp. 55–59.

[43] Rock Products, J–M Forges Ahead in Silica: Vol. 62, No. 8, August 1959, pp. 80–81.

CRUSHED AND BROKEN SLATE

Research on the use of waste slate as a source of raw material for expanded aggregate continued. Production, mainly for roofing granules and lightweight aggregate, increased slightly.

TABLE 33.—Slate (crushed and broken stone) sold or used by producers in the United States [1]

(Thousand short tons and thousand dollars)

Use	1958		1959	
	Quantity	Value	Quantity	Value
Granules [2]	388	$4,289	396	$4,208
Flour	127	703	134	690
Other uses [3]	8	36	7	25
Total	523	5,028	537	4,923

[1] Produced by the following States in 1959 in order of tonnage: Georgia, Vermont, Pennsylvania, Arkansas, Virginia, New York, and California.

[2] Includes crushed slate used for lightweight aggregate.

[3] Includes asphalt filler and unspecified uses.

MISCELLANEOUS STONE

Light-colored volcanic rocks, schists, phyllites, serpentine, chats, chert, flint conglomerate, and other stone that could not logically be classified into any of the six principal varieties are grouped under this category. The output of miscellaneous stone decreased 8 percent, and the value 1 percent. The average value for all uses, $1.20 a ton, was considerably lower than the average for other rock types.

TABLE 34.—Miscellaneous stone (crushed and broken stone) sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1958		1959	
	Quantity	Value	Quantity	Value
Concrete and roadstone	9,882	$10,654	9,249	$10,460
Railroad ballast	2,257	1,400	2,506	1,570
Riprap	5,754	6,081	3,610	4,649
Fill	1,069	857	1,109	1,075
Other uses [1]	1,156	3,364	1,964	4,383
Total	20,118	22,356	18,438	22,137

[1] Includes stone used for agriculture, filler, filtration, flux, roofing granules, stone sand, and unspecified uses.

TABLE 35.—Miscellaneous varieties of stone (crushed and broken stone) sold or used by producers in the United States in 1959 by States

State	Short tons	Value	State	Short tons	Value
Arizona	603, 300	$1, 161, 100	Texas	177, 119	$257, 199
California	7, 062, 190	11, 187, 117	Utah	2, 600	15, 700
Colorado	158, 632	639, 906	Virginia	462	804
Kansas	631, 768	225, 121	Washington	1, 719, 863	1, 545, 569
Maine	4, 484	8, 309	Wyoming	1, 000	1, 000
Maryland	120, 421	240, 421	Other States [1]	4, 506, 733	4, 586, 746
Missouri	769, 553	427, 975			
Montana	106, 487	210, 887	Total	18, 437, 503	22, 136, 899
Nevada	18, 866	25, 341			
New Mexico	60, 302	56, 276	American Samoa	117, 836	142, 903
North Dakota	4, 628	4, 628	Panama Canal Zone	13, 770	16, 320
Oklahoma	1, 085, 780	563, 826	Puerto Rico	72, 000	162, 000
Oregon	1, 215, 619	791, 278	Wake Island	13, 000	8, 840
South Dakota	187, 696	187, 696			

[1] Includes Arkansas, Hawaii, Idaho, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, and Rhode Island.

Roofing Granules.—Production of roofing granules for home construction and building maintenance consistent with general building activity, increased 8 percent. A variety of naturally occurring mineral materials were used in the roofing industry. Some were selected for their natural color, but most were artificially colored. Roofing granules were of two distinct types: Small granules used in asphalt roofing and coarser fragments used in built-up roofing.

Minnesota Mining and Manufacturing Co. purchased a 2,400-acre site in California for a roofing-granule plant.[44]

Innovations in mechanized equipment and the use of roofing granules were described.[45]

TABLE 36.—Roofing granules[1] sold or used in the United States, by kinds

(Thousand short tons and thousand dollars)

Year	Natural		Artificially colored [2]		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1950–54 (average)	392	$3, 554	1, 278	$23, 527	1, 670	$27, 081
1955	366	3, 406	1, 470	30, 452	1, 836	33, 858
1956	323	2, 873	1, 361	30, 854	1, 684	33, 727
1957	312	3, 208	1, 313	31, 798	1, 625	35, 006
1958	389	3, 797	1, 361	33, 307	1, 750	37, 104
1959	446	4, 264	1, 447	34, 372	1, 893	38, 636

[1] Manufactured from stone, slate, slag, and brick.
[2] A small quantity of brick granules is included with artificially colored granules.

---

[44] Western Mining and Industrial News, 3M Buys Acreage For Big Plant in Mother Lode: Vol. 27, No. 5, May 1959, p. 1.

[45] Ray, G. G., Branching Out With Men and Machines: American Roofer and Siding Contractor, vol. 49, No. 4, March 1959, p. 22.

FOREIGN TRADE[46]

Little crushed and broken stone was exported or imported because of its low unit value and high weight. Quartzite from Canada and chalk or whiting and terrazzo from Europe accounted for most of the imports. Exports were virtually limited to border shipments.

TABLE 37.—Stone and whiting imported for consumption in the United States, by classes

[Bureau of the Census]

Class	1958		1959	
	Quantity	Value	Quantity	Value
Marble, breccia, and onyx:				
Sawed or dressed, over 2 inches thick___cubic feet__	525	$5,037	3,544	$25,191
In blocks, rough, etc___do___	172,136	988,345	154,204	923,189
Slabs or paving tiles___superficial feet__	2,419,163	1,859,966	3,420,359	2,626,554
All other manufactures___	---	2,198,397	---	3,047,945
Total___	---	5,051,745	---	6,622,879
Granite:				
Dressed___cubic feet__	63,323	680,203	83,617	870,988
Rough___do___	68,598	331,254	80,784	360,423
Paving blocks, wholly or partly manufactured number___	2,408	56,330	8,885	107,173
Total___	---	1,067,787	---	1,338,584
Quartzite___short tons__	24,203	291,636	160,442	545,273
Slate___	---	299,179	---	403,427
Travertine stone (unmanufactured)___cubic feet__	99,661	323,137	120,901	427,684
Stone (other):				
Dressed: Travertine, sandstone, limestone, etc___cubic feet__	149,328	94,269	223,369	181,997
Rough (monumental or building stone)___do___	11,771	12,817	4,843	6,875
Rough (other)___short tons__	298,884	382,669	748,467	460,021
Marble chip or granito___do___	29,223	313,417	32,678	339,291
Crushed or ground, n.s.p.f___	---	277,118	---	497,586
Total___	---	1,080,290	---	1,485,770
Whiting:				
Chalk or whiting, precipitated___short tons__	856	45,371	1,238	71,322
Whiting, dry, ground, or bolted___do___	9,046	152,865	10,245	168,042
Whiting, ground in oil (putty)___do___	---	---	1	604
Total___	---	198,236	---	239,968
Grand total___	---	8,312,010	---	11,063,585

---

[46] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 38.—Stone exported from the United States

[Bureau of the Census]

Year	Building and monumental stone		Crushed, ground, or broken				Other manufactures of stone (value)
			Limestone		Other		
	Cubic feet	Value	Short tons	Value	Short tons	Value	
1950–54 (average)	305, 624	$716, 552	(1)	(1)	(1)	(1)	$359, 018
1955	437, 644	1, 024, 299	936, 766	$1, 148, 781	169, 074	$2, 923, 813	394, 228
1956	344, 210	975, 777	1, 060, 560	1, 358, 783	175, 364	2, 890, 139	377, 407
1957	415, 903	1, 157, 728	1, 088, 004	1, 649, 697	129, 559	2, 699, 023	506, 180
1958	349, 366	1, 236, 205	767, 757	1, 390, 365	173, 340	3, 696, 951	432, 072
1959	425, 194	1, 261, 687	1, 085, 553	1, 999, 107	157, 911	3, 388, 372	643, 102

[1] Not separately classified before Jan. 1, 1952. Exports 1952: Limestone 803,029 short tons ($789, 733); other 126,123 short tons ($1, 631, 358). 1953: Limestone 691,811 short tons ($703, 833); other 153,105 short tons ($2,204,139). 1954: Limestone 570,013 short tons ($702,526); other 142,622 short tons ($2,395,903).

TABLE 39.—Slate exported from the United States, by uses[1]

Use	1950–54 (average)	1955	1956	1957	1958	1959
Roofing	$13, 067	$12, 801	$6, 747	$6, 168	$12, 026	(2)
Electrical	14, 161	107, 566		276, 177	84, 629	
School slate[3]	83, 659					
Blackboards			135, 516			[2] $126,683
Billiard tables	71, 683					
Structural (including floors and walkways) and granules and flour	263, 997	271, 268	189, 050		212, 460	89, 912
Total	446, 567	391, 635	331, 313	282, 345	309, 115	216, 595

[1] Figures collected by the Bureau of Mines from shippers of products named.
[2] Roofing slate included with blackboards and billiard tables.
[3] Includes slate used for pencils and educational toys.

WORLD REVIEW

Canada.—A recently developed limestone quarry in Manitoba produced crushed limestone at a 220,000-ton annual rate.[47]

A review of industrial minerals of Alberta described extensive beds of limestone and important deposits of silica sand.[48]

Consumption of Canadian roofing granule in 1958 reached a record 134,656 short tons valued at $4,229,980. Imported granules, all from the United States, accounted for 71.4 percent of total consumption. Three-fourths of the imported granules were colored, and the remainder was predominantly black slag.[49]

Colombia.—An estimated 3 million tons of limestone was produced in 1958; 1.8 million tons was used in producing cement, and the remainder was used for flux and the production of carbon dioxide.[50] Considerable interest was shown by a steel mill and glass plant in a deposit of high-magnesium dolomite near Amalfi.

---

[47] Cowie, William G., Industrial Minerals in Manitoba-Production and Utilization: Canadian Min. and Met. Bull. (Montreal), vol. 52, No. 564, April 1959, pp. 269–275.

[48] Govett, G. J., Industrial Minerals of Alberta: Canadian Min. and Met. Bull. (Montreal), vol. 52, No. 564, April 1959, pp. 261–266.

[49] Hanes, F. E., Roofing Granules: Dept. Min. and Tech. Surveys, Ottawa, Review 47, 1958, pp. 1–5.

[50] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 1, January 1960, p. 41.

India.—Investigations by the Geological Survey of India indicate extensive reserves of quartzite adequate for manufacturing silica bricks. This agency also recorded various limestone occurrences.[51] One deposit in Southern India was being considered for use in calcium carbide manufacture. India's annual production of 5,000 tons was reported to be below the average quality of imported material.[52]

Japan.—Limestone and dolomite production totaled 30.3 million tons in 1958, compared with 32.4 million in 1957.

Sandstone production totaled about 355,000 tons in 1958 and 239,000 in 1957.[53]

Turkey.—Although no production statistics were available, the marble industry reportedly continued to expand as new equipment became available. Small quantities of marble were exported to Italy and West Germany.[54]

Union of South Africa.—Sales of limestone for cement, metallurgy, agriculture, and other uses in 1958 totaled about 5.7 million tons, compared with about 5.2 million tons in 1957.[55]

United Arab Republic (Egypt region).—Production of basalt totaled 627,000 tons in 1958, compared with 571,000 tons in 1957. In 1958 granite production amounted to 25,000 tons, marble 11,000 tons, and dolomite 17,000 tons; the 1957 data were not available. Limestone production totaled approximately 7.1 million short tons in 1958, compared with 2.4 million tons for 1957.[56]

United Kingdom.—British Standard Specification 3108, covering limestone for making colorless glasses, was promulgated.[57]

Viet-Nam.—Granite production in 1957 totaled 653,000 tons, compared with approximately 1.5 million tons in 1956. Combined output of limestone, quartz, sandstone, and schist was 617,000 tons in 1957 and about 1.3 million tons in 1956.[58]

Yugoslavia.—Production of limestone totaled 601,000 tons in 1957 and an estimated 574,000 tons in 1956.[59]

TECHNOLOGY

The Bureau of Mines conducted a variety of mining research activities that directly or indirectly affect the crushed stone industry. Some of these technical studies related to rock stability and subsidence, rock fragmentation, block caving, explosives research and testing, cavitation as a means of rock fragmentation, roof control, noise abatement, development of a core-drill assembly, and loading and transportation. The Bureau, in cooperation with several associations, intensified research on vibrations and the resulting effects created by blasting at stone quarries and other mining operations. The three

---

[51] Journal of Mines, Metals and Fuels (Calcutta), Quartzites for Silica Bricks: Vol. 7, No. 4, April 1959, p. 20; Limestone Deposits in Madras State: Vol. 7, No. 7, July 1959, p. 30.

[52] Chemical Age (London), Carbide Industry for India Under Consideration: Vol. 82, No. 2098, Sept. 26, 1959, p. 412.

[53] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 1, July 1959, p. 47.

[54] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 5, November 1959, pp. 51–52.

[55] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 4, October 1959, p. 54.

[56] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 6, December 1959, p. 54.

[57] Ceramic Abstracts, British Standard, 1959, No. 3108: Vol. 42, No. 10, October 1959, p. 275.

[58] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 5, November 1959, p. 57.

[59] Bureau of Mines, Mineral Trade Notes: Vol. 48, No. 6, June 1959, p. 44.

major objectives were: (1) To evaluate the equipment used by industry for measuring blast vibrations; (2) to develop improved techniques and formulas for relating vibrations at a given point to amount of explosives used and to distance from place of detonation; and (3) to establish reliable methods for relating the magnitude of the vibrations to the effects they produce on different types of structures. The Bureau of Mines made comparative evaluations of the effectiveness of explosives in blasting granite.[60]

Reports on methods and practices at limestone, traprock, and granite operations were published by the Bureau of Mines.[61]

Drilling and Blasting.—Quarrying and processing techniques at a new 500-ton-per-hour Georgia granite-gneiss operation stressed current technology in drilling and blasting practices and flexibility of design and automation in crushing and screening operations.[62]

A down-the-hole drill, using bigger bits, permitted wider spacing of holes, larger powder charges, and reduced quarrying costs.[63]

Methods at an underwater quarry featured novel drilling and blasting techniques to produce porous coral rock for a new Florida cement plant.[64]

Quarrying and processing techniques at a South African limestone property featured pneumatic drilling, mass blasting, and truck transportation. Crushing and screening in a modern plant produced sized products for calcining. Rejects were stockpiled for possible use as cement rock or agstone.[65]

A report was published on the abrasive wear of drill bits in rotary rock drilling. Experiments were made with bits that had cutting edges tipped with hard-metal alloys. A simple laboratory test of rock abrasiveness was developed, and the results were compared with those obtained in full-scale drilling.[66]

Drilling in hard limestone at a Kentucky quarry, using a portable compressed air-driven rotary drill, resulted in significant savings, compared with conventional wagon drilling.[67]

Although the use of ammonium nitrate-base blasting agents is well known to the industry and all indications point to increased applications, several developments occurred that should increase efficiency and further reduce costs. The standard procedure of field mixing this type of explosive manually gradually was being replaced by mechani-

---

[60] Atchison, Thomas C., and Tournay, William E., Comparative Studies of Explosives in Granite: Bureau of Mines Rept. of Investigations 5509, 1959, 28 pp.

[61] Marshall, L. G., Mining and Milling Methods, Inland Lime and Stone Co., Port Inland, Mich.: Bureau of Mines Inf. Circ. 7917, 1959, 22 pp.

Marshall, L. G., Coyote-Hole Primary Blasting, Dresser Trap Rock Co., Dresser, Wis.: Bureau of Mines Inf. Circ. 7913, 1959, 18 pp.

Pace, Norman A., and Schroeder, Harold J., Methods and Practice for Producing Granite, Weston-Brooker Co., Warren County, Ga.: Bureau of Mines Inf. Circ. 7857, 1959, 24 pp.

[62] Trauffer, Walter E., New Weston & Booker Crushed Granite Plant Last Word in Design: Pit and Quarry, vol. 51, No. 9, March 1959, pp. 80–86.

[63] Rock Products, Big Downhole Drill: Vol. 62, No. 3, March 1959, p. 147.

[64] Trauffer, Walter E., Lehigh's New Miami Plant: Pit and Quarry, vol. 52, No. 6, December 1959, pp. 76–86.

Meschter, Elwood, Coral Rock Serves as Base and Basis for New Cement Plant: Rock Products, vol. 62, No. 4, April 1959, pp. 82–86.

[65] Lowther, R. E., Remote Lime Plant Proves Progressive: Rock Products, vol. 62, No. 5, May 1959, pp. 120–121, 124–125.

[66] Fish, B. G., Guppy, G. A., and Ruben, J. T., Abrasive Wear Effects in Rotary Rock Drilling: Min. and Met., vol. 68, No. 630, May 1959, pp. 357–383.

[67] Rock Products, Drilling Hard Limestone for Only 4½¢ Per Ton: Vol. 62, No. 2, February 1959, p. 91.

cal methods to insure uniform mixtures. In some instances the fuel oil was mixed with ammonium nitrate at the plant and delivered to the site in trucks, somewhat in the manner of ready-mixed concrete.[68] A comprehensive evaluation of ammonium nitrate powders as applied to quarrying and open-pit mining was published. Experiments with prepackaged mixtures of ammonium nitrate, compared with prill-fuel oil mixtures, indicated substantial reductions in the overall costs of blasting resulting from increased spacing of holes, more tons broken per foot of drillhole, and use of smaller diameter drillholes.[69]

The broad aspects of conducting large-scale blasting operations in thickly populated areas and recent developments in the use of ammonium nitrate explosives were outlined at an American Mining Congress meeting.[70]

Blasting with bagged ammonium nitrate, placed in a series of coyote holes, produced over 1 million cubic yards of crushed basalt for use on an Oregon highway project.[71]

Blasting techniques at a Michigan limestone quarry, using ammonium nitrate and fuel-oil mixtures, were discussed. A truck-mounted loading device automatically mixed and loaded predetermined amounts of ammonium nitrate into each hole. The use of various primers and procedures in dry and wet holes was described.[72]

A machine reportedly designed to mix prilled ammonium nitrate with oil and blow the mixture into horizontal drill holes also subsequently blew sand into the holes for stemming.[73]

Factors affecting safety conditions in rock quarries were enumerated in an article. Proper blasting and loading procedures, quarry layout, equipment, and personnel were major considerations.[74]

Sublevel stoping methods, utilizing blasthole drilling, replaced shrinkage stoping at a Pennsylvania limestone mine. Increased efficiency resulted because the sublevel stoping methods proved more adaptable to the deposit.[75]

The physical processes involved in breaking rock with confined concentrated charges by using simple crater tests were reported in a Bureau of Mines publication.[76]

Contract drilling and blasting in a variety of New England stone quarries by a Massachusetts operator featured rotary and percussion drilling and millisecond delay blasting. The necessity of favorable public relations in thickly populated areas was stressed.[77]

---

[68] McManus, C. E., Trends in Open Pit Mining: Min. Cong. Jour., vol. 46, No. 2, February 1960, pp. 57–60.

[69] Ammons, Bill, Ammonium Nitrate Powders—Their Properties and Performances: Pit and Quarry, vol. 52, No. 1, July 1959, pp. 72–77.

[70] Utley, Harry F., Significant Developments in Industrial Minerals Revealed at A.M.C. Meeting: Pit and Quarry, vol. 52, No. 5, November 1959, pp. 96–98.

[71] Roads and Streets, Big Hill Blasted to Produce Highway Aggregates: Vol. 102, No. 8, August 1959, pp. 163–164.

[72] Patterson, Lewis J., Blasting Limestone In Michigan: Min. Cong. Jour., vol. 45, No. 5, May 1959, pp. 55, 57, 58.

[73] Rock Products, At Last! A Machine For Fast, Easy Placement of Ammonium Nitrate In Horizontal Blast Holes: Vol. 62, No. 7, July 1959, p. 131.

[74] Ziemke, Paul C., Proper Bank Trimming Reduces Quarry Hazard: Pit and Quarry, vol. 52, No. 5, November 1959, pp. 108–111.

[75] Kreider, E. L., Mining Limestone in a Deep Pennsylvania Mine: Explosives Eng., vol. 37, No. 6, November-December 1959, pp. 167–174.

[76] Duvall, Wilbur I., and Atchison, Thomas C., Rock Breakage With Confined Concentrated Charges: Min. Eng., vol. 11, No. 6, June 1959, pp. 605–611.

[77] Pit and Quarry, Contract Drilling and Blasting: Vol. 51, No. 9, March 1959, pp. 116–117, 122.

Introduction of the refraction seismograph reportedly permitted rapid and inexpensive determination of overburden consolidation, and provided data for the operator to determine the most efficient and economical method of removing overburden.[78]

Results of the application of explosions research to blasting in mines and quarries were outlined.[79]

Extensive experiments indicated that many softer rocks could be ripped at considerably less cost than by drilling and blasting. Data pertaining to this method and new types of drills and explosives were published.[80]

Morrison-Knudsen Co., Inc., operated what is reportedly the largest aggregate plant built for a construction project. The plant had a capacity of 2,000 tons of crushed stone and stone sand an hour. Its output of 7 million tons of coarse aggregate and 3 million tons of sand was used at the $700 million Niagara Power Project.[81] Rock removal methods at this project included many new innovations in drilling, blasting, and transportation.[82]

Mining and Processing.—Unconventional methods of mining, crushing, and grinding were investigated. High-frequency electromagnetic induction was patented as a method of fracturing taconite iron ore. A Soviet method of in-place rock crushing by use of a high-voltage electrical discharge was being investigated by the Bureau of Mines. The Colorado School of Mines Research Foundation studied the economics of rock crushing by nuclear detonations and the resulting contamination. Georgia Institute of Technology experimented with a radiation-reduction method, and several papers discussed recent trends in autogenous grinding.

Rigid specifications and low-profit margins for aggregates in highway construction required that mining operations and processing plants be designed to meet specific jobs. Unless properly engineered for the particular problem, these might be too costly and inefficient to produce at a profit. A magazine article emphasized some of the problems.[83]

Development of a high-calcium limestone deposit in southwestern Tennessee, quarrying methods, and the new 250-ton-per-hour processing plant were described. Flexibility of plant design permitted simultaneous production in predetermined quantities of six sizes of crushed limestone.[84]

Production of hard, abrasive traprock in Virginia to meet specifications for concrete aggregate was described. Quarrying operations

---

[78] Pit and Quarry, Seismic Technique Aids Quarry Operations: Vol. 52, No. 1, July 1959, pp. 86–88.

[79] Livingston, Clifton W., The Application of Explosions Research to Blasting in Mines and Quarries: Min. Eng., vol. 11, No. 12, December 1959, p. 1230.

[80] Rock Products, Ripping Gains in Stature: Vol. 62, No. 9, September 1959, pp. 80–82.

[81] Engineering News-Record, Biggest Aggregate Plant Grinds It Out at Niagara: Vol. 163, No. 12, Sept. 17, 1959, pp. 64–66.

Herod, Buren C., Aggregates for Niagara Power: Pit and Quarry, vol. 51, No. 12, June 1959, pp. 74–85.

[82] Boracci, Andrew, Carving a Power Plant Out of Rock: Construction Methods and Equipment, vol. 41, No. 6, June 1959, pp. 136–138, 140, 145, 146, 148, 150.

Boracci, Andrew, Canal Excavation Goes Deep: Construction Methods and Equipment, vol. 41, No. 8, August 1959, pp. 132–134, 138, 141–142.

Pit and Quarry, Aggregates for Niagara Power: Vol. 51, No. 12, June 1959, pp. 74–85.

[83] Pollitz, H. C., Those Tough Rock Specifications: Roads and Streets, vol. 102, No. 7, July 1959, pp. 122–124.

[84] Trauffer, Walter E., Flexibility Highlights Southwestern Tennessee Plant: Pit and Quarry, vol. 51, No. 12, June 1959, pp. 88–91.

featured the use of truck-mounted pneumatic drills and millisecond delay blasting. A new crushing and screening plant was electronically controlled from three stations.[85]

Use of mechanized equipment at a South African dolomite quarry was demonstrated. Data were reported on a 2½-cubic-yard-capacity, tractor-mounted, diesel-driven, hydraulically operated loader, and 6- and 10-cubic-yard-capacity, diesel-driven, shuttle dumpers.[86]

Techniques in the production of crushed granite for use as cement-treated, road-base material at a southern California crushed-stone plant were described.[87]

An unusual byproduct-limestone operation in Illinois was described, whereby a contractor, widening a channel cut through a commercial limestone formation, used barge-mounted percussion drills and two large draglines to bank limestone along the channel. A subcontractor then utilized the material in two portable crushing and screening plants to produce quality limestone products.[88]

Quarrying and processing methods used at a Georgia operation in producing crushed granite for highway construction were described.[89]

Quarrying, loading, transporting, and processing methods at an Iowa limestone property were outlined. Installation of a scalper screen and a secondary crusher eliminated a circulating load on the primary crusher and doubled plant capacity.[90]

Higher rail rates influenced a Wisconsin agricultural limestone producer to open a new quarry and to equip it with a diesel-powered portable crushing and screening plant and a fleet of spreader trucks to haul processed stone to consumers.[91]

Quarrying and processing techniques at a new Pennsylvania operation, designed to produce agricultural limestone and aggregate to meet increasingly tighter specifications, were described.[92] Quarrying methods and processing techniques in producing various sizes of crushed limestone at a new Ohio plant also were described.[93]

Advantages of selective mining by the room-and-pillar method compared with quarrying were exemplified by a Georgia crushed-marble operation, where production was unaffected by weather, stripping was unnecessary, rock was removed in its naturally clean state, and moisture problems were reduced.[94] However, overall costs of pro-

---

[85] Trauffer, Walter E., Virginia Trap Rock Plant—Built Primarily for Asphalt Plant: Pit and Quarry, vol. 51, No. 7, January 1959, pp. 144–147.

[86] South African Mining and Engineering Journal (Johannesburg), The Big Grab: Vol. 70, Part 1, No. 3442, Jan. 30, 1959, pp. 189–191.

[87] Rock Products, Premium Granite Steps up Base-Mix Quality: Vol. 62, No. 8, August 1959, pp. 88–89.

[88] Rock Products, Limestone Spoil Bank Marks Portable Plant Site: Vol. 62, No. 4, April 1959, pp. 124, 126, 128.

[89] Herod, Buren C., Revised Primary, Surge Addition Spark Increase in Production: Pit and Quarry, vol. 52, No. 2, August 1959, pp. 104–106, 110.

[90] Herod, Buren C., Small Firm—Competent Producer: Pit and Quarry, vol. 52, No. 4, October 1959, pp. 124–127.

[91] Mocine, David O., New Business Springs From Rate Hike: Rock Products, vol. 62, No. 7, July 1959, pp. 79, 122.

[92] Trauffer, Walter E., Pennsylvania Firm's Agstone Plant Designed as Separate Department of Highly Flexible Crushed Stone Operation: Pit and Quarry, vol. 51, No. 11, May 1959, pp. 130–134.

[93] Trauffer, Walter E., New Ohio Crushed Stone Plant Features Quick Flexibility, Protection From Delays, Attention to Details: Pit and Quarry, vol. 51, No. 8, February 1959, pp. 74–78.

[94] Herod, Buren, C., Calcium Products Division—Supplier to Modern Industry: Pit and Quarry, vol. 52, No. 5, November 1959, pp. 92–95.

duction continued to be somewhat higher from most underground operations than from quarries.

Mechanized mining by room-and-pillar mining methods of a California limestone deposit produced about 1,500 tons per day with a 10-man crew. Pre-World War II operations, using the glory-hole system of mining, required 140 men to produce the same tonnage.[95]

The usual implication that a portable operation is relatively small is not always true. A combined and coordinated Iowa operation produced 10,000 tons a day to complete production of more than a million tons 2 months ahead of schedule.[96]

Low-cost operation of portable crushing and screening plants in basalt quarries in the Pacific Northwest was described.[97]

A new Southern California plant was divided into two parallel production units (wet and dry) producing 300 tons per hour of crushed stone and washed sand and gravel. Main elements of the plant were two screening towers for the sand and gravel and two for the crushed rock; each tower contained a three-deck vibrating screen.[98]

Modernization and expansion of crushing phases at a Kentucky limestone quarry increased production and enabled the company to meet increasingly rigid State highway specifications.[99]

Introduction of new crusher types greatly increased production at several aggregate plants. Developments included twin-jaw crushing, reduction of abrasive wear in impact-type crushers, disc crushing, and use of alloys in gyratory-crusher concaves.[1]

A crushed-stone plant in Illinois utilized a recycling conveyor above the main conveyor and rotating cylindrical V-screens for blending operations. These screens reportedly had twice the screening capacity of vibrating screens of similar size for materials in the 5- to 100-mesh range.[2]

Modernization of a Canadian limestone plant reportedly increased production 500 percent. In the quarry, pneumatic drills replaced obsolete churn drills; truck haulage was substituted for narrow-gage rail transportation to increase speed and flexibility of operation; and a belt conveyor replaced an outmoded skip hoist to transport broken material from the quarry floor to the rim. A primary gyratory crusher was installed in the quarry, and the crushing and screening plant was redesigned to produce a greater variety of products.[3]

Greater demand for finer screen sizes caused an Alabama limestone producer to redesign his plant flowsheet. By installing a larger sec-

---

[95] Utley, Harry F., Then—Quarry and 3-Mile Haul, Now—New Mine and 30-Mile Haul: Pit and Quarry, vol. 52, No. 5, November 1959, pp. 114–116.

[96] Construction Methods and Equipment, Efficient Plant Pours Out Stone: Vol. 41, No. 12, December 1959, pp. 84–86.

[97] Thomson, Pat, Roving Crushing Plants Bolster Aggregate Stockpile System: Rock Products, vol. 62, No. 3, March 1959, pp. 86–87.

[98] Rock Products, Rinker Rock's Two-in-one Plant Makes Crushed Stone, Sand, Gravel: Vol. 62, No. 2, February 1959, pp. 87, 141.

[99] Pit and Quarry, Aggregate Grading Specifications Dictate Crushing Improvements: Vol. 52, No. 3, September 1959, pp. 128–129, 132, 134.

[1] Rock Products, New Crushers Increase Yield: Vol. 62, No. 9, September 1959, p. 92.

[2] Godfrey, Kneeland A., Jr., Novel Plant Design Pays Off: Rock Products, vol. 62, No. 5, May 1959, pp. 144, 146, 148, 150.

[3] Meschter, Elwood, Canadian Lime Plant Boosts Quarry Capacity 500 Percent: Rock Products, vol. 62, No. 4, April 1959, pp. 94–97.

ondary crusher, more screens, and a tertiary crusher, a higher percentage of fines was produced.[4]

Selecting the proper screening surface for aggregate processing and costs and specifications of wire cloths and perforated screen plates and their application were discussed.[5]

A bibliography on crushing and grinding, published in England, had nearly 3,000 references on various aspects of the subject.[6]

Construction, operation, and application of resonance-type vibrating screen in quarries was described in detail.[7]

Safety and operational efficiency were featured at a new 250 ton-per-hour New York traprock crushing and screening plant. Significant features included dust collection and preventive maintenance.[8]

An unusual use of a surge-pile facility at a Michigan limestone operation was described. During the operating season railroad cars were loaded from four drawpoints in the large concrete tunnel beneath the surge pile; in the winter, the tunnel was used as a garage and service shop.[9]

Drying and classifying waste fines at a 1,000 ton-per-day Pennsylvania crushed-limestone plant yielded aglime and limestone sand products. Beneficiation was accomplished in a 12-foot air separator equipped with an oil-fired heater.[10]

Dense-medium separation at an Illinois limestone operation reduced a 3- to 4-percent chert content to 0.2 percent and removed soft, friable limestone fractions.[11]

Designing and rebuilding a Georgia crushed-stone plant, (without interrupting production), doubled its capacity and resulted in an efficient and flexible operation capable of producing 10 sizes of quartzite simultaneously and up to 25 sizes by blending.[12]

Greater production at peak efficiency was attained at a Kentucky dolomitic limestone plant by close feed control. Flow of material to crushers and screens was regulated by controls in a central power station.[13]

Processing techniques at a South Carolina granite property, including an arrangement of vibrating feeders under storage bins, gave unusual flexibility to the operation.[14]

---

[4] Parsons, R. H., and Johnson, K. I., Revised Markets Compel Change in Plant Flow: Rock Products, vol. 62, No. 7, July 1959, pp. 88–90.

[5] Price, W. L., How To Select the Proper Screening Surface: Rock Products, vol. 62, No. 8, August 1959, pp. 90, 92, 94, 97, 100, 104, 106.

[6] Bickle, W. H., Crushing and Grinding—A Bibliography: Jour. of Am. Ceram. Soc., vol. 42, No. 11, November 1959, p. 294.

[7] Ruff, H., Resonance Screens in Quarries: Quarry Managers Jour., vol. 43, No. 10, October 1959, pp. 387–392.

[8] Meschter, Elwood, New Goals Earmark Rebuilt Plant: Rock Products, vol. 62, No. 6, June 1959, pp. 90–92.

[9] Harkins, Wesley R., Dual Purpose Surge Pile Facility: Skillings' Min. Rev., vol. 47, No. 50, Mar. 14, 1959, pp. 16–17.

[10] Rock Products, That Waste Heap May Be Valuable: Vol. 62, No. 12, December 1959, p. 90.

[11] Godfrey, Kneeland A., Jr., An Industry First—HMS For Crushed Stone: Rock Products, vol. 62, No. 11, November 1959, pp. 97–99, 102.

[12] Trauffer, Walter E., Produces 10 Sizes at One Time—Up to 25 by Blending: Pit and Quarry, vol. 52, No. 5, November 1959, pp. 84–89, 95.

[13] Herod, Buren C., Close Feed Control Boosts Production Efficiency: Pit and Quarry, vol. 51, No. 8, February 1959, pp. 112–115.

[14] Meschter, Elwood, Blue Granite Challenges Road Builder: Rock Products, vol. 62, No. 8, August 1959, pp. 115–116, 118.

Transportation.—New high-capacity off-the-road trucks were announced, featuring pistons to absorb the load instead of conventional springs, a suspension system to replace the usual axles, and protection of the entire steering system above the frame line.[15]

Scrapers sometimes performed excavator-truck operations. Application of this method and comparative costs were discussed.[16]

A unique method of removing broken stone from a deep Illinois quarry was described. Dump trucks transported broken rock over steep grades from shovels to hoppers. The rock was then hoisted in counterbalanced inclined skips to the top of the processing plant.[17]

A cross-country conveyor, designed to follow land contour, was reported to be easily installed and stored in a very small area.[18]

A 5½-mile conveyor carrying 1,000 tons per hour of limestone to an Oklahoma cement plant was considered the longest permanent cross-country belt conveyor in the United States.[19]

At a California limestone mine, diesel trucks were converted to electric. Studies revealed that the electric trucks could haul nearly 50 percent more tonnage in half the time of an equivalent number of diesel trucks.[20]

By using a portable crusher in the quarry, the conveyor could sometimes replace the truck and reduce haulage costs.[21]

Conventional shovel loading and truck haulage at an Oregon limestone quarry were replaced with an 8-ton capacity front-end loader. The loader, operated by one man, loaded and hauled crushed rock directly to the primary crusher hopper.[22]

To increase production at minimum cost at an Indiana limestone property, haulage capacity was improved by adding 15-ton rear-dump haulers and installing a surge-reclaim system between the primary and secondary crushers. These features permitted a single-shift quarry and a two-shift plant operation.[23]

Miscellaneous.—Replenishment of mineral elements in depleted farm lands can be accomplished by many quarry rocks. The agricultural limestone equivalent of farm products was reported.[24]

Operations at an Illinois limestone plant included extensive rehabilitation of quarried areas by backfilling and landscaping.[25]

A field method was devised for quantitatively determining the approximate percentages of magnesium carbonate in limestones. It

---

[15] Rock Products, New Machinery—Radical New Truck: Vol. 62, No. 6, June 1959, p. 152.

[16] Rock Products, Scrapers Show Per-Ton Savings: Vol. 62, No. 9, September 1959, p. 83.

[17] Pit and Quarry, Haulage, Drilling Efficiency Improved at Anna Quarries: Vol. 52, No. 3, September 1959, pp. 88, 96.

[18] Pit and Quarry, The Joy Limberope Conveyor: Vol. 52, No. 6, December 1959, p. 124.

[19] Link-Belt Speeder News, World's Longest Belt Conveyor in Operation at Ideal Cement: January-February 1960, p. 2.

[20] Nalle, Peter B., Electric Truck Haulage at Crestmore: Min. Eng., vol. 11, No. 4, April 1959, pp. 405–408.

[21] Kochanowsky, B. J., Portable Crusher in Open Pits and Quarries Operation: Min. Eng., vol. 11, No. 12, December 1959, p. 1230.

[22] Rock Products, Single Unit Works Limestone Quarry: Vol. 62, No. 2 February 1959, pp. 108, 110, 112, 143.

[23] Rock Products, Stone Plant Licks Expansion-Cost Problem: Vol. 62, No. 6, June 1959, pp. 86–89.

[24] Keller, W. D., Agstone Equivalents of Agricultural Products Vital to National Health and Safety: Pit and Quarry, vol. 51, No. 11, May 1959, pp. 152–158.

[25] Herod, Buren C., Indian Point Limestone Products: Pit and Quarry, vol. 51, No. 11, May 1959, pp. 136–139.

consisted of using a coloring agent that would react with calcium carbonate but not with dolomite.[26]

An article outlined the legal status of rock-excavating operations within highly populated areas and restricted zones.[27]

Changes in rock-products technology increased water consumption and the quantity of subsequently discharged effluents containing suspended inert solids. Resulting problems facing these industries and possible solutions were discussed.[28]

An article relating to present concepts of depreciation and salvage was published.[29]

Use of dry-type air filters on shovels, trucks, loaders, compressors, and crushers at a New Jersey quarry resulted in reduced maintenance costs.[30]

A series of articles on distribution of electric power for quarries and mines was published. Factors bearing on performance, initial installation costs, and maintenance were outlined.[31]

An electronic digital computer was installed at a California cement plant to regulate the crushing and rock-blending system.[32]

Methods of handling over 80 million tons of rock and earth for construction of new Lucin railroad cutoff across Great Salt Lake were described briefly.[33] The Bureau of Mines was preparing a report on mining methods and cost studies at this operation.

---

[26] Schnitzer, W. A., [Simple MgO Determination in Dolomitic Lime]: Zement-Kalk-Gips (Wiesbaden), vol. 11, July 1958, pp. 297–298.

[27] Gray, Albert W., Quarry Operators Do Win Cases: Rock Products, vol. 62, No. 11, November 1959, pp. 120, 122, 142.

[28] Dufor, C. N., and Whetstone, G. W., Are the Rock Industries Polluting our Waters: Rock Products, vol. 62, No. 6, June 1959, pp. 76–80.

[29] McEachern, Webster C., Some Present Concepts of Depreciation and Salvage: Pit and Quarry, vol. 51, No. 11, May 1959, pp. 98–101, 108.

[30] Pit and Quarry, Equipment Maintenance Costs Reduced by Accessory Unit: Vol. 52, No. 5, November 1959, pp. 103, 107.

[31] Anderson, T. H., Well Engineered Electric Power Distribution for Quarries and Mines: Pit and Quarry, vol. 52, No. 1, pt. 1, July 1959, pp. 80–83.

Anderson, T. H., Well Engineered Electric Power Distribution for Quarries and Mines: Pit and Quarry, vol. 52, No. 3, pt. 2, September 1959, pp. 97–101.

[32] Pit and Quarry, Digital Computer to Automate Cement Rock Crushing, Blending: Vol. 51, No. 7, January 1959, pp. 138–139.

Utley, Harry F., Riverside's New Automatic Crushing Storage, Blending Systems: Pit and Quarry, vol. 52, No. 1, July 1959, pp. 122–126, 128–129.

[33] News of Industry, Moving of a Mountain Completed, Winter 1960, pp. 12–13.

Strontium

By Albert E. Schreck [1] and James M. Foley [2]

⁂

IMPORTS continued to provide the bulk of domestic supplies of strontium raw materials in 1959. After being inactive in 1958, domestic mines again reported a small output of these minerals.

DOMESTIC PRODUCTION

Pan Chemical Co., Los Angeles, Calif., and Mineral Products Corp., Seattle, Wash., were the only domestic producers of strontium minerals in 1959. Pan Chemical Co. reported a small output of celestite from its deposit in the Fish Creek Mountains, San Diego, Calif., and Mineral Products Corp.'s output came from a deposit near La Conner, Skagit County, Wash.

TABLE 1.—Strontium minerals sold or used in the United States

Year	Short tons	Value	Year	Short tons	Value
1953	50	$1,000	1956	4,040	$77,160
1954	12	300	1957–59	(1)	(1)
1955	177	4,425			

(1) Figure withheld to avoid disclosing individual company confidential data.

Celestite imported from the United Kingdom and Mexico was converted to various strontium chemicals by the E. I. du Pont de Nemours & Co., Inc., Grasselli, N.J.; Foote Mineral Co., Exton, Pa.; and Barium Products, Ltd., Modesto, Calif.

Pan Chemical Co. and Barium & Chemicals, Inc., Willoughby, Ohio, also manufactured strontium chemicals.

King Laboratories, Inc., Syracuse, N.Y., produced a small quantity of strontium metal.

CONSUMPTION AND USES

The strontium chemical industry was again the largest consumer of strontium minerals. Manufactured strontium compounds served a wide variety of uses. Strontium nitrate was used in pyrotechnics, such as tracer bullets, distress signal rockets and flares, tactical military signal flares, highway and railroad warning fusees, and fireworks, because of the characteristic red color it imparts to a flame.

---

[1] Commodity specialist.
[2] Supervisory statistical assistant.

Other strontium compounds were used in ceramics, greases, corrosion inhibitors, medicines, plastics, and luminous paints.

Celestite was also used by producers of high-purity electrolytic zinc. The mineral is converted to strontium carbonate, which is added to the cell bath to inhibit deposition of lead in the zinc formed at the cathode.

Small quantities of strontium metal were used as a getter to remove traces of gas from vacuum tubes.

PRICES

The prices of various strontium compounds, as quoted in Oil, Paint and Drug Reporter, were as follows: Strontium sulfate, air-floated, 90 percent, 325-mesh, bags, works, $56.70–$66.15 per short ton; strontium carbonate, pure drums, 5-ton lots or more, works, 35 cents per pound, drums, 1-ton lots, works, 37 cents per pound; Technical grade, drums, works, 19 cents per pound; and strontium nitrate, bags, carlots, works, $11 per 100 pounds, less than carlots, works, $12 per 100 pounds.

FOREIGN TRADE[3]

The United Kingdom supplied almost three-fourths of the domestic strontium minerals imported in 1959 and Mexico the remainder, except for a small quantity from Italy.

There were no imports of strontium nitrate; however, 2,000 pounds of strontium carbonate and/or oxide, valued at $358, was imported from France.

TABLE 2.—Strontium minerals[1] imported for consumption in the United States, by countries

[Bureau of the Census]

Country	1958		1959	
	Short tons	Value	Short tons	Value
Italy			11	$2,700
Mexico	[2] 2,336	$38,901	2,182	39,936
United Kingdom	4,350	102,108	5,946	182,769
Total	[2] 6,686	141,009	8,139	225,405

[1] Strontianite or mineral strontium carbonate and celestite or mineral strontium sulfate.
[2] Revised figure.

WORLD REVIEW

Production of strontium minerals was reported from several countries in 1959, but the United Kingdom and Mexico remained the principal producers.

Morocco.—Production of celestite from the deposit of Matemine, S.A., at Tirrhist, increased in tonnage and quality from 1957 to 1958. Material mined in 1957 analyzed 93 percent $SrSO_4$ and in 1958, 95 percent $SrSO_4$.[4]

---

[3] Figures on imports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

[4] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 6, December 1959, p. 55.

TABLE 3.—World production of strontium minerals, by countries,[1] in short tons [2]

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country [1]	1955	1956	1957	1958	1959
Argentina	----------	489	(3)	240	(3)
Italy	77	234	1,226	703	[4] 700
Mexico [5]	2,072	2,313	1,896	2,336	2,182
Morocco: Southern zone	----------	----------	661	1,124	435
Pakistan	486	336	956	510	[4] 550
United Kingdom	5,320	10,304	7,728	[4] 7,500	[4] 9,000
United States	177	4,022	(6)	----------	(6)
World total [1]	8,132	17,698	[4] 13,000	[4] 12,413	[4] 13,500

[1] In addition to countries listed, strontium minerals are produced in Germany, Poland, and U.S.S.R., but data on production are not available; no estimates are included in the total for these countries.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Data not available; estimate by senior author of chapter included in total.

[4] Estimate.

[5] United States imports.

[6] Production included in total; Bureau of Mines not at liberty to publish.

United Kingdom.—An article described the celestite operation of Bristol Mineral & Land Co., Ltd.[5] This firm, England's largest celestite producer, employed about 30 men at its mine and washer at Chipping Sodbury. The celestite, occurring in a clay bed, was mined by open-pit methods, reduced in a jaw crusher, washed, and screened into three sizes. A dewaterer recovered the fines. Celestite has been mined at this locality since 1912.

TECHNOLOGY

An article was published on the variations of grinding hardness in strontium titanate crystals.[6]

Investigations of barium strontium titanates indicated that a ceramic of this type exhibited changes in resistance and capacitance with applied stress, larger than have been noted in other materials. This property may lead to applications of this ceramic in various pressure-sensitive devices.[7]

A comprehensive report on the strontium industry, containing data on resources, occurrences, mining, processing, and uses of strontium minerals and compounds, was published in 1959.[8]

---

[5] Mining Journal (London), Britain's Impressive Output of Strontium: Vol. 253, No. 6475, Sept. 25, 1959, p. 287.

[6] Giardini, A. A., and Conrad, M. A., Directional Hardness of Strontium Titanate by Peripheral Grinding: Jour. Am. Ceram. Soc., vol. 42, No. 4, April 1959, pp. 165–168.

[7] Sauer, H. A., Flaschen, S. S., and Hoesterey, D. C., Piezoresistance and Piezocapacitance Effects in Barium Strontium Titanate Ceramics: Jour. Am. Ceram. Soc., vol. 42, No. 8, August 1959, pp. 363–366.

[8] Schreck, Albert E., and Arundale, J. C., Strontium, A Materials Survey: Bureau of Mines Inf. Circ. 7933, 1959, 45 pp.

Sulfur and Pyrites

By Leonard P. Larson[1] and James M. Foley[2]

◆

STIMULATED by a 10-percent growth in the production of new sulfuric acid, consumption of sulfur in the United States rose 12 percent in 1959 to a new high. Imports of sulfur increased, and exports neared the record high of 1956. Competition in the industry continued as new production facilities in Mexico, France, Canada, and other countries became operative. Domestic producers met competition by offering incentives. Most of the increased demand for sulfur in 1959 was met from producer stocks, which were reduced from 4.6 million tons in 1958 to 3.9 millions tons in 1959.

TABLE 1.—Salient statistics of the sulfur industry, in long tons of sulfur content

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Native-sulfur production	5,308,157	5,799,880	6,484,285	5,578,525	4,645,577	4,639,816
Production (all forms)	6,278,140	7,026,778	7,818,112	7,003,888	6,141,169	6,167,740
Imports (pyrites and sulfur)	116,542	206,127	387,429	668,501	754,987	776,888
Producer stocks (Frasch and recovered sulfur)	[1] 3,024,479	3,301,465	4,055,896	4,579,623	4,619,028	3,949,954
Exports (sulfur)	1,414,970	1,635,652	1,675,331	1,592,979	[2] 1,602,126	1,635,607
Apparent domestic consumption (all forms)	4,920,300	5,625,400	5,744,300	5,553,700	[2] 5,262,800	5,917,100
World production:						
Sulfur, elemental	(3)	8,120,000	9,215,000	8,760,000	8,405,000	9,075,000
Pyrites	(3)	7,100,000	7,500,000	7,900,000	7,700,000	7,000,000

[1] Frasch sulfur only before 1952.
[2] Revised figure.
[3] Data not available.

DOMESTIC PRODUCTION

Sulfur production in the United States was slightly higher in 1959. Of the total, 75 percent was native sulfur, 11 percent recovered sulfur, 7 percent sulfur contained in pyrites, 5 percent sulfur in smelter acid, and 2 percent in other forms.

NATIVE SULFUR

Twelve Frasch-process mines were in operation—seven in Texas and five in Louisiana. Texas maintained its world leadership in the out-

---

[1] Commodity specialist.
[2] Supervisory statistical assistant.

put of elemental sulfur, producing 2,519,090 tons compared with Louisiana's 2,034,544 tons. Texas Gulf Sulphur Company and Freeport Sulphur Company remained the Nation's largest producers; next in order were Jefferson Lake Sulphur Company and Duval Sulphur & Potash Company.

The quantity of Frasch sulfur produced in the United States was fractionally lower (89,600 tons, or 2 percent) than that produced in 1958 and the smallest annual tonnage reported since 1947. Decline in output was attributed to efforts of the producers to maintain the low production schedules established in 1958. Indications are that producers have found it advantageous to operate their smaller properties at a high rate of capacity and control total output by adjustments at their larger properties.

TABLE 2.—Production of sulfur and sulfur-containing raw materials by producers in the United States, in long tons

	1950–54 (average)		1955		1956		1957		1958		1959	
	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content
Native sulfur or sulfur ore:												
Frasch-process mines	5,286,712	5,286,712	5,738,978	5,738,978	6,423,883	6,423,883	5,491,212	5,491,212	4,643,243	4,643,243	4,553,634	4,553,634
Other mines [1]	76,357	21,445	199,899	60,902	212,476	60,402	276,868	87,313	6,292	2,334	331,237	86,182
Total	----------	5,308,157	----------	5,799,880	----------	6,484,285	----------	5,578,525	----------	4,645,577	----------	4,639,816
Recovered elemental sulfur:												
Brimstone	255,212	254,127	400,754	398,601	466,848	464,629	511,936	510,307	641,890	640,096	688,487	686,407
Paste	3,386	1,596	380	179	287	129	452	204	----------	----------	----------	----------
Total	----------	255,723	----------	398,780	----------	464,758	----------	510,511	----------	640,096	----------	686,407
Pyrites (including coal brasses)	954,927	405,720	1,006,943	409,826	1,069,904	431,687	1,067,396	436,012	974,114	403,373	1,056,617	436,871
Byproduct sulfuric acid (basis 100 percent) produced at Cu, Zn, and Pb plants	747,699	244,280	992,903	324,580	1,064,406	347,954	1,194,230	390,394	1,101,754	359,723	969,678	316,600
Other byproduct sulfur compounds [2]	74,517	64,260	106,129	93,712	102,300	89,428	102,157	88,446	106,527	92,400	104,887	88,046
Total	----------	6,278,140	----------	7,026,778	----------	7,818,112	----------	7,003,888	----------	6,141,169	----------	6,167,740

---

[1] Sulfur content estimated for 1950–52.

[2] Hydrogen sulfide and liquid sulfur dioxide. In addition, a quantity of acid sludge is converted to H_2SO_4 but is excluded from the above figures.

According to monthly reports submitted to the Bureau of Mines by the producers, a 12-year low was reached in February when production for the month fell to 317,696 tons, the lowest monthly level of production since 1947, when 298,565 tons was produced. During the remaining months of the year, output fluctuated widely; in April output rose to 390,757 tons; by July, production was reduced to 318,192 tons. Output increased in August and in October reached 483,086 tons, the highest monthly production for the year. By the end of the year the monthly rate of production was 411,531 tons.

Texas Gulf Sulphur Company produced about 2.3 million long tons of sulfur during 1959.[3] Of this total, approximately 90 percent was produced at four Frasch mines in Texas; namely, Boling, Spindletop, Moss Bluff, and Fannett. The company also shared in the output of Frasch sulfur at Long Point Dome.

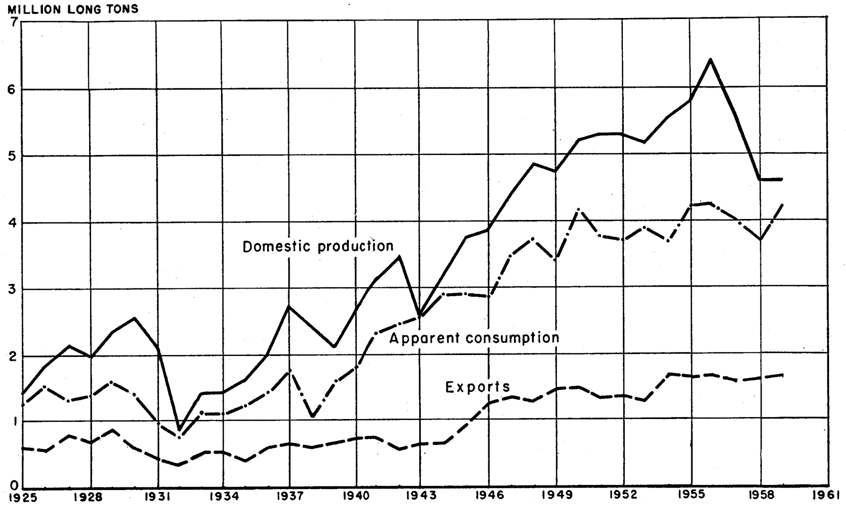

FIGURE 1.—Domestic production, apparent consumption, and exports of native sulfur, 1925–59.

In an apparent move to increase its profit margin by reducing or eliminating certain handling and shipping charges, Texas Gulf Sulphur Company instituted the development of a new marine terminal at Beaumont, Tex. The new terminal will handle molten and bulk sulfur and will serve as a shipping point for most of the sulfur produced by the company in Texas. New bulk-sulfur conveyors will load either ships or barges at the rate of 1,200 tons per hour. Capacity of dockside bulk storage is over 2 million long tons. Liquid storage facilities presently include three steam-heated tanks and, when a fourth unit is completed, will provide a capacity of 27,000 tons. The basin and the channel that connect the Beaumont terminal with the Neches River were dredged to a depth of 36 feet, permitting passage of 15,000- to 20,000-ton dry-cargo vessels. A sulfur filtration plant being

---

[3] Texas Gulf Sulphur Company, Annual Report, 1959, p. 4.

erected at Spindletop mine near Beaumont, Tex., was scheduled for completion in 1960.

Other developments by the company included establishment of a sulfur storage terminal at Tampa, Fla. (initial storage capacity, 50,000 tons of bulk material and 7,500 tons of liquid sulfur). The terminal will be supplied with sulfur by specially designed oceangoing vessels (molten sulfur capacity, 7,500 tons).

Frasch-process mines operated by the Freeport Sulphur Company produced about 2 million long tons of elemental sulfur during 1959.[4] Production came principally from company mines at Grande Ecaille and Garden Island Bay, south of New Orleans. Smaller properties at Chacahoula and Bay Ste. Elaine were responsible for nearly all of the remaining company production. In December, after 7 years of operation, the Bay Ste. Elaine sulfur plant was closed and the equipment moved to Lake Pelto and placed on a standby basis. Although not a major property, it provided the company an opportunity to perfect its sea-water process.

Jefferson Lake Sulphur Co. produced a total of 344,723 long tons of sulfur from its three Frasch mines in the United States which includes 44,306 tons produced at its Long Point Dome for the account of Texas Gulf Sulphur Company. Of this total, 171,900 tons was produced at Long Point Dome (Fort Bend County, Tex.), 85,355 tons at Clemens Dome (Brazoria County, Tex.), and 87,468 tons from Starks Dome (Calcasieu Parish, La.). Sales and shipments by the company totaled 358,359 long tons.[5]

During its 22-year history of operations at Orchard Dome, Duval Sulphur & Potash Co. had drilled 639 holes from which sulfur was obtained at depths of 408 to 3,156 feet. During 1959, mining operations were extended into an area of the dome in which sulfur occurred at greater depths than previously mined by the Frasch process. In January superheated water was introduced into wells in this area, and production was begun about 2 months later. Throughout 1959 the production rate from this deep deposit was satisfactory. Refinements in production techniques, installation of automatic controls on boilers, and a plantwide efficiency program reduced costs in 1959; they were reduced further by increased production.

All major sulfur producers (Frasch, sour gas, and pyrites) were expected to join the Sulphur Institute, organized during the year. Patterned after the American Petroleum Institute (API), this new organization would promote the use of sulfur through technical research and development of new processes, based on the use of sulfur or sulfuric acid; establish standards and specifications for sulfur; supply and disseminate technical information; and make studies of economic trends in the industry. To obtain financial support for the organization a tentative assessment of 5 cents per ton for producers of elemental sulfur and 3 cents per ton for all other producers was suggested. Offices were scheduled to be opened by the institute in Washington, D.C., and in London, England.

---

[4] Freeport Sulphur Company, Annual Report, 1959, p. 4.

[5] Jefferson Lake Sulphur Company, Annual Report, 1959, p. 4.

TABLE 3.—Sulfur produced and shipped from Frasch mines in the United States

Year	Produced (long tons)			Shipped	
	Texas	Louisiana	Total	Long tons	Approximate value (thousands)
1950–54 (average)	3, 744, 115	1, 542, 597	5, 286, 712	5, 237, 290	$121, 059
1955	3, 657, 717	2, 081, 261	5, 738, 978	5, 839, 300	163, 156
1956	3, 994, 393	2, 429, 490	6, 423, 883	5, 675, 913	150, 356
1957	3, 366, 377	2, 124, 835	5, 491, 212	5, 035, 240	122, 915
1958	2, 587, 760	2, 055, 483	4, 643, 243	4, 644, 021	109, 272
1959	2, 519, 090	2, 034, 544	4, 553, 634	5, 222, 206	121, 777

TABLE 4.—Sulfur ore (10–70 percent S) produced and shipped in the United States, in long tons[1]

Year	Produced (long tons)	Shipped		Year	Produced (long tons)	Shipped	
		Long tons	Value			Long tons	Value
1950–54 (average)	76, 357	69, 887	$500, 720	1957	276, 868	172, 169	$1, 521, 425
1955	199, 899	199, 899	1, 697, 052	1958	6, 292	153, 574	1, 504, 849
1956	212, 476	185, 532	1, 577, 857	1959	331, 237	151, 932	1, 418, 126

[1] California, Nevada (except 1954), Utah (1952 only), and Wyoming (except 1953–58).

RECOVERED SULFUR

Seven new plants to obtain sulfur from the purification of natural and other industrial gases were completed or under construction during 1959. Productive capacity of two others was being expanded. Of total added capacity, 165,000 tons (60 percent) was at oil refineries, and 109,000 tons (40 percent) at natural gas cleaning plants.

Production of recovered sulfur in 1959 was 686,400 tons, 7 percent greater than the output in 1958. Of this total, approximately 406,200 tons (59 percent) was recovered at oil refineries.

In 1959 recovered sulfur was produced by 53 plants in Arkansas, California, Delaware, Illinois, Indiana, Louisiana, Michigan, Minnesota, Montana, New Jersey, New Mexico, North Dakota, Oklahoma, Pennsylvania, Texas, West Virginia, and Wyoming.

A 150-ton sulfur-recovery plant at Wood River, Ill., was constructed by Industrial Gencon, Inc., Houston, Tex., for Anlin Co. of Illinois, a subsidiary of the Anlin Co., Houston, Tex. The plant utilized refinery gases obtained from an adjoining Shell Oil Co. refinery.

Tidewater Oil Company began construction of a new sulfur-recovery and cycling plant at the New Hope Smackover Field in Franklin County, northeast Texas. The new facility, with a planned capacity of 50 million cubic feet of raw natural gas, was to have a daily production capacity of 224 tons of sulfur. Completion of the plant was scheduled for early fall of 1960.

A Tears-type sulfur-recovery plant, having a designed capacity of 8.3 tons per day and capable of producing 12.5 tons, was installed by the Sun Oil Company at its Toledo, Ohio, refinery. The new equipment was designed to recover sulfur from small volumes of hydrogen sulfide gas. The main piece of equipment is a multipurpose, five-pass marine-type boiler.

A 12.5-ton-per-day sulfur-recovery plant was to be constructed by the Pan American Petroleum Corporation at its gasoline plant in the Empire Field, Eddy County, N. Mex.

PYRITES

Production of pyrites (ores and concentrates) totaled 1.1 million tons, 8 percent more than the 1 million tons produced in 1958; sulfur content totaled 436,871 tons.

The quantity of pyrites sold or consumed by producing companies totaled 1,030,316 tons. Of this amount, 131,685 tons having a sulfur content of 63,456 tons valued at $845,086 was sold, and 898,631 tons having a sulfur content of 361,199 tons valued at $7,261,902 was consumed. (The corrected figure for tonnage of pyrites sold in 1958 is 116,282 instead of the 11,282 previously reported.)

Tennessee was the largest pyrites-producing State, followed by Virginia, California, Colorado, Montana, Arizona, Pennsylvania, and Utah. The Tennessee Copper Co. recovered pyrites flotation concentrate in Polk County, Tenn., as a coproduct of copper. The concentrate was roasted, and the recovered gases were used in manufacturing sulfuric acid. General Chemical Division, Allied Chemical & Dye Corp., produced a substantial quantity of pyrites at the Gosson mine in Carroll County, Va. Bethlehem Steel Corp. recovered pyrites in Lebanon, Pa.

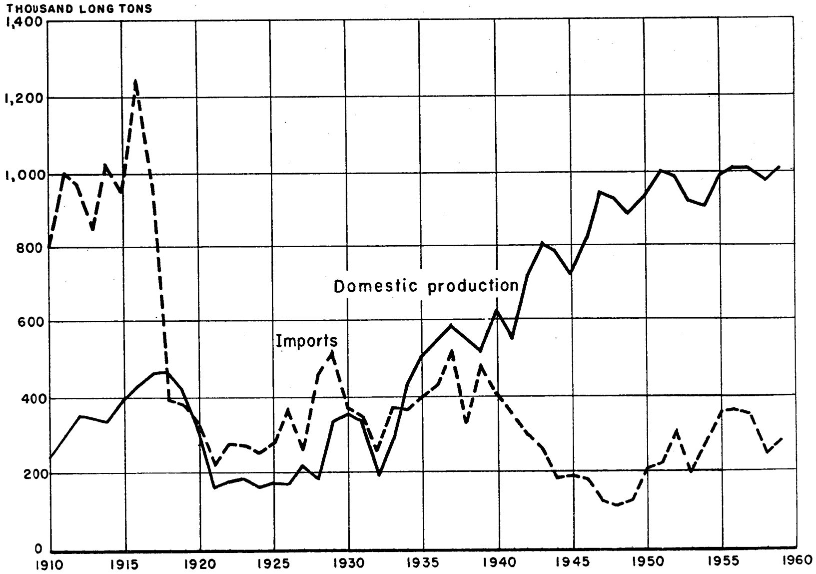

FIGURE 2.—Domestic production and imports of pyrites, 1910–59.

TABLE 5.—**Pyrites (ores and concentrates) produced in the United States, in long tons**

Year	Quantity		Value	Year	Quantity		Value
	Gross weight	Sulfur content			Gross weight	Sulfur content	
1950-54 (average)	954,927	405,720	$5,165,600	1957	1,067,396	436,012	$9,087,000
1955	1,006,943	409,826	8,391,000	1958	974,114	403,373	7,987,000
1956	1,069,904	431,687	9,743,000	1959	1,056,617	436,871	8,148,000

In the Western States considerable pyrite was produced by Mountain Copper Co., Ltd., at the Hornet mine in Shasta County, Calif. In Colorado, pyrites was recovered by Rico Argentine Mining Co. at Mountain Springs mine, Dolores County, and by Climax Molybdenum Co. from its operations in Lake County. The Anaconda Co. produced pyrites from its mines at Butte, Mont. In Arizona, Ray Mines Division, Kennecott Copper Corp., produced pyrite from its mine in Pinal County. In Utah, United States Smelting & Refining Co. produced pyrites from its mine in Lake County.

BYPRODUCT SULFURIC ACID

Output of byproduct sulfuric acid (100-percent H_2SO_4) at copper and zinc plants in the United States totaled 1,086,000 short tons, 12 percent below the 1,234,000 tons produced in 1958 and the lowest since 1954. Of this total, 803,578 tons, 74 percent, was recovered at zinc plants and 282,461 tons at copper plants. Production at copper plants was 43 percent lower than in 1958, reversing the upward trend that began in 1949. Output of acid at zinc plants increased 9 percent in 1959.

Byproduct acid was produced at 16 plants in California, Idaho, Illinois, Indiana, Kansas, Montana, Ohio, Oklahoma, Pennsylvania, Tennessee, Texas, Utah, and Washington.

TABLE 6.—**Byproduct sulfuric acid[1] (basis, 100 percent) produced at copper, zinc and lead plants in the United States, in short tons**

	1950-54 (average)	1955	1956	1957	1958	1959
Copper plants [2]	205,554	329,114	384,659	482,181	495,576	282,461
Zinc plants [3]	631,869	782,938	807,477	855,357	738,385	803,578
Total	837,423	1,112,052	1,192,136	1,337,538	1,233,961	1,086,039

[1] Includes acid from foreign materials.

[2] Includes acid produced at a lead smelter. Excludes acid made from pyrites concentrates in Arizona Montana, Tennessee, and Utah.

[3] Excludes acid made from native sulfur.

OTHER BYPRODUCT-SULFUR COMPOUNDS

In addition to the elemental sulfur recovered, a small quantity of sulfur dioxide and hydrogen sulfide was recovered from industrial gases. Virtually all of the hydrogen sulfide was recovered at oil refineries, and the entire production of sulfur dioxide was obtained from smelter gases. Hydrogen sulfide and/or sulfur dioxide was produced at 12 plants in California, Louisiana, Michigan, New Jersey, Pennsylvania, and Tennessee.

CONSUMPTION AND USES

Despite a lower demand for sulfur from a strikebound steel industry (under normal conditions accounting for 7 percent), consumption of sulfur in the United States recovered from a 2-year low to reach a new high in 1959. The loss in sulfur sales to the steel industry was more than offset by the increased demand for sulfur by other large consumers, such as the fertilizer, chemical, paper, pigment, and rayon industries. As shown in table 9, apparent consumption of sulfur in all forms during the year was about 5,917,100 tons, an increase of better than 12 percent over 1958, and 172,800 tons (3 percent) over the record established in 1956.

Considerable improvement was noted in the world sulfur market during 1959. Total free-world consumption of sulfur in all forms was at a new high of 16 million long tons, an increase of 5 percent over 1958 and 1 percent over the 15.8 million reported in 1956, the previous high year.

TABLE 7.—Production of new sulfuric acid[1] (100 percent H_2SO_4) by geographic divisions and States, in short tons

[U.S. Department of Commerce]

Division and State	1955	1956	1957	1958	1959
New England[2]	183,698	201,758	183,092	174,531	195,614
Middle Atlantic:					
Pennsylvania	855,913	815,016	795,929	647,972	764,239
New York and New Jersey	1,547,113	1,577,476	1,541,278	1,458,124	1,673,150
Total	2,403,026	2,392,492	2,337,207	2,106,096	2,437,389
North Central:					
Illinois	1,305,576	1,272,453	1,241,474	1,219,517	1,368,644
Indiana	562,315	519,853	493,151	468,993	479,064
Michigan	261,493	220,604	241,587	298,946	334,609
Ohio	745,051	714,454	713,201	607,791	767,089
Other[3]	720,435	789,369	760,127	697,879	849,807
Total	3,594,870	3,516,733	3,449,540	3,293,126	3,799,213
South:					
Alabama	243,024	251,314	314,669	243,899	309,516
Florida	1,233,281	1,497,155	1,738,945	1,830,104	2,036,707
Georgia	256,075	339,751	318,325	302,195	345,552
North Carolina	152,159	137,127	120,207	119,613	149,774
South Carolina	160,711	146,046	131,933	133,748	152,241
Virginia	537,095	527,257	488,707	469,182	504,223
Kentucky and Tennessee	974,827	1,035,739	995,277	893,530	1,014,735
Texas	1,477,179	1,552,202	1,605,445	1,600,683	1,674,284
Delaware and Maryland	1,353,567	1,325,004	1,094,275	1,081,210	1,153,071
Louisiana	788,311	782,330	727,144	653,573	640,180
Other[4]	459,035	402,121	428,682	496,206	541,565
Total	7,635,264	7,996,046	7,963,609	7,823,943	8,521,848
West[5]	1,502,502	1,630,319	1,834,777	1,882,727	1,950,384
Total United States	15,319,360	15,737,348	15,768,225	15,280,423	16,904,448

[1] Includes information for Government-owned and privately operated plants.
[2] Includes data for plants in Maine, Rhode Island, Massachusetts, and Connecticut (1955–58).
[3] Includes data for plants in Missouri, Wisconsin, Iowa, Kansas, and Minnesota (1959 only).
[4] Includes data for plants in West Virginia, Mississippi, Arkansas, and Oklahoma.
[5] Includes data for plants in Arizona, California, Colorado, Idaho, Nevada (1956–59), New Mexico (1956–59), Montana, Utah, Washington, and Wyoming.

TABLE 8.—Apparent consumption of native sulfur in the United States, in long tons

	1950–54 (average)	1955	1956	1957	1958	1959
Apparent sales to consumers [1] [2]	5,273,836	5,846,702	5,730,800	5,090,660	4,663,625	5,225,245
Imports	1,942	34,627	212,229	499,401	590,687	642,488
Total	5,275,778	5,881,329	5,943,029	5,590,061	5,254,312	5,867,733
Exports:						
Crude	1,383,892	1,600,951	1,651,307	1,578,359	[3] 1,577,919	1,611,908
Refined	31,078	34,701	24,024	14,620	[3] 24,207	23,699
Total	1,414,970	1,635,652	1,675,331	1,592,979	[3] 1,602,126	1,635,607
Apparent consumption	3,860,808	4,245,677	4,267,698	3,997,082	[3] 3,652,186	4,232,126

[1] Production adjusted for net change in stocks during the year.

[2] Includes native sulfur from mines that do not use the Frasch process. A small quantity was consumed before 1954; however, this tonnage was not included in the above figures.

[3] Revised figure.

TABLE 9.—Apparent consumption of sulfur in all forms in the United States, in long tons [1]

	1950–54 (average)	1955	1956	1957	1958	1959
Native sulfur [2]	3,860,800	4,245,700	4,267,700	3,997,100	[3] 3,652,200	4,232,100
Recovered sulfur shipments	230,600	380,100	432,300	472,700	590,800	709,100
Pyrites:						
Domestic production	405,700	409,800	431,700	436,000	403,400	436,900
Imports	114,600	171,500	175,200	169,100	164,300	134,400
Total pyrites	520,300	581,300	606,900	605,100	567,700	571,300
Smelter-acid production	244,300	324,600	348,000	390,400	359,700	316,600
Other production [4]	64,300	93,700	89,400	88,400	92,400	88,000
Grand total	4,920,300	5,625,400	5,744,300	5,553,700	[3] 5,262,800	5,917,100

[1] Crude sulfur or sulfur content.

[2] In addition, a small quantity of native sulfur from mines that do not use the Frasch process was consumed; however, this tonnage was not included in the above figures before 1954.

[3] Revised figure.

[4] Hydrogen sulfide and liquid sulfur dioxide. In addition, a quantity of acid sludge is converted to H_2SO_4 but is excluded from the above figures.

STOCKS

On December 31, 1959, producer stock of Frasch sulfur totaled 3,809,708 long tons, 14 percent below the 4,441,757 on hand December 31, 1958. Of this, 3,376,001 tons was held at the mines and 433,707 tons was elsewhere. Stock of recovered sulfur in the hands of producers was 140,246 tons at the end of 1959, compared with 177,271 tons at the end of 1958, about 21 percent less. Data on pyrites stock are not available.

PRICES

Posted prices of sulfur in the United States remained unchanged at $25 per long ton of bright sulfur, f.o.b. Gulf ports, with discounts of $1 per ton for offcolor grades and $1.50, f.o.b. mine. Actual prices of sulfur remained unsettled as U.S. producers moved to counter Mexican imports through wider use of special price concessions. It was reported that July 15, 1959, Freeport Sulphur Company initiated an allowance of $3.50 per ton for water shipments of sulfur to ports on the East Coast. A special discount of $1 per ton was given for barge shipments on the Mississippi River and other inland waterways.

In December 1959, sulfur was quoted in E&MJ Metal and Mineral Markets at $23.50 per long ton, bright, and $22.50 per long ton, dark, f.o.b. mines; $24–$25 per long ton, f.o.b. vessel, Galveston. Mexican, f.o.b. mine for internal use, $21–$23; export, f.o.b. vessel, $20–$22. Oil, Paint and Drug Reporter December 28, 1959, quoted sulfur, crude, domestic, bright, f.o.b. cars, mines, at $23.50 per long ton; sulfur, crude, export, f.o.b. vessels, Gulf ports, $25 per long ton; and sulfur, crude, United States and Canadian, f.o.b. vessel, Gulf ports, $25 per long ton. Domestic dark sulfur prices were $1 per ton lower. Prices of Mexican sulfur f.o.b. vessel, Coatzacoalcos, $24 for filtered and $23 for dark.

E&MJ Metal and Mineral Markets quoted domestic and Canadian pyrites, per long ton, nominal, at $9–$11 delivered to consumers' plants. Oil, Paint and Drug Reporter quoted Canadian pyrites (48–50 percent sulfur), mines, at $5–$6 per long ton.

FOREIGN TRADE[6]

Imports.—Although imports of sulfur into the United States were at a high level, they did not maintain the sharply rising trend that began with the introduction of Mexican Frasch sulfur in 1954. Total imports including Frasch sulfur from Mexico, recovered sulfur, and sulfur content of pyrites from Canada, were about 4 percent higher than in 1958. Foreign producers were aided in selling sulfur to American consumers by low freight rates on foreign vessels, whose use by U.S. suppliers for movement to domestic ports is forbidden by law.

TABLE 10.—U.S. sulfur imports (for consumption) and exports

[Bureau of the Census]

Year	Imports				Exports			
	Ore		In any form, n.e.s.		Crude		Crushed, ground, refined, sublimed, and flowers	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)
1950–54 (average)	1, 468	$43	474	[1] $33	1, 383. 892	$36, 228	31, 078	$2, 166
1955	24, 152	595	10, 475	264	1, 600, 951	48, 708	34, 701	2, 454
1956	14, 750	359	197, 479	4, 975	1, 651, 307	48, 305	24, 024	1, 777
1957	14, 454	350	484, 947	[1] 11, 882	1, 578, 359	43, 940	14, 620	1, 458
1958	18, 906	445	571, 781	13, 106	[2] 1, 577, 919	[2] 39, 507	[2] 24, 207	[2] 1, 932
1959	11, 593	255	630, 895	13, 646	1, 611, 908	39, 967	23, 699	2, 033

[1] Data known to be not comparable with other years.
[2] Revised figure.

---

[6] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

Exports.—Shipments of sulfur from the United States to foreign ports increased in spite of the growing competition from new foreign sulfur sources. Major importing countries in order of their volume were Canada, the United Kingdom, Brazil, India, and Australia. All sales of U.S. sulfur outside the North American Continent were handled by the Sulfur Export Corp., owned jointly by the four U.S. Frasch producers.

TABLE 11.—Sulfur exported from the United States, by countries of destination

[Bureau of the Census]

Country	Crude				Crushed, ground, refined, sublimed, and flowers			
	1958		1959		1958		1959	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)
North America:								
Canada	332,262	$8,663	287,500	$7,200	5,469,872	$258	6,886,332	$355
Central America	167	7	1,649	57	851,956	37	455,255	20
Mexico	--------	--------	20	1	410,383	55	461,176	63
West Indies	16,750	417	36,342	829	215,565	15	171,400	13
Total	349,179	9,087	325,511	8,087	6,947,776	365	7,974,163	451
South America:								
Argentina	[1]37,701	[1]968	32,776	821	[1]220,225	[1]44	196,900	43
Bolivia	--------	--------	--------	--------	--------	--------	39,600	1
Brazil	[1]97,343	[1]2,453	126,391	3,167	1,011,495	85	1,088,968	132
Chile	--------	--------	--------	--------	20,000	3	47,298	10
Colombia	--------	--------	314	10	671,656	38	105,162	15
Paraguay	29	(2)	1,606	41	26,213	1	--------	--------
Peru	2,991	95	4,909	133	345,700	11	632,400	26
Uruguay	6,133	154	3,262	82	224,702	7	112,155	4
Venezuela	2,080	67	3,291	110	657,753	47	800,909	57
Total	[1]146,277	[1]3,737	172,549	4,364	[1]3,177,744	[1]236	3,023,392	288
Europe:								
Austria	25,717	665	10,000	250	--------	--------	--------	--------
Belgium-Luxembourg	100,180	2,483	53,675	1,338	60,700	6	--------	--------
Finland	41,567	1,021	12,600	315	--------	--------	--------	--------
France	99,065	2,474	85,945	2,130	--------	--------	26,000	2
Germany, West	63,869	1,594	86,290	2,153	493,400	95	446,348	88
Greece	999	25	--------	--------	15,829,183	360	27,463,487	564
Netherlands	10,400	255	41,799	1,013	25,500	5	131,250	27
Norway	--------	--------	--------	--------	240,000	6	424,500	12
Portugal	--------	--------	--------	--------	26,400	4	57,600	8
Sweden	--------	--------	9,825	242	10,000	2	6,000	1
Switzerland	40,905	1,023	34,700	868	71,923	13	215,450	39
United Kingdom	279,053	6,587	273,230	6,636	--------	--------	--------	--------
Yugoslavia	2,000	61	2,000	50	6,953,516	155	--------	--------
Other Europe	7,421	167	33,920	829	79,700	15	80,548	14
Total	671,176	16,355	643,984	15,824	23,790,322	661	28,851,183	755
Asia:								
India	114,028	2,859	124,699	3,119	11,487,515	319	3,354,653	114
Indonesia	7,800	191	7,700	189	3,199,865	96	420,800	24
Iran	6,000	215	2,260	75	--------	--------	--------	--------
Israel	7,500	184	25,069	615	223,818	21	253,052	16
Japan	--------	--------	--------	--------	66,200	14	292,050	54
Korea, Republic of	1,844	61	913	37	2,052,573	42	4,980,193	99
Lebanon	2,499	62	1,000	25	23,976	1	196,321	8
Pakistan	3,065	100	2,137	71	--------	--------	87,184	3
Philippines	1,944	50	900	32	626,529	31	529,018	31
Turkey	--------	--------	--------	--------	3,950	(2)	14,400	3
United Arab Republic (Syria)[3]	--------	--------	49	3	326,690	8	217,960	5
Other Asia	561	17	6,840	190	301,428	8	607,692	11
Total	145,241	3,739	171,567	4,356	18,312,544	540	10,953,323	368

See footnotes at end of table.

TABLE 11.—Sulfur exported from the United States, by countries of destination—Continued

[Bureau of the Census]

Country	Crude				Crushed, ground, refined, sublimed, and flowers			
	1958		1959		1958		1959	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)
Africa:								
Algeria	23,560	$589	9,000	$225				
Belgian Congo					925,872	$22	65,988	$2
Morocco	7,700	193						
Tunisia			15,833	384				
Union of South Africa	65,900	1,655	61,385	1,502	220,480	19	1,678,386	90
United Arab Republic (Egypt)[3]			36	1	113,695	7	47,900	7
Other Africa	4,428	111	4,920	123	4,000	1		
Total	101,588	2,548	91,174	2,235	1,264,047	49	1,792,274	99
Oceania:								
Australia	[1]124,604	[1]3,045	123,084	3,000	267,450	53	250,575	46
New Zealand	39,854	996	84,039	2,101	463,502	28	241,735	26
Total	[1]164,458	[1]4,041	207,123	5,101	730,952	81	492,310	72
Grand total	[1]1,577,919	[1]39,507	1,611,908	39,967	[1]54,223,385	[1]1,932	53,086,645	2,033

[1] Revised figure.
[2] Less than $1,000.
[3] Effective July 1, 1958.

TABLE 12.—Pyrites, containing more than 25 percent sulfur, imported for consumption in the United States, by customs districts, in long tons

[Bureau of the Census]

Customs district	1950–54 (average)	1955	1956	1957	1958	1959
Buffalo	[1]185,711	[1]38,954	[1]30,214	[1]40,842	296,002	230,606
Chicago	7					
Connecticut			18			262
Duluth and Superior	9					
Michigan	53	[1]24,348	25,188	20,744	16,768	13,182
New York	54				217	
Pittsburgh		682	763	54		
Rochester	10			208		
St. Lawrence	1,993	8,973	10,032		13,373	14,640
Vermont	4,848	7,348	7,063	8,766	16,523	21,948
Washington			18	18	177	
Total:						
Long tons	[1]192,685	[1]80,305	[1]73,296	[1]70,632	343,060	280,638
Value	[1]$541,365	[1]$519,756	[1]$479,950	[1]$408,342	$1,193,973	$868,495

[1] In addition to data shown, an estimated 232,920 long tons ($627,620) was imported through the Buffalo customs district in 1954; 277,020 long tons ($706,840) through the Buffalo customs district and 840 long tons ($4,900) through the Michigan customs district in 1955; 292,520 long tons ($865,020) through the Buffalo customs district in 1956; and 282,400 long tons ($889,100) through the Buffalo customs district in 1957.

WORLD REVIEW

NORTH AMERICA

Canada.—Production of all forms of sulfur in Canada, measured by mine shipments, totaled 757,017 long tons in 1958, slightly below the 759,758 tons produced in 1957. Of this total, 457,524 tons was sulfur contained in pyrites, 215,228 tons was sulfur contained in smelter gases, and 84,265 tons was elemental sulfur recovered from natural gas and nickel sulfide ores. Imports of elemental sulfur totaled 335,117 tons in 1958; all except 1,009 tons was imported from the United States. Exports of sulfur totaled 6,793 tons. No tonnage figures were available for exports of pyrite from Canada.

Preliminary figures for 1959 indicated that the production of sulfur in all forms in Canada, measured by mine shipments, totaled 968,550 long tons. Of this total, 403,946 long tons was sulfur contained in pyrites, 278,204 tons sulfur contained in smelter gases, and 286,400 tons elemental sulfur recovered from natural gas and nickel sulfide matte at Port Colborne, Ontario.

At the end of 1959, six recovery plants in Alberta and one each in Saskatchewan and British Columbia had a combined annual capacity of 650,000 long tons. Their production in 1959 totaled about 264,000 tons, of which 213,000 tons was recovered in the Province of Alberta. In addition to the six plants in operation, three others were being constructed in Alberta: Canadian Oil Co. at Innesfail; Standard Oil Co. of California, at Nevis; and Imperial Oil Co., at Nottingham.

Other sulfur-recovery projects underway in Canada included the following: Irving Refinery, St. Johns, New Brunswick, refinery gas, 4,500 tons; Sherbrooke Metallurgical, Port Maitland, Ontario, smelter gas, 45,000 tons; and New Manitoba Mining and Smelting, Winnipeg, Manitoba, nickel concentrates, capacity unknown.

Texas Gulf Sulphur Co., Devon Palmers Oil, Ltd., and Shell Oil Co., Canada, Ltd., began production on June 3, 1959, at their new sulfur-extraction plant 25 miles south of Calgary, Alberta. It had a rated daily capacity of 370 long tons of sulfur, produced from 30 million cubic feet of sour gas. The natural gas processed at the plant was reported to contain 34 percent hydrogen sulfide. According to Alberta Oil and Industry Report for December, production of sulfur at Okotoks totaled 52,523 long tons.

Royalite Oil Co., Ltd., Calgary, Alberta, recovered 9,284 long tons of sulfur from its Turner Valley gas-processing plant. Output during 1958 totaled 9,236 tons.[7]

Jefferson Lake Petrochemicals of Canada, Ltd., produced 47,718 long tons of sulfur from its Peace River plant in British Columbia in 1959; sales totaled 40,372 tons, and inventories at yearend totaled 66,718 tons. In 1958 production was reported at 55,896 tons, and no sales were made during the year. Shipments of sulfur from the plant site were by rail to the ports of Vancouver and Prince Rupert. Modern port facilities were scheduled to be completed and in operation at Vancouver by September 1960.

During the year a contract was executed between Westcoast Transmission Co. and Jefferson Lake Petrochemical of Canada, Ltd., for the

---

[7] Royalite Oil Company, Ltd., Annual Report 1959, pp. 1, 4.

construction of a plant and facilities at Coleman, Alberta, to convert concentrated hydrogen sulfide gas obtained from the Savanna Creek field into elemental sulfur. Plans also were underway for construction of an 800-ton-per-day sulfur-recovery plant 7 miles north of Calgary.[8]

TABLE 13.—World production of elemental sulfur, by countries, in long tons [1]

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country	1955	1956	1957	1958	1959
Frasch:					
Mexico	475,487	758,415	990,118	1,201,483	1,293,181
United States	5,738,978	6,423,883	5,491,212	4,643,243	4,553,634
Total	6,214,465	7,182,298	6,481,330	5,844,726	5,846,815
From sulfur ores:					
Argentina	17,651	27,298	28,788	31,545	[2] 30,000
Bolivia (exports)	3,975	3,418	783	392	----------
Chile	56,338	37,272	18,492	24,015	[2] 20,000
Colombia	5,413	4,921	[2] 5,000	6,693	[2] 8,900
Greece	3,600	1,322	2,826	[2] 3,000	[2] 3,000
Italy:					
Crude	181,629	168,061	175,982	158,665	119,272
For agriculture	6,500	6,700	6,000	5,600	6,400
For acid manufacturing	59,000	68,900	65,633	65,928	[2] 70,000
Japan	199,676	243,312	253,548	178,052	215,274
Mexico	5,000	5,000	17,797	35,446	17,700
Philippines	[2] 3,700	----------	[2] 1,300	[2] 1,300	----------
Spain	6,500	6,200	3,356	3,700	3,500
Taiwan	4,854	7,864	9,433	6,178	5,533
Turkey	11,318	13,681	12,893	12,622	13,174
United Arab Republic (Egypt Region)	605	99	----------	7,127	6,900
U.S.S.R.[2]	200,000	200,000	200,000	300,000	320,000
United States	60,902	60,402	87,313	2,334	86,182
Total [2]	830,000	855,000	890,000	845,000	925,000
Total native sulfur	7,045,000	8,040,000	7,370,000	6,690,000	6,770,000
Recovered:					
Belgium-Luxembourg [2]	400	400	400	400	400
Bulgaria	1,146	2,206	2,591	2,800	[2] 2,800
Canada	[3] 25,976	[3] 29,879	[3] 89,916	140,369	286,400
France	2,850	2,300	27,528	126,542	419,273
Germany:					
East	93,985	92,748	100,190	104,679	[2] 105,000
West: Recovered	70,900	59,000	78,700	72,800	76,800
Iran	18,000	18,000	16,665	12,800	[2] 13,000
Italy [2]	5,000	5,000	2,000	4,000	5,000
Mexico	25,728	14,577	41,642	27,641	46,231
Netherlands	6,900	12,200	14,400	20,800	[2] 20,000
Netherlands Antilles: Aruba	29,476	29,022	[2] 30,000	[2] 30,000	[2] 30,000
Sweden	28,419	30,338	33,310	33,465	37,576
Trinidad [2]	5,000	5,000	5,000	5,000	5,000
United Arab Republic (Egypt Region)	3,755	2,950	3,445	[2] 3,000	2,408
U.S.S.R.[2] [4]	160,000	200,000	240,000	290,000	370,000
United Kingdom: From refinery gases	45,891	52,973	39,142	49,561	[2] 55,000
United States	398,780	464,758	510,511	640,096	686,407
Total [2] [4]	925,000	1,020,000	1,235,000	1,565,000	2,163,000
From sulfide ores:					
Norway	98,863	95,382	95,149	89,123	77,111
Portugal	15,465	16,922	16,675	17,373	15,888
Spain	34,500	46,100	43,374	[2] 45,000	[2] 45,000
Total [5]	148,828	158,404	155,198	[2] 150,000	137,999
World total (estimate)	8,120,000	9,215,000	8,760,000	8,405,000	9,075,000

[1] Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Estimate.
[3] Shipments.
[4] Sulfur equivalent recovered from sulfide ores, natural gas, petroleum, anhydrite and gypsum.
[5] U.S.S.R. production from sulfide ores included with recovered sulfur data.

---

[8] Jefferson Lake Petrochemicals of Canada, Ltd., Annual Report 1959, pp. 2–3.

TABLE 14.—World production of pyrites (including cupreous pyrites), by countries,[1] in thousand long tons[2]

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country[1]	1950–54 (average) gross weight	1955		1956		1957		1958		1959	
		Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content
North America:											
Canada (sales)	430	784	361	935	423	1,041	460	1,064	458	939	404
Cuba	[3] 59	130	63	65	32	36	17	33	17	[4] 25	[4] 12
United States	955	1,007	410	1,070	432	1,067	436	974	403	1,057	437
South America: Venezuela	------	------	------	59	14	15	4	14	[4] 4	14	[4] 3
Europe:											
Austria	6	------	------	------	------	------	------	------	------	------	------
Bulgaria	142	118	[4] 49	107	[4] 45	107	[4] 45	69	[4] 29	112	[4] 47
Czechoslovakia	[4] 197	320	[4] 134	333	[4] 140	364	[4] 153	379	[4] 159	394	[4] 165
Finland	227	294	[4] 125	289	128	392	[4] 126	251	105	254	107
France	281	301	133	299	135	319	134	327	144	290	128
Germany:											
East	109	141	[4] 48	157	53	157	53	[4] 148	[4] 51	[4] 148	[4] 51
West	511	580	206	634	253	596	237	557	224	462	189
Greece	179	229	[4] 100	237	[4] 104	231	102	160	71	197	87
Italy	1,068	1,296	592	1,349	634	1,448	652	1,490	676	1,498	[4] 674
Norway	728	830	362	840	363	830	360	775	335	720	312
Poland	116	139	56	152	61	207	76	208	75	[4] 210	[4] 76
Portugal	684	725	297	659	297	656	302	589	271	620	285
Rumania	(5)	179	72	178	71	174	70	[4] 174	[4] 70	[4] 175	[4] 70
Spain	1,916	2,290	1,110	2,259	1,084	2,225	1,068	2,014	931	[4] 2,018	[4] 935
Sweden	397	388	191	486	390	494	245	329	163	341	[4] 168
United Kingdom	11	6	2	4	2	4	1	3	[4] 1	[4] 3	[4] 1
Yugoslavia	154	223	116	252	131	308	123	326	130	285	114
Asia:											
China	(5)	(5)	(5)	(5)	(5)	(5)	(5)	[4] 492	[4] 221	[4] 689	[4] 310
Cyprus	983	1,318	[4] 633	1,603	[4] 770	1,650	[4] 792	1,658	[4] 796	917	446
Japan	2,328	2,693	1,131	3,049	1,296	3,324	1,404	3,306	1,378	2,100	652
Philippines	[3] 2	30	14	------	------	18	8	19	[4] 8	25	[4] 11
Taiwan	18	29	11	29	11	33	12	32	12	33	13
Turkey	[3] 25	16	[4] 8	19	[4] 9	48	23	80	39	87	42
Africa:											
Algeria	29	21	10	6	3	19	8	24	11	28	[4] 12
Morocco: Southern zone	2	1	1	2	(6)	6	2	18	6	14	5
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	27	21	9	19	8	20	8	58	24	40	17
Union of South Africa	83	352	138	430	[4] 163	388	160	493	205	495	195
Oceania: Australia	170	223	106	187	88	227	108	227	109	[4] 238	[4] 114
World total (estimate)	14,000	17,000	7,100	17,900	7,500	18,900	7,900	18,300	7,700	16,700	7,000

---

[1] Pyrites is produced in North Korea, and U.S.S.R., but production data are not available; estimates for these countries are included in the totals. Negligible quantities are produced in Brazil, India, Republic of Korea, and Tunisia.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Average for 1952–54.

[4] Estimate.

[5] Data not available; estimate included in total.

[6] Less than 500 tons.

Steelman Gas, Ltd., formed in 1957 by Dome Petroleum, Ltd., and Provo Gas Producers, Ltd., began production at its 3.5-ton-per-day sulfur-recovery plant in southwestern Saskatchewan.

British American Oil Co. increased production capacity of its sulfur-recovery plant at Pincher Creek, Alberta. Based on a raw-gas feed rate of 196 million cubic feet per day, the plant would recover 690 long tons of sulfur per day. Natural gas from Pincher Creek contained approximately 11 percent hydrogen sulfide, equal to 3.5 long tons of recoverable sulfur from 1 million cubic feet of gas. According to the Alberta Oil and Gas Industry Monthly Report for December 1959, production of sulfur from Pincher Creek in 1959 totaled 120,315 long tons, up 73 percent from the 69,577 tons produced in 1958. At Nevis, Alberta, the company expanded its gas-producing plant to recover 75 tons of sulfur per day from Nevis field gas, which contains 6.8 percent H_2S.

According to a report by the Canadian Petroleum Association's Central Reserve Committee, the estimated proved reserves of sulfur in Canada as of December 31, 1959 totaled 50,799,000 long tons, an increase of 4,060,000 tons during the year. Of this total, 1,377,000 tons was in British Columbia; 49,364,000 tons in Alberta; and 58,000 tons in Saskatchewan.[9]

Mexico.—Production of all forms of sulfur in Mexico totaled 1,357,112 long tons, 7 percent greater than the 1,264,570 tons produced in 1958. Of this total, 1,293,181 tons (95 percent) was produced at four Frasch mines, 17,700 tons (1 percent) from volcanic sulfur, and 46,231 tons (4 percent) from oil refineries.

Producer stock of sulfur on hand as of December 31, 1959, totaled 879,547 long tons, 14 percent greater than the 774,325 tons on hand December 31, 1958. Of the sulfur on hand, 875,846 tons was Frasch sulfur, 3,209 tons recovered sulfur, and 500 tons sulfur from volcanic sources.

Exports of Frasch sulfur from Mexico were about 4 percent lower than those reported for the previous year. Of the total exported, 59 percent went to the United States. Exports of sulfur to France declined 46 percent (from 115,116 tons in 1958 to 61,989 tons in 1959) as the output of recovered sulfur increased in France.

Cia Exploradora del Istmo, a Texas Gulf Sulphur Co. operating subsidiary, produced approximately 100,000 long tons of Frasch sulfur from the Nopalapa dome in 1959. No shipments had been made from the property since production began on February 7, 1957; as a result stock at the mine site totaled about 330,000 tons.[10]

Central Minera, S.A., a Texas International Sulphur Co. operating subsidiary, began production at its 300-ton-per-day plant near Minitatlan, Veracruz. The company reported that samples taken from producing wells contained 99.06 to 99.3 percent pure sulfur; also, it had a proved reserve in excess of 5 million tons on 130 acres. Most of the 123,000-acre concession held by the company has not been explored.

The Labor Court in Mexico City approved Texas Gulf's petition to terminate its labor contract and to suspend operations at Nopalapa

---

[9] Engineering and Mining Journal, vol. 161, No. 4, April 1960, p. 220.

[10] Texas Gulf Sulphur Company, Annual Report 1959, pp. 4–5.

Dome. Operations at the property were begun in 1957 to meet contract obligations to the Mexican Government, but none of the sulfur produced has been shipped.

Cia de Azufre Veracruz, S.A., an operating subsidiary of Gulf Sulphur Corp., produced 281,285 long tons of Frasch sulfur from Las Salinas Dome; an increase of 19,000 tons, or 7 percent over the output in 1958 (263,089 long tons) and 58 percent over the 178,393 tons in 1957. Shipments totaling 204,963 tons were 26 percent lower than the 275,306 tons reported for 1958 and 12 percent higher than the 182,376 tons reported in 1957. Of the total shipments, 200,000 tons was exported and 4,000 tons consumed by domestic industries. Stock of Frasch sulfur increased by more than 281 percent from 27,000 tons in 1958 to more than 103,000 tons in 1959.

TABLE 15.—Exports of sulfur (Frasch) from Mexico, by countries of destination, in long tons[1]

[Compiled by Bertha M. Duggan and Corra A. Barry]

Country	1958	1959	Country	1958	1959
North America:			Asia:		
Canada	1,009	4,299	India	----------	19,637
United States	607,381	673,628	Israel	27,224	29,185
South America:			Africa: Union of South Africa	52,530	59,479
Argentina	----------	6,109	Oceania:		
Peru	----------	1,713	Australia	72,592	46,636
Venezuela	----------	3,901	New Zealand	3,768	21,619
Europe:			Other countries	132	4
Austria	----------	492			
Belgium	----------	26,846	Total	1,005,501	1,064,784
France	144,696	77,820			
Germany, West	----------	8,071			
Netherlands	34,197	8,069			
Sweden	3,150	5,668			
United Kingdom	58,822	71,608			

[1] Compiled from Customs Returns of Mexico.

Pan American Sulphur Co. produced 887,000 long tons of Frasch sulfur at Jaltipan Dome in 1959, 8 percent greater than the output of 822,000 tons reported in 1958. Shipments totaled 856,000 tons, 46,000 tons (6 percent) more than the 810,000 tons shipped in 1958. Yearend stocks totaled 580,000 tons, an increase of 31,000 tons during the year.

Trinidad.—Production of sulfur at the Texaco Pointe á Pierre refinery totaled 4,900 tons in 1958. The plant operated at a level of 20 tons per day, but had the capacity to produce 30 tons per day of high-purity sulfur pellets.[11]

SOUTH AMERICA

Argentina.—About 40 percent of the Argentina sulfur requirement, estimated at 50,000 tons annually, was to be supplied from a recently completed sulfur-processing plant in the Andes Department, Salta Province, near the Chilean border.[12]

---

[11] British Sulphur Corp. (London), Sulphur, Current Events: Quart. Bull. No. 25, July 1959, p. 48.

[12] Engineering and Mining Journal, vol. 160, No. 11, November 1959, p. 176.

Brazil.—Industria Brasileira de Enxofre, S.A., a subsidiary of Refineria e Exp'oracao de Petroleo Uniao, announced plans to recover sulfur from refinery waste gases.[13]

Chile.—Production of sulfur in 1958 totaled 24,000 long tons, of which 20,100 tons was refined and 1,500 tons was semirefined. The quantities reported, by company, were as follows: Sociedad Azufrera "Aucanquilcha," Antofagasta, 11,000 tons; Sociedad Azufrera "Borlando," Antofagasta, 3,000 tons; Luis Freire, Antofagasta, 3,000 tons; Urdangarín Hermanos, Antofagasta, 600 tons; and Compañía Azufrera Nacional, Arica, 5,700 tons. Production in 1957 totaled 17,200 tons of refined sulfur and 1,000 tons of semirefined (sublime).

According to the Chilean Sulphur Producers Association, about 70 percent of the production was from the mountains east of Antofagasta and 30 percent from the mountains near Arica. The association reported that none of the member firms were undertaking exploration or development, because known deposits could more than supply domestic requirements and Chilean production could not compete in world markets. There were plans to study refining methods to obtain better and lower priced production. In late 1958, the various companies were planning to import a Japanese autoclave to be set up and tested in Antofagasta under Japanese technicians.

EUROPE

France.—Production capacity at Société Nationale des Petrolés d'Aquitaine sulfur-recovery plant at Lacq was increased to 689,000 long tons. Sulfur production rose from 126,542 tons in 1958 to 419,273 tons in 1959. Sulfur imports declined from 302,645 tons valued at $8.7 million to 191,823 tons valued at $4.9 million in 1959; the greatest decrease was from Mexico.[14] Exports of sulfur quadrupled, compared with 1958, from 56,010 to 220,353 tons. More than 80 percent of the exports were to other European countries. Most shipments were made through the port of Bayonne, 80 kilometers from Lacq.

The loading installation at Bayonne was designed to have a rated capacity of 1,000 tons per hour. Allowing for trimming, this should permit the loading of more than 800 tons per hour in a ship's hold. For delivery to stockpile, an average rate of 900 tons per hour was expected. Only 400 to 600 tons may be expected when loading from stockpile, where services of a bulldozer are required. Ships drawing more than 7 metres (21 feet), of 5,000 to 6,000 tons, and of standard construction, could not be accommodated at the port of Bayonne.[15]

Italy.—Production of sulfur ore in Italy during 1959 totaled 1,401,800 long tons containing 16 to 20 percent sulfur. Output of raw-fused sulfur decreased to 119,600 tons, 24 percent below the 158,700 tons reported in 1958; whereas the output of ground sulfur increased 14 percent to 21,342 tons, compared with 18,700 tons in 1958.[16] Exports of sulfur totaled 28,500 tons, 4 percent lower than in 1958.

---

[13] Chemical Trade Journal and Chemical Engineer (London), vol. 145, No. 3778, Oct. 30, 1959, p. 815.

[14] U.S. Embassy, Paris, France, State Department Dispatch 1124, Feb. 2, 1960.

[15] British Sulphur Corp. (London), Sulphur, Sulfur in France: Quart. bull. No. 26, October 1959, pp. 27–28.

[16] U.S. Embassy, Rome, Italy, State Department Dispatch 1068, May 9, 1960, encl. 1, p. 3.

Stocks of sulfur on hand January 1, 1960, totaled 224,400 tons, 2 percent lower than the 229,700 tons held January 1, 1959.

United Kingdom.—Output of high-purity elemental sulfur in the United Kingdom during 1958 totaled 49,561 tons, 6 percent below the record of 52,973 tons produced in 1956. Installed sulfur-recovery capacity in the United Kingdom in 1958 totaled 90,000 tons. British Petroleum Co. operated two sulfur-recovery plants, one at Grangemouth in Scotland, and one at Isle of Grain in Kent, having an aggregate capacity of 70 tons per day. In addition to facilities for producing recovered sulfur from refinery gases, the Isle of Grain plant had facilities to produce sulfuric acid from sludge. The Grangemouth plant was built in 1954 (capacity, 20 tons per day) and used exit gases from the catalytic cracker at the oil refinery.

Esso Petroleum Co. produced the most recovered sulfur in the United Kingdom, accounting for approximately one-third of the total output in 1958. Installed capacity of the two-unit company plant at Fauley, near Southampton, was 100 tons per day. The first unit (40 tons) was completed in 1953 and the second unit (60 tons) toward the end of 1958.

The Shell Chemical Co. sulfur-recovery plant, at its Stanlow Chesshire refinery, had the capacity to recover 20,000 tons of sulfur annually. Hydrogen sulfide for the plant was obtained from the catalytic-cracker exit gases and the hydrodesulphurizer unit, where the sulfur was removed from crude oil by the trickle-phase technique developed by the Royal Dutch Shell Group. The company was constructing a new hydrodesulphurizer plant at its Shell Haven refinery to remove sulfur by the same trickle-phase technique used at the Stanlow refinery. A 15,000-ton-per-year liquid sulfur-recovery plant was to be installed to treat hydrogen sulfide from the company unit at Shell Haven, although the greater part of the H_2S will come from the new hydrodesulphurizer. Initially the plant is expected to operate at 50 percent of capacity.

Messrs. Hardman & Holden of Manchester operated a solvent-extraction plant based on the use of spent oxide obtained from several local gas plants. Plant capacity was about 9,800 tons per annum.[17]

ASIA

Japan.—The output of refined sulfur totaled 215,274 long tons. In 1958 the output was 178,100 tons.

Imports of refined sulfur during the first 6 months of 1959 were 59 tons. The 1958 imports consisted of 95 tons of crude and 59 tons of refined sulfur.

During the first 6 months of 1959, the demand for sulfur was adversely affected by the decline in rayon production, which is the largest single use of sulfur in Japan.

Japan, one of the leading producers of pyrites in the world, produced 1.64 million tons of pyrites during the first 6 months of 1959.[18]

---

[17] British Sulphur Corp. (London), Sulphur, Brimstone Production in the United Kingdom: Quart. Bull. No. 26, October 1959, pp. 32–35.

[18] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 3, March 1960, pp. 32, 35.

AFRICA

Egypt.—Small shipments of sulfur were made from mines at Gemsa on the Red Sea. Output was expected to reach 20,000 tons annually in 1960, when milling equipment imported from England was expected to begin operating.[19]

About 3,445 long tons of sulfur was recovered from petroleum refinery gases during 1957, compared with 2,953 tons in 1956; all output was consumed locally.

Imports of sulfur in 1957 totaled 14,726 tons valued at $112,800. Of this amount, 10,359 tons was imported from Italy and 2,748 from the United States.

Sulfuric acid production in 1957 totaled 87,764 tons, compared with 78,938 in 1956.[20]

Morocco.—The Cie. Miniere et Mettalurgique, Kettara mine produced 18,159 long tons of iron pyrites in 1958. Output in 1957 totaled 6,161 tons. Domestic consumption of pyrites in 1958 totaled 18,159 tons and 6,240 tons in 1957.[21]

Union of South Africa.—Production of sulfuric acid in 1958 was estimated by trade sources at 412,000 short tons. Official trade statistics are not available.

African Explosive & Chemical Industries (AE&CI) was the only commercial producer of sulfuric acid, except for the uranium mines and the O'Kiep Copper Co., that manufactured sulfuric acid for their own use. AE&CI output for 1959 was expected to total 402,000 tons of 100-percent H_2SO_4.[22]

Transvaal Gold Mining Estates announced plans to construct a sulfuric acid plant to burn pyrites. Acid produced at the plant was to be used with phosphate rock in manufacturing super phosphate.[23]

Liquid sulfur dioxide was produced in South Africa for the first time early in 1959 at the Umbogintwini plant of the African Explosives and Chemical Industries.[24]

Standard Vacuum Oil Co. completed the installation of a 33-ton-per-day sulfur-recovery plant at its oil refinery at Durban. The entire sulfur output was sold to South Africa Industrial Cellulose Corp., Ltd. (ASICCOR), for use at its viscose plant at Umkomaas, Natal.[25]

OCEANIA

Australia.—Representing the first production of elemental sulfur in Australia, a new 40-ton-per-day elemental sulfur-recovery plant, at the Altona works of the Standard Vacuum Refining Co. (Australia), Ltd., came on stream in July 1959.[26]

Production of sulfuric acid was begun in July at a new 100-ton-per-day, 100-percent sulfuric acid plant at the Shell Oil Co. Geelong refinery, which used both Far Eastern and Middle Eastern crude

---

[19] Mining World, vol. 21, No. 8, July 1959, p. 86.
[20] Bureau of Mines, Mineral Trade Notes: Vol. 48, No. 4, April 1959, p. 44.
[21] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 6, December 1959, p. 50.
[22] Work cited in footnote 21, p. 55.
[23] Mining World, vol. 21, No. 8, July 1959, pp. 85–86.
[24] South African Mining and Engineering Journal, The Johannesburg Liquid Sulfur Dioxide at Umbogintwini: Vol. 70, No. 3454, Apr. 24, 1959, p. 925.
[25] Work cited in footnote 11.
[26] Work cited in footnote 11, p. 47.

petroleum. Middle Eastern Kurvait crude petroleum, containing 2.5 percent by weight of combined sulfur, was the main refinery feedstock.[27]

Tariff board recommendations designed to raise sulfuric acid production from local resources were rejected by the Commonwealth Government. Pending results of a new inquiry, the old bounty act and regulations were continued for 1 year beginning July 1, 1959.[28]

New Zealand.—The New Zealand import licensing schedule for 1960 exempted crude sulfur.[29]

TECHNOLOGY

Quantitative information on design and operation of molten sulfur filters was presented in an article.[30] It was concluded that increased rates of filtration could be obtained from existing equipment by increasing the amount of filter aid, cleaning filters more frequently, and using relatively coarse filter aids. These measures gave a more porous cake, which was slightly less efficient as a barrier for small ash particles; consequently, if extremely high filtration efficiency were desired, some sacrifice in rate would need to be made.

Thermodynamic properties of pure sulfur were studied and the results published in an article appearing in the trade press.[31] Information was presented on the preparation of test specimens of pure sulfur, the calorimetric method of determining heat capacities of sulfur used in the experiment, and the thermodynamic data.

The maximum stability limits for pyrites were investigated by holding synthetic mixtures, natural pyrite, and natural marcasite at fixed temperatures and pressures for various periods. Two techniques were employed; one used rigid silica tubes, and the other collapsible metal tubes. The products were quenched and identified at room temperatures by magnetic, optical, and X-ray methods.[32]

A special high-strength-alloy steel, manufactured for the first time as a tubular steel product, was used successfully in a 7-mile-submarine pipeline to transport sulfur.[33] The pipeline, which extends from the powerplant at the mine to an inshore barge-loading wharf at Grand Isle, La., was buried in a trench 5 feet below the Gulf bottom.[34] It consists of three concentric pipes: a 14-inch-outside-diameter protective casing, a 7⅝-inch-outside-diameter, hot-water-jacket line, and a 6-inch-outside-diameter sulfur line. Strapped to the outside of the 14-inch casing are two additional lines, used to furnish the mine with

---

[27] Chemical Engineering and Mining Review, Sulfuric Acid Making Plant at Shell's Geelong Refinery: Vol. 51, No. 5, Feb. 16, 1959, pp. 56–58.

[28] Chemical Engineering and Mining Review, Australia, Sulphuric Acid Industry: Vol. 51, No. 10, July 15, 1959, pp. 42–45.

[29] Foreign Commerce Weekly, New Zealand to End Discriminatory Dollar Goods Licensing in 1960: Vol. 62, No. 19, November 1959, p. 10.

[30] Donovan, J. R., and Barnett, B. J., Filtration of Molten Sulfur: Ind. and Eng. Chem., vol. 51, No. 2, February 1959, pp. 165–168.

[31] West, E. D., The Heat Capacity of Sulfur From 25° to 450° C. The Heat and Temperature of Transition and Fusion, Jour. Am. Chem. Soc., Vol. 81, January 1959, p. 29.

[32] Kullerud, G., and Yoder, H. S., Pyrite Stability Relations in the Fe-S System: Econ. Geol., vol. 54, No. 4, June–July 1959, pp. 533–572.

[33] Cockwell, C. M. and Shilstone, J. M., Design, Welding Procedure and Fabrication of Concentric Molten Sulphur Pipeline: Welding Jour., April 1960, p. 334.

[34] Lee, C. O., Bartlett, Z. W., and Feiraband, The Grand Isle Mine: Min. Eng., vol. 12, No. 6, June 1960, pp. 518–590.

a limited amount of fresh water, and to return water from the hot-water-jacket line to the mine for reheating and reuse.

The 14-inch outside casing was made of conventional X–42-grade pipe steel having a minimum yield strength of 42,000 p.s.i., whereas the inner pipes (the 7⅝ inch and 6 inch) were made of manganese molybdenum alloy steel having a minimum yield strength of about 60,000 p.s.i.

After the pipeline was laid, but before it was buried, the outer 14-inch casing was placed in 10,000 p.s.i. tension by exerting a pull on each end of the casing; while in tension, the ends were fixed to anchor structures. This tensile stress was relieved when the casing reached its operating temperature of 110° F.

Before the inner lines were placed in operation, the lines were heated to 225° F. and allowed to expand approximately 30 feet. While in this expanded state the ends of the lines were permanently fastened to the outer casing. Movement of the lines was prevented because they were tied together and securely anchored to the outer casing.

As the temperature of the inner lines was raised from 225° F. to the operating temperature of 300° F., where further expansion was restricted, a compressive thermal stress developed. At operating temperatures the combined stresses in the inner lines was calculated to be about 60 percent of yield strength. If the temperature of the inner lines were lowered again below the 225° F. at which the lines were fastened to the outer casing, the thermal stresses would be reversed into tension. At atmospheric temperatures the combined stresses would be about 70 percent of yield strength. Longitudinal movement of the pipelines is confined; consequently no expansion joints are required.

Sulfur and water enter the pipelines at the mine at about 320° F.; the sulfur is discharged at 280° F., thus avoiding high viscosities at temperatures above 320° F. and providing a margin over the freezing of sulfur around 240° F. With a soil temperature of 75° F. the casing temperature should be about 110° F., and the heat loss 90 B.t.u. per linear foot per hour, or 75 million B.t.u. per day. Pump pressures of 900 p.s.i.g. will be required at the mine to deliver maximum capacity of 4,500 tons of sulfur per day, or 470 gallons per minute.

A new sulfur-recovery process, reported to show greater potential advantages in control and efficiency over the main commercial method (the Claus process) was described.[35] The process uses a basic aqueous solution of multivalent ion with a chelating agent to absorb hydrogen sulfide and oxidize it to sulfur.

Fluidized bed roasting of arsenical pyrites at the Stroms Bruk plant, Sweden, was discussed in an article appearing in the trade press.[36] The process proved satisfactory for reducing the arsenic content of pyrite concentrates from a maximum of 0.4 to 0.06–0.07 percent in the pyrite residue.

---

[35] Sulphur, New Desulphurization Process: British Sulphur Corp. (London), Special Issue 1959, pp. 7–10.

[36] British Sulphur Corp. (London), Sulphur, A Novel Method of Fluidized Bed Roasting of Arsenical Pyrites: Special issue 1959, pp. 1–2.

An investigation of the Gazel process for the desulfurization of iron was described.[37] The results of the investigations indicated that the addition of 5 to 10 kg. of sodium carbonate to a long ton of pig iron reduced the sulfur content from 70 to 90 percent. For iron containing 0.100 to 0.200 percent sulfur, 8 kg. of sodium carbonate was required to reduce the sulfur content 70 to 80 percent. The results of more than 100 experimental heats showed that the process was suitable for desulfurizing pig iron from acid blast furnaces. Tests also showed that desulfurization increased as silicon content increased. No experiments were run with silicon greater than 1 percent.

Efficient control of sulfuric acid-plant stock gases was obtained by using knitted wire-mesh filters.[38]

Sulfur, 99.999 percent pure, was made by a new method. In a process developed by the National Bureau of Standards (NBS), sulfur was mixed with sulfuric acid and then melted. Organic impurities were removed with nitric acid, the sulfur cooled, resolidified, and the acid poured off. After washing with water, the sulfur was remelted, cooled, and rewashed. Helium was then bubbled through the sulfur for 8 hours to remove the remaining sulfuric acid.[39]

Recent research into the production of selenium from pyrites was reported.[40]

Fluosolids treatment of Yanahara pyrrhotite resulted in a profit on copper, sulfuric acid, and iron ore, and also reduced mining costs.[41]

Elemental sulfur may be recovered from sulfur ores containing 30 to 40 percent free sulfur by a continuous process. In the process, sulfur-bearing ore is ground and fed to a deisel-grade, fuel oil solvent. Heated to dissolve the sulfur, the hot slurry is contacted with an additional quantity of solvent countercurrently. Fuel oil and the contained sulfur are then separated from the gangue by adding hot water. The fuel oil solvent is cooled, the sulfur precipitated and collected, and the solvent recycled for further use.[42] A similar process was described for the solvent extraction of sulfur from ores obtained from the Leviathan mine in California, using an organic polysulfide as the solvent.[43]

Water was being used to scrub H_2S and CO_2 from sour natural gas at the Lacq gasfield near Paw in southwestern France.[44] The natural gas, containing 15.3 percent H_2S and 9.6 percent CO_2, was scrubbed with water at 1,000 p.s.i. and atmospheric temperature, reducing the H_2S and CO_2 content of the gas to 2 and 8 percent, respectively. The remaining acid gases were removed by scrubbing with monoethanolamine and caustic soda.

---

[37] Journal of Metals, Gazel Process For Iron Desulfurization: Vol. 12, No. 3, March 1960, p. 321.

[38] Massey, O. D., Demisters for Sulfuric Acid Plant Stocks: Chem. Eng. Prog., vol. 55, No. 5, May 1959, pp. 114–118.

[39] Chemical and Engineering News, Research: Vol. 37, No. 8, Feb. 23, 1959, p. 94.

[40] Chemical Age (London), Possibilities of Producing Selenium From Pyrites: Vol 81, No. 2069, Mar. 7, 1959, p. 404.

[41] Kurushima, Hidesaburo, and Foley, R. M., Fluosolids Roasting of Dawa's Yanahara Sulfides: Min. Eng., vol. 10, No. 10, October 1958, pp. 1057–1061.

[42] Bartlett, Joseph W., and Soltes, Elton D. (assigned to Delhi-Taylor Oil Corp., a corporation of Delaware), Sulfur Extraction Process: U.S. Patent 2,890,941, June 16, 1959.

[43] Capell, R. G., Wright, J. H., and Gruse, W. A. (assigned to Gulf Research and Development Co., Pittsburgh, Pa.), Recovery of Elemental Sulfur From Sulfur Bearing Solid Mineral Matter: U.S. Patent 2,897,065, July 28, 1959.

[44] Chemical Engineering, Water Scrubbing Removes Acid Gas: Vol. 66, No. 10, May 18, 1959, p. 63.

Of the 185 million cubic feet per day desulfurized in 1959, 75 million cubic feet was desulfurized by water scrubbing. The balance was treated with diethanolamine and caustic soda. Desorption of water requires no heating, whereas regeneration of 20 percent DEA solution requires heating to 125° C. Cold desorption of water in the new process was estimated to save 75,000 pounds of steam per hour.

Uruguay.—Administracion National de Combustibles Alcohol y Portland of Montevideo will recover sulfur from exit gases at its new refinery.[45]

---

[45] Chemical Trade Journal and Chemical Engineer (London), vol. 144, No. 3740, Feb. 6, 1959, p. 314.

Talc, Soapstone, and Pyrophyllite

By Donald R. Irving[1] and Betty Ann Brett[2]

◆

DOMESTIC mine production and sales of talc, soapstone, and pyrophyllite reached new peaks in 1959, exceeding the previous marks set in 1956 by 8 and 6 percent, respectively. World production also was the highest ever recorded.

TABLE 1.—Salient statistics of the talc, soapstone, and pyrophyllite industries

[Thousand short tons and thousand dollars]

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Mine production:						
Quantity	622	726	739	684	[1] 718	795
Value [2]	[3] $3,508	$4,517	$4,859	$4,796	[1] $4,718	$5,651
Sold by producers:						
Quantity	612	719	735	692	694	782
Value	$11,461	$15,225	$15,026	$14,411	$14,206	$17,068
Imports for consumption:						
Quantity	22	29	23	20	23	25
Value	$702	$986	$749	$701	$785	$861
Exports: [4]						
Quantity	23	35	42	40	59	59
Value	$721	$961	$1,083	$1,265	$1,451	$1,707
World: Production (estimated):						
Quantity	1,600	1,790	1,930	2,070	2,000	2,400

[1] Revised figure.
[2] Partly estimated.
[3] Average for 1953–54 only.
[4] Excludes powders—talcum (in package), face, and compact.

DOMESTIC PRODUCTION

New York, California, and North Carolina again ranked first, second, and third as producers of talc, soapstone, and pyrophyllite in 1959. North Carolina continued to be the major pyrophyllite-producing State, followed by Pennsylvania (sericite schist) and California. Talc and soapstone were produced in 14 States at 77 mines. Pyrophyllite was produced in 3 States at 13 mines.

---

[1] Assistant to the chief, Division of Minerals.
[2] Statistical clerk.

TABLE 2.—Talc, soapstone, and pyrophyllite sold by producers in the United States, by classes

Year	Crude			Sawed and manufactured			Ground[1]			Total		
	Short tons	Value at shipping point		Short tons	Value at shipping point		Short tons	Value at shipping point		Short tons	Value at shipping point	
		Total	Average		Total	Average		Total	Average		Total	Average
1950-54 (average)	19,095	$195,425	$10.23	965	$328,546	$340.46	591,707	$10,937,076	$18.48	611,767	$11,461,047	$18.73
1955	47,032	340,243	7.23	1,311	397,476	303.19	671,043	14,487,640	21.59	719,386	15,225,359	21.16
1956	42,085	265,631	6.31	1,052	441,848	420.01	691,661	14,318,414	20.70	734,798	15,025,893	20.45
1957	57,382	330,131	5.75	1,212	519,664	428.77	633,330	13,561,497	21.41	691,924	14,411,292	20.83
1958	61,287	349,471	5.70	801	400,453	499.94	631,804	13,455,650	21.30	693,892	14,205,574	20.47
1959	64,856	349,484	5.39	710	416,144	586.12	716,837	16,302,657	22.74	782,403	17,068,285	21.82

[1] Includes some crushed material.

TABLE 3.—Pyrophyllite[1] produced and sold by producers in the United States

Year	Production (short tons)	Sales					
		Crude		Ground		Total	
		Short tons	Value	Short tons	Value	Short tons	Value
1950-54 (average)	122,497	4,070	$23,559	116,068	$1,592,767	120,138	$1,616,326
1955	158,460	19,830	124,904	[2] 135,506	2,005,069	155,336	2,129,973
1956	167,756	20,847	121,497	141,143	1,808,502	161,990	1,929,999
1957	160,538	26,414	127,865	135,368	1,925,973	161,782	2,053,838
1958	[3] 155,476	20,732	135,790	122,419	1,886,531	143,151	2,022,321
1959	154,625	31,615	186,090	123,236	1,936,397	154,851	2,122,487

[1] Includes sericite schist, 1953-59.
[2] Includes a small quantity of sawed material.
[3] Revised figure.

TABLE 4.—Crude talc, soapstone, and pyrophyllite produced in the United States

State	1958		1959	
	Short tons	Value [1] (thousands)	Short tons	Value [1] (thousands)
California	[2] 129,638	[2] $1,339	148,266	$1,500
Georgia	(3)	(3)	53,692	107
Maryland and Virginia	26,674	115	28,817	75
Nevada	5,391	41	5,824	50
North Carolina	126,158	614	127,296	647
Texas	60,827	168	60,945	283
Washington	4,000	21	4,073	23
Other States [4]	365,477	2,420	366,095	2,966
Total	[2] 718,165	[2] 4,718	795,008	5,651

[1] Partly estimated.
[2] Revised figure.
[3] Included with "Other States."
[4] Includes States indicated by footnote 3 and Alabama, Arkansas, Montana, New York, Pennsylvania and Vermont.

CONSUMPTION AND USES

Ceramics, paint, insecticides, roofing, rubber, asphalt filler, and paper continued to consume more than 82 percent of the talc and soapstone sold by producers. More talc, soapstone, and pyrophyllite were used by the ceramic industry than by any other. Ceramics, insecticides, and paint accounted for 61 percent of talc and soapstone sold, compared with 59 percent in 1958. Ceramics and insecticides required 55 percent of the pyrophyllite sold in 1958 and 1959.

TABLE 5.—Talc, soapstone, and pyrophyllite sold or used by producers in the United States, by uses, in short tons

Use	Talc and soapstone		Pyrophyllite	
	1958	1959	1958	1959
Asphalt filler	18,493	29,034	(1)	(1)
Ceramics	187,668	213,185	36,273	47,868
Crayons	701	635	---	---
Foundry facings	4,823	6,964	---	---
Insecticides	37,888	51,073	42,285	37,436
Paint	102,058	120,780	5,480	1,677
Paper	18.302	21,848	---	---
Plaster products	---	---	4,399	8,205
Rice polishing	2,666	1,969	---	---
Roofing	53,044	50,453	64	502
Rubber	24,431	30,728	12,458	11,459
Textile	8,556	11,936	---	---
Toilet preparations	9,541	9,634	---	---
Other	[2] 82.570	[3] 79,313	[3] 42,192	[3] 47,704
Total	550,741	627,552	143,151	154,851

[1] Figure included with "Other" to avoid disclosing individual company confidential data.
[2] Includes adhesive, composition floor and wall tile, export, fertilizer, instrument wire and cable, joint cement, refractories, stucco, vault manufacturing, and miscellaneous products.
[3] Includes uses indicated by footnote 1 and battery, exports, joint cement, refractories, and related products.

PRICES

The price quotations in trade journals for talc remained unchanged in 1959. These quotations merely indicate the range of prices; actual prices are negotiated between buyer and seller and are based on a wide range of specifications.

TABLE 6.—Prices quoted on ground talc, in bags, carlots, 1959, per short ton

[Oil, Paint and Drug Reporter]

Grade	1959
Domestic, f.o.b. works:	
Ordinary:	
California	$33.00–$39.50
Vermont	19.40
Fibrous (New York):	
Off-color	28.00
325-mesh:	
99.5 percent	31.00
99.95 percent, micronized	38.00
Imported (Canadian) f.o.b. mines	20.00–35.00

TABLE 7.—Prices quoted on talc, carlots, 1959, per short ton, f.o.b. works

[E&MJ Metal and Mineral Markets]

Grade [1]	1959
Georgia: 98 percent minus-200 mesh:	
Gray, packed in paper bags	$10.50–$11.00
White, packed in paper bags	12.50– 15.00
New Jersey: Mineral pulp, ground, bags extra	10.50– 12.50
New York: Double air-floated, short fiber, 325-mesh	18.00– 20.00
Vermont:	
100 percent through 200-mesh, extra white, bulk basis [2]	12.50
99½ percent through 200-mesh, medium white, bulk basis [2]	11.50– 12.50
Virginia:	
200-mesh	10.00– 12.00
325-mesh	12.00– 14.00
Crude	5.50

[1] Containers included, unless otherwise specified.
[2] Packed in paper bags, $1.75 per ton extra.

FOREIGN TRADE [3]

About 71 percent of all imports came from Italy. Imports from this country increased 5 percent in quantity and 9 percent in value over 1958. The increase in imports from France also was substantial. Among the major foreign sources, only India and Japan exported less to the United States than in 1958. The value of imports of manufactures, except toilet preparations, was $52,509. Products of equal value from Switzerland and West Germany amounted to $42,462 of this sum.

Both tonnage and value of exports other than talcums increased, mainly because of overall price increases and an increase in quantity of 89 tons. The value of these exports was $256,000 greater than in 1958.

---

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 8.—Talc, steatite or soapstone, and French chalk imported for consumption in the United States, by classes and by countries

[Bureau of the Census]

Country	Crude and unground		Ground, washed, powdered, or pulverized, except toilet preparations		Cut and sawed		Total unmanufactured	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1950–54 (average)	161	$26,015	21,593	[1]$642,821	104	$32,670	21,858	[1]$701,506
1955	125	20,300	28,882	[1]936,312	72	29,363	29,079	[1]985,975
1956	117	17,555	23,128	[1]684,954	106	46,761	23,351	[1]749,270
1957	277	42,265	20,032	[1]622,472	86	36,616	20,395	[1]701,353
1958								
Canada	--------	----------	1,556	23,465	--------	----------	1,556	23,465
France	--------	----------	3,008	65,370	1	401	3,009	65,771
India	29	5,935	929	25,333	--------	----------	958	31,268
Italy	2	105	17,069	619,516	9	2,715	17,080	622,336
Japan	--------	----------	--------	----------	89	37,998	89	37,998
Mexico	--------	----------	198	3,900	--------	----------	198	3,900
Total	31	6,040	22,760	737,584	99	41,114	22,890	784,738
1959								
Belgium-Luxembourg	--------	----------	40	344	--------	----------	40	344
Canada	--------	----------	1,588	24,404	--------	----------	1,588	24,404
France	--------	----------	4,817	100,101	2	555	4,819	100,656
India	54	5,020	420	12,037	--------	----------	474	17,057
Italy	331	13,058	17,593	663,273	8	2,551	17,932	678,882
Japan	--------	----------	10	448	64	31,166	74	31,614
Mexico	114	375	305	6,496	--------	----------	419	6,871
United Kingdom	--------	----------	5	713	--------	----------	5	713
Total	499	18,453	24,778	807,816	74	34,272	25,351	860,541

---

[1] Data known to be not comparable with other years.

TABLE 9.—Talc, pyrophyllite, and talcum powders exported from the United States

[Bureau of the Census]

Year	Talc, steatite, soapstone, and pyrophyllite				Powders—talcum (in packages), face and compact (value, thousands)
	Crude and ground		Manufactures, n.e.c.		
	Short tons	Value (thousands)	Short tons	Value (thousands)	
1950–54 (average)	22,575	$634	168	$87	$1,263
1955	35,230	859	135	102	1,246
1956	42,333	1,009	69	74	1,371
1957	39,985	1,127	291	138	1,322
1958	58,647	1,358	212	93	1,341
1959	58,751	1,532	197	175	1,276

WORLD REVIEW

Estimated world production of talc, soapstone, and pyrophyllite set a new record, as output in Japan, Norway, and the United States increased substantially over 1958.

TABLE 10.—World production of talc, soapstone, and pyrophyllite, by countries,[1] in short tons [2]

[Compiled by Liela S. Price and Berenice B. Mitchell]

Country [1]	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada (shipments)	27,607	27,160	29,326	34,725	35,405	38,884
United States	621,715	725,708	739,039	684,453	718,165	795,008
Total	649,322	752,868	768,365	719,178	753,570	833,892
South America:						
Argentina	26,543	25,211	24,920	26,239	[3] 26,500	[3] 26,500
Brazil	18,657	27,190	30,684	23,023	31,422	[3] 31,000
Paraguay	[4] 116	[3] 110	[3] 110	[3] 110	[3] 110	[3] 110
Peru	[5] 105	3,708	4,031	2,689	2,073	1,694
Uruguay	941	1,249	1,580	1,566	1,990	2,335
Total	46,362	57,468	61,325	53,627	62,095	[3] 61,600
Europe:						
Austria	65,144	77,905	72,813	80,915	78,074	56,475
Finland	4,944	5,265	8,146	9,259	7,330	8,505
France	116,775	132,683	126,840	145,505	155,205	162,040
Germany, West (marketable)	33,708	38,889	39,463	32,854	[3] 33,000	[3] 33,000
Greece	1,649	2,315	2,205	2,205	----------	----------
Italy	86,736	110,292	105,005	102,592	120,704	116,613
Norway	74,841	88,598	82,154	117,965	63,383	[3] 127,000
Portugal	7	11	95	----------	----------	----------
Spain	20,792	25,168	30,405	32,064	32,131	[3] 35,000
Sweden	12,828	13,695	14,492	13,918	15,242	[3] 15,000
United Kingdom	3,291	5,641	4,270	4,256	[3] 4,400	[3] 4,400
Yugoslavia	----------	2,922	----------	----------	----------	----------
Total [1] [3]	440,000	525,000	510,000	565,000	535,000	580,000
Asia:						
Afghanistan	778	694	882	[3] 770	[3] 770	[3] 770
India	33,906	47,476	52,478	49,253	51,520	70,572
Japan	342,708	251,479	345,846	469,109	377,994	624,133
Korea, Republic of	15,577	12,092	15,719	12,434	17,581	19,272
Taiwan	2,988	5,807	6,758	5,938	3,677	7,101
Total [1] [3]	440,000	430,000	565,000	705,000	615,000	900,000
Africa:						
Egypt	3,730	6,878	7,706	6,031	7,253	[3] 7,000
Kenya	257	----------	----------	----------	----------	----------
Morocco	----------	----------	----------	----------	5,413	3,915
Swaziland	----------	----------	----------	22	157	1,008
Union of South Africa	7,227	1,581	1,968	2,314	765	1,412
Total	11,214	8,459	9,674	8,367	13,588	[3] 13,335
Oceania: Australia	11,985	14,075	14,979	16,484	17,539	[3] 16,000
World total (estimate) [1] [2]	1,600,000	1,790,000	1,930,000	2,070,000	2,000,000	2,400,000

[1] Talc or pyrophyllite is reported in China, Rumania, and U.S.S.R., but data are not available; estimates for these countries are included in total.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Estimate.

[4] Average for 1953–54.

[5] Average for 1951–54.

Austria.—Talc-mining operations in Rabenwald, Styria, were described.[4]

Canada.—Newfoundland Minerals, Ltd., Manuels, Newfoundland, began shipping crude pyrophyllite to its parent company, American Encaustic Tiling Co., Inc., Lansdale, Pa., in October, when dock and ore-loading facilities were completed at Long Pond.[5] By the end of

---

[4] Vetter, Hans [Production of Talc in Rabenwald]: Euro-Ceram., vol. 9, No. 2, 1959, pp. 43–45; Ceram. Abs., July 1959, p. 192.

[5] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 4, April 1960, p. 38.

the year 6,000 short tons had been shipped. Approximately 30 persons were employed.

The output of talc, soapstone, and pyrophyllite was 35,405 tons valued at $429,136 in 1958, compared with 34,725 short tons valued at $427,673 in 1957.[6]

In Newfoundland pyrophyllite was mined at Manuels, about 12 miles southwest of St. John's. Quebec mines produced ground talc, soapstone blocks, and crayons. Talc of various particle sizes was shipped from the Madoc, Ontario, area.

An average of 76 persons was employed in the industry, and the payroll was $213,576. Fuel costs were $7,575, and 1,367,107 kw.-hr. of electricity was purchased for $28,458. Containers and process supplies cost $105,097.

Imports of talc and soapstone in 1958 totaled 16,593 tons valued at $584,666. Exports were 1,931 tons, worth $24,713.

TABLE 11.—Talc and soapstone exported from Austria, France, and Italy, by countries of destination, in short tons [1] [2]

[Compiled by Corra A. Barry]

Country of destination	Exporting countries					
	Austria		France		Italy	
	1958	1959	1957	1958	1958	1959
Algeria	-----	-----	1,953	3,468	-----	-----
Austria	-----	-----	-----	-----	313	(3)
Belgium-Luxembourg	2,339	3,046	3,831	3,993	303	(3)
Canada	-----	-----	-----	-----	1,417	(3)
Denmark	131	159	-----	-----	17	-----
France	1,366	1,379	-----	-----	4,061	(3)
Germany:						
East	1,424	313	-----	-----	-----	-----
West	17,326	19,034	5,528	4,601	6,744	5,920
Hungary	1,980	1,575	-----	-----	-----	-----
Italy	1,498	964	-----	-----	-----	-----
Morocco: Southern zone	-----	-----	582	790	6	-----
Netherlands	878	1,068	918	705	667	(3)
Philippines	-----	11	-----	-----	1,062	(3)
Poland	26,124	6,886	-----	-----	-----	-----
Portugal	-----	-----	-----	-----	197	(3)
Saar	123	-----	-----	-----	44	-----
Sweden	88	66	633	526	86	-----
Switzerland	2,797	2,996	9,081	7,235	1,382	(3)
Union of South Africa	-----	-----	-----	-----	1,002	(3)
United Kingdom	634	560	6,449	6,052	10,107	7,899
United States	-----	-----	3,121	3,428	18,016	16,412
Yugoslavia	116	26	-----	-----	195	-----
Other countries	40	-----	3,520	2,685	3,997	11,511
Total	56,864	38,083	35,616	33,483	49,616	41,742

[1] Compiled from Customs Returns of Austria, France, and Italy.
[2] This table incorporates some revisions.
[3] Data not separately recorded.

India.—A deposit estimated to contain 6 million tons of talc-magnesite rock suitable for making refractories was discovered at Pathar Pahar in the Singhbhum district of Bihar.[7]

---

[6] Canada, Department of Trade and Commerce, Dominion Bureau of Statistics, The Talc and Soapstone Industry, 1958: Ind. Merchandising Div., Cat. No. 26–218, Ottawa, 1959, 7 pp.

[7] Central Glass Ceramics Research Institute Bulletin (Calcutta, India), Soapstone Deposits: Vol. 6, No. 2, 1959, p. 93.

High-quality talc suitable for cosmetics was mined at Jaipur, Udaipur, Mewar, and Ajmer-Merwara, in Rajasthan; Bhedaghat and Gwari (near Jabalpur), in Madhya Pradesh; Karimnagar, Anandpur, Cuddapah, and Kurnool, in Andhra Pradesh; and Sundargurh, Keonjhar, and Nilgiri, in Orissa. The most important deposits were those in Jaipur, Udaipur, and Mewar.[8]

The largest producer was the Jaipur Mineral Development Syndicate, Ltd., of Jaipur City. This firm produced an estimated 40,000 tons of ground talc a year and exported large quantities to European countries and the United States. Ground talc was priced at $24.50 to $28.50 per short ton f.o.b. Jaipur. Rail freight to Bombay and port handling charges were about $6.50 a short ton. Ocean freight to U.S. east coast ports was about $36 per short ton. Ocean insurance and other charges were about 1 percent of the invoice price. A typical chemical analysis of the higher quality talc showed 32.3 percent M_gO, 61.6 percent SiO_2, 0.5 percent Fe_2O_3, 0.8 percent Al_2O_3, and 4.6 percent H_2O. TiO_2, MnO, and CaO were nil.

Korea, Republic of.—Pyrophyllite production in 1958 was 6,441 short tons; talc production was 11,140 short tons.[9]

Union of South Africa.—Production and exports of wonderstone, a massive pyrophyllite, more than doubled in 1958 over 1957.

TABLE 12.—Salient statistics of the pyrophyllite (wonderstone) industry in Union of South Africa[1]

	1957	1958
Production short tons	595	1,255
Exports:		
Quantity do	554	1,112
Value	$54,544	$101,828
Local sales:		
Quantity short tons	115	125
Value	$8,714	$9,747

[1] U.S. Embassy, Johannesburg, Union of South Africa, State Department Dispatch 52: Aug. 28, 1959, encl. 1, p. 2; encl. 2, p. 2; encl. 3, p. 2.

TECHNOLOGY

References on pyrophyllite were included in a bibliography of domestic resources of selected minerals published in 1959.[10] The geology of several pyrophyllite deposits in the Koli-Hirvivaara area of northern Karelia, Finland,[11] and of the talc and pyrophyllite deposits in Paraguay[12] were described.

---

[8] U.S. Consulate, Bombay, India, State Department Dispatch 551: Mar. 18, 1959, 2 pp.

[9] U.S. Embassy, Seoul, Korea, State Department Dispatch 615: Apr. 27, 1959, p. 2.

[10] Grametbaur, A. B., Selected Bibliography of Andalusite, Kyanite, Sillimanite, Dumortierite, Topaz, and Pyrophyllite in the United States: Geol. Survey Bull. 1019–N, 1959, pp. 973–1046.

[11] Aurola, Erkki, The Kyanite and Pyrophyllite Deposits in Northern Karelia (Finland): Geol. Tutkimuslaitos, Geotek. Julkaisuja, No. 63, 1959, 36 pp.; Chem. Abs., vol. 53, No. 22, Nov. 25, 1959, col. 21478e.

[12] Eckel, E. B., Geology and Mineral Resources of Paraguay, A Reconnaissance: Geol. Survey Prof. Paper 327, 1959, pp. 90–91, 93–94.

The results of tests using talc and pyrophyllite in sagger bodies[13] and in manufacturing other ceramic bodies[14] were reported.

Articles were published describing the properties of various steatite bodies.[15]

Patents were issued for using talc in admixture with gilsonite or other asphaltic bitumen to prepare carbonaceous cation-exchange materials,[16] in compositions for coating alumina rods used in flame spraying,[17] and in a felted vibration-damping material.[18] Dry, free-flowing fire-extinguishing compositions were developed, which used 50 to more than 90 percent of finely ground talc with or without dried ammonium sulfate, diammonium phosphate, a metallic stearate drying agent, and an absorbent such as magnesium carbonate.[19]

The use of micaceous talc or mica in a simulated-snow composition to be applied from an aerosol bomb was suggested.[20]

An air separator suitable for classifying ground talc was patented.[21]

---

[13] Alekseev, N. S., Dikerman, N. I., and Kirshenbaum, Ya. B. [Increasing the Life of Saggers]: Steklo i Keramika (Moscow), vol. 13, February 1956, pp. 23–26; Ceram. Abs., June 1959, p. 159.

Beznosikova, A. V., and Kordonskaya, R. K. [Investigation of the Phase Composition of a Talc-Alumina Sagger Body]: Steklo i Keramika (Moscow,) vol. 13, No. 7, July 1956, pp. 23–26; Ceram. Abs., July 1959, pp. 182–183.

Shtaveman, A. V. [Pyrophyllite of the Suranskoye Deposit as a Ceramic Raw Material]: Steklo i Keramika (Moscow), vol. 16, No. 2, February 1959, pp. 31–34.

[14] Ishii, Eiichi, Sugiura, Masatoshi, Sano, Shiro, Hirai, Michio [Forsterite Porcelain as a High-Frequency Insulator: I, Properties of Forsterite Porcelain from Talc and Sea-Water Magnesia]: Nagoya Kogyo Gijutsu Shikensho Hokuku, vol. 6, No. 6, 1957, pp. 42–46; Ceram. Abs., April 1960, p. 90.

Royer R. [An investigation of Stoneware Bodies Containing Talc for Firing Temperatures of 1,000°–1,100° C]: Sprechsaal, vol. 91, 1958, pp. 454–456.

Shiraki, Yoichi, and Iizuma, Tsunetaro [Dielectric Loss and Insulation Resistance of Bodies Made of Chlorite, Pyrophyllite, and Sericite]: Yogyo Kyokai Shi, vol. 67, No. 760, 1959, pp. 107–116; Ceram. Abs., April 1960, p. 92.

Sata, Toshiyuki, and Kiyoura, Raisaku [Bone Ash-Talc-Quartzite Bodies]: Yogyo Kyokai Shi, vol. 66, No. 756, 1958, pp. 294–298; Ceram. Abs., May 1959, p. 132.

[15] Berdov, G. I. [Steatite Ceramics for Metal-Ceramic Joints]: Izvest. Vysshikk Ucheb. Zavedenii, Fiz., No. 5, 1958, pp. 84–89; Chem. Abs., vol. 53, No. 8, Apr. 25, 1959, col. 7541h.

Berry, T. F., Allen, W. C. and Hassett, W. A., Role of Powder Density in Dry-Pressed Ceramic Parts: Bull. Am. Ceram, Soc. vol. 38, No. 8, August 1959, pp. 393–400.

Bojarski, Z. [Suitability of Austrian Talc for Steatite Bodies]: Prace Inst. Ministerstwa Hutnictwa, vol. 9, 1957, pp. 227–235; Ceram. Abs., August 1959, p. 218.

Lavrent'eva, L. G., and Presnov, V. A. [Polymorphism of Steatite Ceramics. II. Effect of the Thermal Treatment of the Ceramics on the Crystalline Phase Composition]: Izvest. Vysshikk Ucheb. Zavedenii, Fiz., No. 5, 1958, pp. 48–51; Chem. Abs., vol. 53, No. 8, Apr. 25, 1959, col. 7541e.

Yasuno, Fukutaro [Studies on the Deterioration of Steatite Bodies: I, Thermal Expansion of Deteriorated Bodies and Their Chemical Compositions]: Yogyo Kyokai Shi, vol. 67, No. 761, 1959, pp. 165–171; Ceram. Abs., April 1960, p. 91.

[16] Goren, M. B., Pickell, M. W., and Garwin, L. (assigned to Kerr-McGee Oil Industries, Inc.), Cation Exchange Materials and Their Preparation: U.S. Patent 2,911,373, Nov. 3, 1959.

[17] Ault, N. N. (assigned to Norton Co.), Alumina Rods for Coating Articles: U.S. Patent 2,882,174, Apr. 14, 1959.

[18] Baymiller, J. W., and Merrifield, P. E. (assigned to Armstrong Cork Co., Lancaster, Pa.), Asbestos-Containing Vibration Damping Sheet Material: U.S. Patent 2,887,428, May 19, 1959.

[19] Cawood, E. E. C., and Anderston, S. B. (assigned to Nu-Swift, Inc.), Improvement in or Relating to Fire-Extinguishing Materials: British Patents 815,711 and 815,712, July 1, 1959.

[20] Hohnstine, J. T., Versocki, J. A. and Steckhahn, F. L. (assigned to American Home Products Corp.), Simulated Snow Composition Containing Mineral Filler: U.S. Patent 2,894,928, July 14, 1959.

[21] Lykken, H. G. (assigned to The Microcyclomat Co.), Aerodynamic Classifier: U.S. Patent 2,915,179, Dec. 1, 1959.

Thorium

By James Paone[1]

◆

THORIUM applications in high-temperature alloys and in atomic-energy gained increased attention in 1959. A long-range program for developing suitable thorium reactors was started by the Atomic Energy Commission (AEC). Domestic production of thoria-containing minerals declined, and requirements for the commodity were met by production from previous years and by imports. Consumption of thorium for magnesium-thorium alloys exceeded all other uses of thorium. Magnesium-thorium alloys were used in every missile produced or under development during the year.

Canada's first byproduct thorium plant came into production. The plant recovered thorium products from solutions discarded from a uranium-recovery process in the Blind River area, Ontario. The major source of thorium in the free world, in recent years, the Van Rhynsdorp monazite-lode mine in the Union of South Africa, closed.

LEGISLATION AND GOVERNMENT PROGRAMS

Effective thermal breeder reactors that would make use of the latent nuclear energy in thorium were being developed under a long-range program initiated by AEC. A major objective of the program was the development of a thermal breeder reactor capable of converting thorium to uranium 233, a fissionable fuel material, at a doubling time of not more than 25 years. "Doubling time" is used to define the time theoretically necessary to produce sufficient excess fissionable material to start up a second similar reactor. Initially the new program emphasized basic research, with sufficient development effort to permit an evaluation of reactor technology.

At the end of the year the General Services Administration (GSA) was preparing to sell approximately 550 short tons of Government-owned thorium residue. Offers were to be received for a period of 45 days, and sales would be subject to AEC regulations governing the use of source materials in a manner consistent with the National welfare. The residue, in the form of wet filter cake, was derived from the processing of columbite-uranium concentrate under a Defense Materials Production Act contract and was stored at the Granite City Engineer Depot, Granite City, Ill.

The Office of Minerals Exploration (OME) continued to include thorium in the list of minerals eligible for financial assistance. No exploration contracts for thorium were made in 1959.

---

[1] Commodity specialist.

DOMESTIC PRODUCTION

Mine Production.—Thoria production from domestic sources was about 35 tons. Mine shipments of monazite, bastnasite, thorite concentrates, and a thorium-rare earth residue from processing euxenite totaled 1,143 tons valued at $206,000, compared with 2,021 tons valued at $286,000 in 1958. Of this total, 799 tons of monazite and thorite concentrates containing about 35 tons of ThO_2 was processed into thorium metal compounds.

Domestic thoria sources included thorite, euxenite, and monazite. Thorite was produced in Idaho by Agency Creek Thorium and Rare Metals Corp. of America, in Montana by Sawyer Petroleum Co., and in Colorado by several firms. Euxenite was produced in Idaho by Porter Brothers Corp. Byproduct thorium residue was recovered from the euxenite concentrate by Mallinckrodt Chemical Works, St. Louis, Mo., and the residue was stockpiled by GSA. The Titanium Alloy Mfg. Division, National Lead Co., produced byproduct monazite from its Skinner property, Duval County, Fla. In addition, monazite was shipped by the Rutile Mining Company of Florida, from its stockpile from 1958 dredging operations near Jacksonville, Fla., and by J. R. Simplot Co. from its separation plant in Valley County, Idaho.

Salmon River Uranium Development, Inc., Northwest Prospecting and Development Co., Nuclear Fuels and Rare Metals Corp., and New Mexico Thorium Co., engaged in exploration and development activities in Idaho, Montana, and New Mexico. Development of properties in the Lemhi Pass area, indicated that it held promise of being one of the most important thorite areas in the United States.[2]

Thorium deposits of alluvial monazite in the western piedmont of North and South Carolina between the Savannah and Catawba Rivers, estimated to contain 53,000 tons of thorium, were described.[3]

Refinery Production.—Principal domestic refiner of thorium compounds continued to be Lindsay Chemical Division, American Potash and Chemical Corp., West Chicago, Ill. Others included Davison Chemical Division, W. R. Grace & Co., Pompton Plains, N.J., and Erwin, Tenn., and Vitro Chemical Co., formerly Heavy Minerals Co., Chattanooga, Tenn. Mallinckrodt Chemical Works, St. Louis, Mo., continued to recover thorium residue for GSA from Idaho euxenite processed primarily for columbium and uranium.

Heavy Minerals Co., Vitro Uranium, and Vitro Rare Metals consolidated to form Vitro Chemical Co., a subsidiary of Vitro Corp. of America.

Thorium was sold by Davison Chemical Division, Sylvania-Corning Nuclear Corp., Westinghouse Electric Corp. (Lamp Division), Horizons, Inc., National Research Corp., Nuclear Materials and Equipment Corp., Vitro Corp. of America, and Ronson Metals Corp. National Lead Co. of Ohio processed thorium metal for the AEC.

---

[2] Anderson, A. L., Thorite and Rare Earth Deposits in the Lemhi Pass Area, Lemhi County, Idaho: Pres. at Annual Meeting AIME, San Francisco, Calif., Feb. 15–19, 1959.

[3] Overstreet, W. C., Theobald, P. K., Jr., and Whitlaw, J. W., Thorium and Uranium Resources in Monazite Placers of the Western Piedmont, North and South Carolina: Min. Eng., vol. 11, No. 7, July 1959, pp. 709–714.

Reactor-grade (high-purity) thorium oxide was produced by Davison Chemical Division and by Lindsay Chemical Division. High-purity thorium oxide ceramic also was made by National Beryllia Corp., Hackettstown, N.J.

CONSUMPTION AND USES

Nonenergy Uses.—Consumption of thorium by domestic industry increased 11 percent over that in 1958. Foundry use of magnesium-thorium alloys dropped, but significant increases in the use of thorium in such alloys as sheet, plate, and other forms resulted in an overall gain of about 14 percent. Thorium application for gas-mantle manufacture remained at a comparatively high level. Thorium also was used in refractories, chemical reagents, electrical equipment, castings, and research.

TABLE 1.—Thorium consumption for nonenergy purposes, in pounds of contained ThO_2

Use	1954	1955	1956	1957	1958	1959
Magnesium alloys	4,647	23,944	50,000	100,000	120,000	136,000
Gas-mantle manufacture	9,765	44,566	40,000	40,000	40,000	45,000
Refractories and polishing compounds	24	105	200	----------	5,000	5,000
Chemical and medical products	3,738	3,898	4,000	4,000	6,000	5,000
Electronic products	2,016	926	1,000	1,000	1,000	1,000
Total	20,190	73,439	95,200	145,000	172,000	191,000

Chief producer of magnesium-thorium alloys was Dow Chemical Co. Thorium increases the operating range of magnesium alloys 400° to 600° F. while maintaining light weight. Eight magnesium-thorium alloys were offered for elevated-temperature service; the American Society for Testing Materials (ASTM) designation and thorium weight-percent content are given in table 2. Magnesium-thorium alloys were used in nearly every missile produced or under development. About 40 percent of a *Titan* intercontinental ballistic missile skin structure incorporates magnesium-thorium sheet and extrusions, amounting to about 2,000 pounds. Each of the five *Discoverer* satellites launched by the end of 1959 incorporated over 600 pounds of magnesium-thorium alloys in its skin and fairings to enable the satellite to resist aerodynamic heating, compressive buckling, and temperature reversals, while passing around the Earth.

TABLE 2.—Magnesium-thorium alloys

Alloy designation		Thorium content, weight-percent	Forms produced
ASTM	Producing company		
HK31A	HK31XA	3.0	Sand castings, sheet, and plate.
HM21A	HM21XA	2.0	Sheet, plate, and forgings.
HM31A	HM31XA	3.0	Extrusions.
HZ32A	ZT1	3.0	Sand castings.
ZH62A	TZ6	1.8	Do.
HM11XA	----------	1.2	Die castings.
HZ21	ZTX (British)	2.5	Extrusions, sheet, and forgings.
	TZ4 (British)	2.0	Castings.

Principal supplier of thorium-magnesium master alloy for magnesium-thorium alloys was Dominion Magnesium, Ltd., Toronto, Canada; others included Magnesium Elektron, Ltd., Davison Chemical Co., and Rio Tinto Dow, Ltd., Toronto, Canada.

Energy Uses.—A total of 25 kilograms of uranium 233 went to the Southwest Atomic Energy Associates for use in a critical facility to determine the nuclear parameters of an epithermal thorium-uranium 233 breeder.[4]

The AEC Oak Ridge Operations Office, assigned responsibility for the development of a thermal breeder reactor capable of converting thorium to fissionable fuel material with a doubling time of not more than 25 years, started a systematic investigation and evaluation of all reactor types to determine their thermal breeding potential. Development of the liquid-metal fuel system at Brookhaven National Laboratory and the molten-salt concept at Oak Ridge National Laboratory was to be curtailed unless evaluation studies demonstrated that the two concepts had promising potentials.

The small requirements of the AEC for thorium were met primarily from thorium metal and compounds produced at the Fernald, Ohio, pilot plant prior to 1956. After using this material the AEC indicated that it would meet further thorium requirements from commercial sources. A small pilot plant at the AEC Oak Ridge National Laboratory prepared special types of thorium oxide powders for use in its homogeneous reactor program.

PRICES

Monazite quotations listed in E&MJ Metal and Mineral Markets remained steady during 1959 as follows:

Type and grade, rare-earth oxide including thoria, percent:	*Price per pound, c.i.f. U.S. ports*
Massive; 55	$0.13
Sand; 55	.15
Sand; 66	.18
Sand; 68	.20

Prices for thorite type minerals were on a negotiated basis between buyer and seller but probably ranged from $1.25 per pound of contained thoria for 10 percent concentrates to $2.25 for 20 percent concentrates.

Thorium compounds offered for sale in 1959 by a leading producer in 100-pound lots or more were as follows:

Thorium compound:	*ThO_2, percent*	*Price per pound*
Carbonate	80–85	[1] $6.25–8.00
Chloride	50	7.00
Fluoride	80	5.50
Nitrate (mantle grade)	46	3.00
Oxide	97–99	5.50–8.50
Other forms:		
Metal (nuclear grade) [2]	-----	19.55
Thorium hardener (for alloying)	20–40	12.50–15.00

[1] Variable, depending on rare-earth content.
[2] F.o.b. AEC, Feed Materials Production Center, Fernald, Ohio.

---

[4] Atomic Energy Commission, Major Activities in the Atomic Energy Program: January–December 1959, p. 84.

The following prices per pound for nuclear-grade thorium metal remained in effect in 1959:

	Powder or pellets	*Thorium ingot*
Less than 10 lb	$50	$54
10 to 100 lb	41	45
100 to 500 lb	34	38
500 to 2,000 lb	26	30
Over 2,000 lb	20	24

FOREIGN TRADE

Exports of monazite were made by the Union of South Africa, Australia, and Malaya. Madagascar exported thorianite, and Canada exported thorium salts from a byproduct recovery plant in Ontario. India and Brazil retained embargoes on exports of thorium.

WORLD REVIEW

World requirements for thorium were met by production of monazite in the Union of South Africa, in Australia, the Federation of Malaya, India, and the United States; thorianite mined in Madagascar and thorite mined in the United States also contributed to the requirements for thorium. Byproduct thorium from a Canadian uranium mill began supplying world markets.

NORTH AMERICA

Canada.—Canada's first thorium plant, at Elliot Lake, Ontario, in the Blind River uranium field began production. The plant uses a solvent-extraction process for the recovery of thorium from the waste liquors produced in the Algom-Quirke uranium-treatment plant and has annual capacity of 250 tons of thorium salts a year. The plant produces a 15 percent thorium concentrate, refined metallurgical-grade thorium sulfate, and thorium oxide. Part of the concentrate is upgraded at the plant to produce metallurgical-grade thorium oxide for the Canadian market, and the remainder is shipped without further processing to the United States and England for refining. Processing in the United States was on a custom basis for Rio Tinto Dow, Ltd. Processed products included thorium hydroxide, thorium oxide, anhydrous thorium fluoride, thorium metal, and a thorium-magnesium master alloy.[5] Trial shipments of the various products were made in May.[6]

Production during the year was 27 tons valued at $116,000.

Monazite found in the ore minerals in the Elliot Lake uranium ores was described.[7]

SOUTH AMERICA

Brazil.—Export restrictions imposed in 1956 on atomic-energy resources continued in effect.

---

[5] Mining World, vol. 21, No. 12, November 1959, p. 31.

[6] Griffiths, J. W., A Survey of the Uranium Industry in Canada: Dept. of Mines and Tech. Surveys (Ottawa, Canada), Bull. MR 34, November 1959, 94 pp.

[7] Roscoe, S. M., Monazite: Canadian Min. Jour. (Quebec), vol. 80, No. 7, July 1959, pp. 65–66.

Venezuela.—Deposits of thorium ore were discovered on Capture Island, Delta Amacuro Federal Territory, on the southern shores of the Gulf of Paria, in eastern Venezuela. Exploitation of the deposits was being considered.[8]

EUROPE

France.—The Le Bouchet plant, which started operations in 1957, continued to process the uranothorite ore mined in Madagascar. Thorium production was about 300 tons of oxide.

Germany, West.—Production of thorium began during the year.[9] However, details of the operations were not available.

U.S.S.R.—Thorium and its compounds were being investigated. Although thorium has not been extensively used in atomic-energy programs, the Soviets have conducted extensive metallurgical research on the commodity and have worked out precise measurements of its nuclear properties.

United Kingdom.—England's major producer of thorium oxides and salts, Thorium, Ltd., was acquired by Rio Tinto and Dow Chemie A. G., the Swiss subsidiary of Dow Chemical Co.[10]

The uranium and thorium resources of the United Kingdom were described.[11]

ASIA

Ceylon.—Improvements in Ceylon's monazite processing plant were expected to increase the plant's capacity to 250 tons of refined monazite a year. Monazite production in 1958 was reported at 112 tons of concentrate and in 1957 at 137 tons.

Chief monazite sources were the Beruwala and Kaikawala beaches on the west coast.

India.—The Alwaye plant continued to process monazite at a rate of 1,500 tons of monazite a year. Crude thorium hydroxide, the most important plant product, was shipped for further treatment to the Government-owned installation at Trombay. Thorium nitrate, principal product of the Trombay plant, supplied Asian and some European markets.

The coastal region stretching from Quilon to Cape Comorin, particularly that in the State of Kerala, was said to contain the largest, as well as the richest, mineralized area of heavy mineral sands in India.[12] The mineral content of India heavy sands are as follows:

Mineral:	*Percent abundance*	*Element content, percent*
Ilmenite	65–75	TiO_2–59
Rutile	3– 8	TiO_2–95
Zircon	5–10	ZrO_2–65
Sillimanite	5–10	Al_2O_3–63
Monazite	1– 2	ThO_2–8
Quartz	5–10	----------

---

[8] Mining Journal (London), vol. 254, No. 6490, Jan. 8, 1960, p. 43.

[9] Chemical Age (London), vol. 81, No. 2066, Feb. 14, 1959, pp. 291, 292.

[10] Mining Journal (London), vol. 253, No. 6481, Nov. 6, 1959, p. 454.

[11] Bowie, S. H. V., The Uranium and Thorium Resources of the Commonwealth: Jour. of the Royal Soc. of Arts, vol. 107, No. 5038, September 1959, pp. 704–718.

[12] Mining Journal (London), vol. 253, No. 6479, Oct. 3, 1959, p. 392.

Korea, Republic of.—Projects under investigation to improve Korean mineral output were reported to include a $750,000 expenditure for the output of thorium.

Malaya, Federation of.—Monazite produced in Malaya supplied some of the thorium requirements of the free world.

AFRICA

Egypt.—A Soviet-Egyptian economic assistance agreement signed in 1958 provided for planning black-sand exploitation and for delivery of equipment to Egypt for separation and refinement of Egyptian black sands. Under the agreement, the plant would be expanded to a capacity of 30,000 tons a year of sand containing ilmenite, magnetite, zircon, and monazite. The plan also included a plant for producing 250 tons per year of thorium nitrate.

Madagascar.—The French Commissariat à l'Energie Atomique and the Société Péchiney established a company, Sotrasum, to undertake large-scale mining of thorium-bearing sand in Madagascar.[13] It was expected that the new firm would treat 100,000 tons of sand a year; monazite yield from the sand would be 1,500 tons a year.

Nigeria.—Information on grade and quantity of thorium concentrates or ores produced in Nigeria in 1959 was not available. However, Nigeria reported a combined production of about 1,200 tons of thorite and zircon.

Union of South Africa.—The Anglo American Co. monazite mine near Van Rhynsdorp, a major source of thorium in the free world, shut down in March. An official announcement in the Union during the latter part of 1958 stated that monazite sales contracts with American buyers would not be renewed.[14]

OCEANIA

Australia.—Monazite mined from beach-sand deposits of heavy minerals was shipped to foreign countries.

TECHNOLOGY

Alkyl amines for extracting thorium from preprocess sulfate liquors were described.[15] The amines are versatile extractants for economical recovery of relatively high-grade thorium products from sulfate liquors.

Existing processes and those that may have future application involving extraction of thorium from its ores were detailed at a meeting of Britain's Society of Chemical Industry.[16] Highlighted at the meeting were descriptions of ore breakdown with the sulfuric acid and the caustic processes; intermediate purification employing a cellulose phosphate process and a selective oxalite precipitation; final purification by solvent extraction using tributyl phosphate in an inert diluent; calcium reduction of oxide to metal powder; and electrolytic

---

[13] Foreign Trade (Ottawa), vol. 112, No. 8, Oct. 10, 1959, p. 15.

[14] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 6, December 1959, p. 29.

[15] Crouse, D. J., Jr., and Brown, K. B., The Amex Process: Ind. Eng. Chem., vol. 51, No. 12, December 1959, pp. 1461–1464.

[16] Buddery, J. H., Jamrack, W. D., and Wells, R. A., The Extraction of Thorium: Chem. Ind. (London), No. 8, Feb. 21, 1959, pp. 235–244.

refining of thorium. Thorium extraction from thorite by a hydrochloric or nitric acid leach and uranium-barren residues from the Blind River area of Canada, with di-ethylhexyl hydrogen phosphate (EHP) in kerosine, were also described.

Technologists of the Indian Bureau of Mines discussed methods of separating constituents of India's heavy mineral sands. A gravity concentrate from the beach sand is air-dried, screened to 30-mesh, and passed through Wetherill and other types of electromagnets for separation of magnetite and ilmenite. The remaining sand is passed under high-intensity electromagnets, and the 60 percent monazite from the operation is treated further in wet and dry concentrating tables and electromagnetic fields. A final dry concentration process results in a 98-percent-pure monazite.

Australian metallurgists developed a process for high-purity thorium. In this process thorium oxide is heated to a high temperature with carbon to form thorium carbide. A small quantity of iodine is added to an evacuated vessel containing the heated thorium. The volatile thorium iodide produced is conveyed to an electrically heated filament and thorium metal deposits on the filament, building up a metal rod. The iodine liberated by thermal decomposition of the iodide is recycled. The Australian process is similar to a process developed in the United States for making high-purity thorium.

A new technique for preparing high-purity thorium for basic studies of the metal's properties was announced at a meeting of the Electrochemical Society at Philadelphia in May. High-purity thorium oxide is reduced by calcium in an inert atmosphere at 1742° F. with calcium chloride present.

Preparation of thorium metal by electrolytic reduction of thorium oxide in two systems was described.[17] The systems included a fused KF-ThF_4 mixture and a fused $NaCl$-KCl-$ThCl_4$ mixture. Electrolysis in the fluoride melt proved to be a superior process, because the resultant metal had a higher purity and a larger average particle size.

Research workers from Battelle Memorial Institute described a method for treating thorium whereby adherent electroplates of most metals can be applied. The method involves anodic pickling in hydrochloric acid and chemical pickling in sulfuric acid prior to plating. Preliminary tests showed that copper, iron, nickel, and silver plated directly on thorium appeared most promising.[18]

Research at laboratories in Albany, Oreg., on arc melting of thorium indicated that high-purity, contamination-free thorium can be produced by melting consumable electrodes into a water-cooled copper crucible.[19]

The AEC announced that the Oak Ridge National Laboratory would reprocess chemically the spent thorium-uranium fuel elements from the Consolidated Edison thorium reactor, the Elk River reactor, and the Borax-IV, Boiling Reactor Experiment No. 4, until the time when such processing services became available from private sources.

---

[17] Meyer, L. H., Electrolytic Reduction of Thorium Oxide: Jour. Electrochem. Soc., vol. 107, No. 1, January 1960, pp. 43–47.

[18] Beach, J. G., and Schaer, G. R., Electroplating on Thorium: Jour. Electrochem. Soc., vol. 106, No. 5, May 1959, pp. 392–393.

[19] Roberson, A. H., Thorium Arc Melting: Progress in Nuclear Energy, ser. V, vol. 2 (Metallurgy and Fuels), Pergamon Press, New York, N.Y., 1959, pp. 56–62.

Tin

By J. W. Pennington [1] and John B. Umhau [2]

❖

CONSUMPTION of tin in the United States increased 7 percent despite 4 months of interrupted operations at most tinplate mills during the steel strike. Domestic imports of tin, reversing a 6-year downward trend, rose 6 percent, and tinplate receipts were the highest since 1910. The average price of Straits tin in the United States exceeded that of 1958 by 7 percent and was the highest since 1952.

World production of tin increased 5 percent but was exceeded by world consumption which rose 11 percent. As a result of increased demand, export restrictions imposed on participating tin-producing countries were relaxed under the International Tin Agreement.

TABLE 1.—Salient tin statistics

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Production:						
From domestic mines, long tons	108.30	99.24	----------	----------	----------	50
From domestic smelters [1] do	30,549	22,329	17,631	1,564	(2)	(2)
From secondary sources do	29,003	28,340	29,440	24,260	22,810	23,410
Imports for consumption:						
Metal do	66,361	64,815	62,590	56,158	41,149	43,493
Ore (tin content) do	28,037	20,112	16,688	94	5,440	10,773
Exports (domestic and foreign) do	743	1,107	890	1,531	1,341	1,371
Consumption:						
Primary do	56,357	59,828	60,470	54,429	47,998	45,833
Secondary do	31,560	30,655	29,854	28,078	24,587	31,540
Monthly price of Straits tin at New York:						
Highest cents per pound	138.30	110.00	113.75	103.00	99.625	104.875
Lowest do	88.525	85.75	92.88	87.13	86.50	98.00
Average do	106.38	94.73	101.26	96.17	95.09	102.012
World:						
Mine production long tons	[3] 183,000	197,200	199,300	200,100	[3] 153,000	161,400
Smelter production do	[3] 186,900	198,200	199,100	195,100	[3] 158,300	154,100

[1] Includes tin content of alloys made directly from ores.
[2] Figure withheld to avoid disclosing individual company confidential data.
[3] Revised figure.

LEGISLATION AND GOVERNMENT PROGRAMS

The Export Control Act of 1949, extended to June 30, 1960, governed shipments of tin by destinations. Exports were under general license to the free world. Regulations administered by the Office of Export Supply, U.S. Department of Commerce, required a license for exports of detinned tinplate and terneplate scrap and detinned cans.

---

[1] Assistant chief, Branch of Base Metals.
[2] Commodity-industry analyst.

However, exports of terneplate and tinplate scrap and old tin cans were exempted from licensing.

The foreign assets control regulations of the U.S. Treasury Department prohibited the entry of Chinese tin. Tin of U.S.S.R. origin could enter the United States but required a permit (none was issued) on the presumption that it might be of Chinese origin. Entrance of alloys that might include Chinese and/or Soviet tin also was prohibited.

Under the Office of Minerals Exploration (OME), successor to Defense Minerals Exploration Administration (DMEA), loans up to 50 percent of total allowable costs were available for exploration of eligible domestic tin deposits. According to an OME release,[3] of the five tin-exploration contracts executed under DMEA, which involved $534,831 (Government participation $481,348), certificates of discovery were issued on three contracts totaling $498,831, and two contracts were terminated or cancelled without certification.

Tin continued on the Department of Agriculture, Commodity Credit Corp., list of materials eligible for acquisition for the Government supplemental stockpile through agricultural surplus barter or exchange transactions. At the end of 1959, 5,564 tons of tin was on order from barter transactions.

To promote domestic mine production of tin, legislation (S. 1957) was introduced to authorize a Federal purchase program for tin. Purchases were to be limited to 10,000 long tons of tin in concentrate during a 10-year period, with base prices of $1.40 a pound for tin in concentrate from lode mines and $1.25 a pound for tin in concentrate from placer deposits. Purchase would include tin concentrate produced in the United States and possessions and the Commonwealth of Puerto Rico.

DOMESTIC PRODUCTION

MINE PRODUCTION

Domestic mines produced only 50 long tons of tin, recovered as a byproduct of molybdenum in Colorado.

Reports were published on tin deposits in the Cape Mountain District,[4] in the Ear Mountain Area,[5] and in the Brooks Mountain and York areas,[6] Seward Peninsula, Alaska.

SMELTER PRODUCTION

Tin smelting was continued on a small scale by Wah Chang Corp., Texas City, Tex. Tin production by this firm began at Texas City on April 23, 1958. As in 1958, the production-payment provision of the contract of sale was administered by the Federal Facilities Corp. (FFC), General Services Administration. Under this program

---

[3] Office of Mineral Exploration, Minerals Exploration Program Under Authority of the Defense Production Act: October 1959, 14 pp.

[4] Mulligan, John J., and Thorne, Robert L., Tin-Placer Sampling Methods and Results, Cape Mountain District, Seward Peninsula, Alaska: Bureau of Mines Inf. Circ. 7878, 1959, 69 pp.

[5] Mulligan, John J., Tin Placer and Lode Investigations, Ear Mountain Area, Seward Peninsula, Alaska: Bureau of Mines Rept. of Investigations 5493, 1959, 53 pp.

[6] Mulligan, John J., Sampling Stream Gravels for Tin, Near York, Seward Peninsula, Alaska: Bureau of Mines, Rept. of Investigations 5520, 1959, 25 pp.

in fiscal 1959, FFC received $123,551 (mortgages repaid, $55,000; interest on mortgages, $46,000; and smelter production, $21,951).[7] The notes bear interest at 4 percent a year, with curtailment by annual installments over a 10-year period. The purchaser was obliged to pay $5 per short ton on smelter production in excess of 2,000 short tons. Payment of $21,951 was made on about 4,400 tons of tin produced during the year ending April 22, 1959. In order that Wah Chang Corp. might fulfill commitments to smelt 8,000 tons of tin concentrate for the Indonesian Government during the year ending May 1, 1960, the modified sales contract was extended for an additional year beginning April 23, 1959.

SECONDARY TIN[8]

Secondary tin production continued virtually unchanged at 23,000 long tons. Almost 80 percent was recovered from seven scrap items—tinplate, composition or red brass, solder, lead-base drosses, bronze, railroad-car boxes, and auto radiators. About one-half of the secondary tin was recovered in bronze and brass, which totaled 1,360 long tons more than in 1958. Tin reclaimed in solder, second in rank, dropped 6 percent, and tin in type metal, fell 24 percent. Recovery of tin from scrap in babbitt increased 16 percent, whereas that recovered as metal dropped 6 percent below 1958. Tin in old scrap was the smallest recorded.

The quantity of tinplate scrap treated increased for the seventh consecutive year to the record level of 703,000 tons. Lower recovery per ton of scrap (for the 13th consecutive year) continued to reflect treatment of a larger proportion of electrolytic tinplate carrying a thinner coating of tin.

TABLE 2.—Secondary tin recovered in the United States, in long tons

Year	Tin recovered at detinning plants			Tin recovered from all sources			
	As metal	In chemicals	Total	As metal	In alloys and chemicals	Total	
						Long tons	Value
1950–54 (average)	2,880	456	3,336	3,111	25,892	29,003	$69,391,675
1955	2,580	620	3,200	2,970	25,370	28,340	60,140,288
1956	2,700	690	3,390	3,260	26,180	29,440	66,776,900
1957	2,840	500	3,340	3,540	20,720	24,260	52,266,470
1958	2,820	490	3,310	[1] 3,410	[1] 19,400	22,810	48,571,100
1959	2,710	670	3,380	3,220	20,190	23,410	53,487,000

[1] Revised figure.

---

[7] Budget of the United States Government for the Fiscal Year Ending June 30, 1961, p. 262.

[8] The assistance of Archie J. McDermid and Edith E. den Hartog is acknowledged.

TABLE 3.—Tin recovered from scrap processed in the United States, by kind of scrap and form of recovery, in long tons

Kind of scrap	1958	1959	Form of recovery	1958	1959
New scrap:			As metal:		
Tinplate	3,290	[1] 3,380	At detinning plants	3,010	2,910
Tin-base	1,105	1,665	At other plants	[2] 400	310
Lead-base	2,805	2,635			
Copper-base	2,030	2,265	Total	3,410	3,220
Total	9,230	9,945	In solder	4,520	4,260
			In tin babbitt	230	180
Old scrap:			In chemical compounds	[2] 650	855
Tin cans	20	(1)	In lead-base alloys	3,600	3,135
Tin-base	970	730	In brass and bronze	10,400	11,760
Lead-base	5,200	3,885			
Copper-base	7,390	8,850	Total	19,400	20,190
Total	13,580	13,465	Grand total	22,810	23,410
Grand total	22,810	23,410			

[1] Figures for tinplate scrap include old tin-coated containers to avoid disclosing individual company confidential data.

[2] Revised figure.

TABLE 4.—Secondary tin recovered from scrap processed at detinning plants in the United States

	1958	1959
Tinplate scrap treated [1] .... long tons	662,921	702,875
Tin recovered in the form of:		
Metal .... do	2,820	2,710
Compounds (tin content) .... do	490	670
Total [2] .... do	3,310	3,380
Weight of tin compounds produced .... do	945	1,270
Average quantity of tin recovered per long ton of tinplate scrap used .... pounds	11.18	10.77
Average delivered cost of tinplate scrap .... per long ton	$29.55	$33.12

[1] Tinplate clippings and old tin-coated containers have been combined to avoid disclosing individual company confidential data.

[2] Recovery from tinplate scrap treated only. In addition, detinners recovered 296 long tons (290 tons in 1958) of tin as metal and in compounds from tin-base scrap and residues in 1959.

TABLE 5.—Tin recovered from gross weight of purchased scrap consumed in the United States in 1958, in long tons

Type of scrap and class of consumer	Gross weight of scrap						Tin recovered		
	Stocks, beginning of year	Receipts	Consumption			Stocks, end of year	New	Old	Total
			New	Old	Total				
COPPER-BASE SCRAP									
Secondary smelters:									
Auto radiators (unsweated)	2, 696	38, 461	--------	36, 358	36, 358	4, 799	--------	1, 563	1, 563
Brass, composition or red	3, 797	73, 562	26, 536	45, 735	72, 271	5, 088	1, 134	1, 721	2, 855
Brass, low (silicon bronze)	234	2, 496	1, 766	517	2, 283	447	--------	2	2
Brass, yellow	4, 933	53, 210	7, 334	44, 703	52, 037	6, 106	14	397	411
Bronze	1, 718	22, 661	6, 853	15, 341	22, 194	2, 185	534	1, 215	1, 749
Low-grade scrap and residues	6, 495	40, 876	19, 910	22, 200	42, 110	5, 261	17	--------	17
Nickel silver	530	2, 622	405	2, 233	2, 638	514	3	19	22
Railroad-car boxes	79	669	--------	592	592	156	--------	28	28
Total	20, 482	234, 557	62, 804	167, 679	230, 483	24, 556	1, 702	4, 945	6, 647
Brass mills: [1]									
Brass, low (silicon bronze)	2, 464	16, 909	16, 853	56	16, 909	2, 052	1	--------	1
Brass, yellow	19, 676	138, 820	137, 772	1, 048	138, 820	14, 466	75	--------	75
Bronze	918	1, 689	1, 638	51	1, 689	907	79	3	82
Mixed alloy scrap	3, 338	5, 025	5, 025	--------	5, 025	8, 806	4	--------	4
Nickel silver	1, 892	5, 596	5, 554	42	5, 596	2, 153	--------	--------	--------
Total	28, 288	168, 039	166, 842	1, 197	168, 039	28, 384	159	3	162
Foundries and other plants: [2]									
Auto radiators (unsweated)	120	5, 476	--------	5, 322	5, 322	274	--------	239	239
Brass, composition or red	1, 837	5, 478	2, 335	3, 677	6, 012	1, 547	110	174	284
Brass, low (silicon bronze)	155	1, 237	19	1, 246	1, 265	185	--------	--------	--------
Brass, yellow	2, 294	11. 534	5, 059	6, 752	11, 811	1, 904	5	54	59
Bronze	1, 526	1, 891	634	1, 268	1, 902	1, 183	54	98	152
Low-grade scrap and residues	1, 498	4, 153	726	4, 440	5, 166	517	--------	--------	--------
Nickel silver	51	85	3	79	82	51	--------	1	1
Railroad-car boxes	3, 527	39, 831	--------	39, 493	39, 493	3, 850	--------	1, 876	1, 876
Total	11, 008	69, 685	8, 776	62, 277	71, 053	9, 511	169	2, 442	2, 611
Total tin from copper-base scrap	--------	--------	--------	--------	--------	--------	2, 030	7, 390	9, 420
LEAD-BASE SCRAP									
Smelters, refiners, and others:									
Babbitt	1, 637	12, 372	--------	12, 711	12, 711	1, 298	--------	616	616
Battery lead plates	15, 633	285, 837	--------	272, 196	272, 196	29, 274	--------	571	571
Drosses and residues [3]	20, 301	62, 741	69, 171	--------	69, 171	13, 871	2, 668	--------	2, 668
Solder and tinny lead	330	10, 678	506	10, 129	10, 635	373	137	2, 748	2, 885
Type metals	1, 394	22, 144	--------	22, 194	22, 194	1, 344	--------	1, 265	1, 265
Total	39, 295	393, 772	69, 677	317, 230	386, 907	46, 160	2, 805	5, 200	8, 005
TIN-BASE SCRAP									
Smelters, refiners, and others:									
Babbitt	128	488	--------	570	570	46	--------	476	476
Block-tin pipe	31	442	--------	454	454	19	--------	450	450
Drosses and residues	406	1, 932	1, 758	--------	1, 758	580	1, 105	--------	1, 105
Pewter	22	50	--------	51	51	21	--------	44	44
Total	587	2, 912	1, 758	1, 075	2, 833	666	1, 105	970	2, 075
TINPLATE SCRAP									
Detinning plants	--------	--------	659, 924	2, 997	662, 921	--------	3, 290	20	3, 310
Total tin recovered	--------	--------	--------	--------	--------	--------	9, 230	13, 580	22, 810

---

[1] Lines in brass mill and total sections do not balance, as stocks include home scrap and purchased scrap assumed to equal receipts.

[2] Omits "machine shop scrap" consumption totaling 22,840 long tons gross weight, mostly brass and bronze in 1958.

[3] Includes composition foil.

TABLE 5.—Tin recovered from gross weight of purchased scrap consumed in the United States in 1959 in long tons—Continued

Type of scrap and class of consumer	Gross weight of scrap						Tin recovered		
	Stocks, beginning of year	Receipts	Consumption			Stocks, end of year	New	Old	Total
			New	Old	Total				
COPPER-BASE SCRAP									
Secondary smelters:									
Auto radiators (unsweated)	4,799	39,371	--------	39,749	39,749	4,421	--------	1,709	1,709
Brass, composition or red	5,088	84,800	29,629	55,470	85,099	4,789	1,266	2,085	3,351
Brass, low (silicon bronze)	446	1,834	1,391	598	1,989	291	--------	1	1
Brass, yellow	6,106	56,814	7,369	50,015	57,384	5,536	21	452	473
Bronze	2,185	27,471	7,808	19,847	27,655	2,001	613	1,572	2,185
Low-grade scrap and residues	5,261	29,704	20,536	9,857	30,393	4,572	20	--------	20
Nickel silver	514	2,827	470	2,260	2,730	611	4	19	23
Railroad-car boxes	155	773	--------	825	825	103	--------	39	39
Total	24,554	243,594	67,203	178,621	245,824	22,324	1,924	5,877	7,801
Brass mills: [1]									
Brass, low (silicon bronze)	2,052	22,762	22,762	--------	22,762	2,888	--------	--------	--------
Brass, yellow	14,466	184,036	184,036	--------	184,036	14,573	5	--------	5
Bronze	907	2,130	2,130	--------	2,130	601	104	--------	104
Mixed alloy scrap	8,806	5,607	5,607	--------	5,607	10,245	5	--------	5
Nickel silver	2,153	6,944	6,944	--------	6,944	2,888	--------	--------	--------
Total	28,384	221,479	221,479	--------	221,479	31,195	114	--------	114
Foundries and other plants: [2]									
Auto radiators (unsweated)	273	6,293	--------	6,287	6,287	278	--------	283	283
Brass, composition or red	1,547	5,379	2,452	3,224	5,676	1,495	113	153	266
Brass, low (silicon bronze)	185	832	30	808	838	212	--------	--------	--------
Brass, yellow	1,905	11,011	4,373	6,446	10,819	8,860	4	55	59
Bronze	273	6,293	--------	6,288	6,288	278	82	117	199
Low-grade scrap and residues	517	9,130	4,014	4,058	8,072	1,610	28	--------	28
Nickel silver	51	90	1	96	97	27	--------	1	1
Railroad-car boxes	3,850	48,149	--------	49,777	49,777	2,255	--------	2,364	2,364
Total	8,601	87,177	10,870	76,984	87,854	15,015	227	2,973	3,200
Total tin from copper-base scrap	--------	--------	--------	--------	--------	--------	2,265	8,850	11,115
LEAD-BASE SCRAP									
Smelters, refiners, and others:									
Babbitt	1,298	13,539	--------	13,729	13,729	1,109	--------	666	666
Battery lead plates	29,254	319,569	--------	323,244	323,244	25,579	--------	339	339
Drosses and residues	13,848	69,180	67,963	--------	67,963	15,065	2,620	--------	2,620
Solder	408	10,074	79	9,867	9,946	536	15	[3] 1,816	1,831
Type metals	1,344	22,020	--------	22,399	22,399	964	--------	1,064	1,064
Total	46,152	434,382	68,042	369,239	437,281	43,253	2,635	3,885	6,520
TIN-BASE SCRAP									
Smelters, refiners, and others:									
Babbitt	47	369	--------	345	345	71	--------	287	287
Block-tin pipe	17	408	1	408	409	16	1	404	405
Drosses and residues	584	2,565	2,653	--------	2,653	496	1,664	--------	1,664
Pewter	21	53	--------	46	46	28	--------	39	39
Total	669	3,395	2,654	799	3,453	611	1,665	730	2,395
TINPLATE SCRAP									
Detinning plants	--------	--------	702,875	--------	702,875	--------	3,380	--------	3,380
Total tin recovered	--------	--------	--------	--------	--------	--------	9,945	13,465	23,410

---

[1] Lines in brass mills and total sections do not balance, as stocks include home scrap and purchased scrap assumed to equal receipts.

[2] Omits "machine shop scrap."

[3] Includes composition foil.

CONSUMPTION

Total tin consumption in the United States increased 7 percent. Three items—tinplate, solder, and bronze and brass—consumed more than 80 percent of the tin used. Consumption of tin in tinplate (the leading use of primary tin, which took 55 percent of 1959 total) dropped 13 percent from 1958. The decline resulted from interrupted operations at most of the tinplate mills during a strike in the steel industry from July 15 to November 9.

Of the total output of tinplate, electrolytic represented 91 percent (90 percent in 1958) and hot-dipped 9 percent (10 percent in 1958). Hot-dipped-tinplate production was the smallest since 1902.

The United States required about 42 percent (48 percent in 1958) of world consumption of tin for tinplate. Nearly 90 percent of the tinplate was used for making cans, of which 60 percent was for the food pack and 40 percent for nonfood products. The tonnage of tinplate shipments to can makers was 4 percent less than 1958. Can shipments, however, rose 4 percent to the highest recorded. Ranking second in tonnage among products packed in 1959, beer cans made the largest gain, increasing for the eighth consecutive year to an alltime record.

TABLE 6.—Consumption of primary and secondary tin in the United States, in long tons

	1950–54 (average)	1955	1956	1957	1958	1959
Stocks on hand Jan. 1 [1]	24,974	23,326	27,757	28,446	32,030	30,003
Net receipts during year:						
Primary	57,518	64,544	62,099	59,215	46,553	51,269
Secondary	2,783	2,191	2,185	2,868	2,524	2,471
Terne	608					
Scrap	30,217	30,262	28,999	26,758	23,680	30,814
Total receipts	91,126	96,997	93,283	88,841	72,757	84,554
Available	116,100	120,323	121,040	117,287	104,787	114,557
Stocks on hand Dec. 31 [1]	24,715	27,757	28,446	32,030	30,003	35,521
Total processed during year	91,385	92,566	92,594	85,257	74,784	79,036
Intercompany transactions in scrap	2,403	2,083	2,270	2,750	2,199	1,663
Tin consumed in manufactured products	[2] 88,982	90,483	90,324	82,507	72,585	77,373
Primary	56,357	59,828	60,470	54,429	47,998	45,833
Secondary	31,560	30,655	29,854	28,078	24,587	31,540

[1] Stocks shown exclude tin in transit or in other warehouses on Jan. 1, as follows: 1955, 1,340 tons; 1956, 2,005 tons; 1957, 1,815 tons; 1958, 1,310 tons; 1959, 1,940 tons; and 1960, 1,900 tons.

[2] Includes tin losses in manufacturing.

TABLE 7.—Tin content of tinplate produced in the United States

Year	Total tinplate (all forms)			Tinplate (hot-dipped)			Tinplate (electrolytic)			Tinplate waste-waste, strips, cobbles, etc.		
	Gross weight (short tons)	Tin content (long tons)[1]	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 (long tons)	Tin per short ton of plate (pounds)	Gross weight (short tons)	Tin content [2] (long tons)	Tin per short ton of plate [2] (pounds)
1950-54 (average)	4,738,467	31,514	14.9	1,485,081	17,078	25.7	3,019,369	13,089	9.7	234,017	1,347	------
1955	5,422,444	33,549	13.9	1,062,850	13,395	28.2	4,002,068	20,154	11.3	357,526	------	------
1956	5,689,061	34,761	13.7	1,006,196	13,041	29.0	4,305,774	21,720	11.3	377,091	------	------
1957	5,715,384	32,046	12.6	686,616	8,370	27.3	4,593,587	23,676	11.6	435,181	------	------
1958	5,367,098	29,136	12.2	476,697	5,793	27.2	4,489,275	23,343	11.7	401,126	------	------
1959	4,768,040	25,275	11.9	396,739	4,685	26.5	3,997,171	20,590	11.5	374,130	------	------

[1] Includes small tonnage of secondary pig tin and tin acquired in chemicals.
[2] After June 1954, not separately reported but included in above figure on tinplate.

TABLE 8.—Consumption of tin in the United States, by finished products, in long tons of contained tin

Product	1958			1959		
	Primary	Secondary [1]	Total	Primary	Secondary [1]	Total
Alloys (miscellaneous)	263	99	362	309	138	447
Babbitt	1,993	1,519	3,512	2,157	1,981	4,138
Bar tin	855	226	1,081	1,174	243	1,417
Bronze and brass	3,135	11,104	14,239	3,868	13,241	17,109
Chemicals including tin oxide	546	816	1,362	790	1,043	1,833
Collapsible tubes and foil	751	84	835	930	113	1,043
Pipe and tubing	108	20	128	79	40	119
Solder	7,412	8,912	16,324	7,046	12,986	20,032
Terne metal	138	281	419	58	242	300
Tinning	1,890	36	1,926	2,057	74	2,131
Tinplate [2]	29,136	------------	29,136	25,275	----------	25,275
Type metal	91	1,252	1,343	129	1,263	1,392
White metal	1,552	139	1,691	1,764	142	1,906
Other	128	99	227	197	34	231
Total	47,998	24,587	72,585	45,833	31,540	77,373

[1] Includes 2,300 long tons of tin contained in imported 94/6 tin-base alloys in 1958 and 3,045 in 1959; also tin content of alloys imported in 1959 under the category of "Babbitt metal and solder."
[2] Includes small tonnage of secondary pig tin and tin acquired in chemicals.

TABLE 9.—Consumer receipts of primary tin, by brands, in long tons

Year	Banka	English	Katanga	Longhorn	Straits	Others	Total
1950-54 (average)	2,917	4,276	3,955	8,210	34,239	3,921	57,518
1955	3,268	3,873	6,744	30	47,844	2,785	64,544
1956	7,190	3,373	6,341	----------	43,468	1,727	62,099
1957	6,897	3,726	3,154	----------	41,460	3,978	59,215
1958	8,785	4,779	2,143	----------	25,999	4,847	46,553
1959	8,369	10,537	595	----------	24,496	7,272	51,269

STOCKS

Tinplate mills, holding nearly 75 percent of plant stocks of pig tin in the United States, increased inventories 2,820 long tons. At the end of the year, pig-tin stocks at other industrial plants increased 1,825 tons.

On December 31, 1959, the Commodity Credit Corp. inventory contained 1,900 tons of tin, and General Service Administration reported 3,933 tons of tin in the Federal Facilities inventory. In addition, the national stockpile contained inventories of tin which may not be disclosed.

TABLE 10.—Industry tin stocks in the United States, in long tons

	1950-54 (average)	1955	1956	1957	1958	1959
At plants:						
Pig tin—virgin	13,656	16,205	16,290	20,126	18,173	22,830
In process [1]	11,059	11,552	12,156	11,904	11,830	12,691
Total	24,715	27,757	28,446	32,030	30,003	35,521
Other pig tin:						
In transit in United States	886	2,005	1,815	1,310	1,940	1,900
Jobbers-Importers	492	260	620	660	1,050	1,945
Afloat to United States	3,519	5,340	5,500	1,735	1,660	1,855
Total	4,897	7,605	7,935	3,705	4,650	5,700
Grand total industry	29,612	35,362	36,381	35,735	34,653	41,221

[1] Includes secondary pig tin (long tons) as follows: 1950–54 (average), 296; 1955, 246; 1956, 304; 1957, 327; 1958, 281; and 1959, 270.

PRICES

The tin market in 1959 was comparatively steady, mainly reflecting activity of the International Tin Council and operations of the manager of the buffer stock. The range in price was the smallest since 1934 (excepting the periods of Government-price stabilization during World War II).

On the London market the cash price averaged £785.4 per long ton in 1959 against £734.9 in 1958. After the 1958 high of £765 on November 10, 1958, the price receded to the low of £744.5 on January 2. From this point the market had a steady and continuing rising trend until November 10 when the price reached £799, the high for 1959. The price eased downward during the remainder of the year. Prices of 3 months and of cash tin averaged virtually the same in 1959.

On the Singapore market the price of Straits tin ex-works was £781.6 for 1959 (£724.7 for 1958). The lowest quotation was £749.3 on January 3 and the highest, £804.8, on February 27.

TABLE 11.—Monthly prices of Straits tin for prompt delivery in New York, in cents per pound [1]

Month	1958			1959		
	High	Low	Average	High	Low	Average
January	93.750	90.625	92.68	100.625	98.000	99.351
February	95.250	92.750	93.75	104.875	100.875	102.708
March	95.875	93.000	94.33	104.375	101.875	103.030
April	94.250	92.500	92.98	102.875	102.125	102.500
May	95.250	94.000	94.49	104.000	102.500	103.044
June	95.000	94.250	94.62	104.750	103.250	104.153
July	96.500	93.875	94.89	103.000	101.625	102.310
August	95.750	94.000	94.94	103.000	101.500	102.327
September	95.625	86.500	94.01	102.875	101.875	102.429
October	97.750	95.000	96.47	103.375	101.500	102.202
November	99.625	97.625	98.96	101.625	100.000	100.958
December	99.125	98.250	98.97	99.750	98.500	99.131
Total	99.625	86.500	95.09	104.875	98.000	102.012

[1] Compiled from quotations published in the American Metal Market.

FOREIGN TRADE [9]

The principal tin items in the foreign trade of the United States in 1959 were imports of metallic tin, high tin alloys, and tin concentrate and exports of tinplate and tin cans. Of less importance was the trade in tin scrap, including tin-alloy scrap, tinplate scrap, tinplate circles, cobbles, strip, and scroll. Significant quantities of tin ingot, miscellaneous tin manufactures, and tin compounds were exported. Tin contained in babbitt, solder, type metal, and bronze imported and exported is shown in the Lead and Copper chapters.

TABLE 12.—Foreign trade of the United States in tin concentrate and tin

[Bureau of the Census]

Year	Imports				Exports			
	Concentrate (tin content)		Bars, blocks, pigs, grain or granulated		Ingots, pigs, bars, etc.			
					Domestic		Foreign	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)
1950–54 (average)	28,037	$63,870	66,361	$150,450	250	$541	493	$1,289
1955	20,112	[1] 36,773	64,815	131,606	254	504	853	1,748
1956	16,688	32,317	62,590	136,412	439	821	451	1,018
1957	94	118	56,158	120,739	1,112	1,526	419	919
1958	5,440	11,244	41,149	84,624	917	1,336	424	899
1959	10,773	23,282	43,493	96,666	943	1,890	428	970

[1] Data known to be not comparable to other years.

---

[9] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 13.—Tin concentrate (tin content) imported for consumption in the United States, by countries

[Bureau of the Census]

Country	1958		1959	
	Long tons	Value	Long tons	Value
Argentina	1	$623	(1)	$137
Bolivia	81	147,942	106	145,871
Canada	14	21,500	---	---
Indonesia	5,105	10,675,775	7,946	17,994,804
Japan	(1)	312	---	---
Malaya, Federation of	---	---	6	11,839
Mexico	45	15,750	100	164,908
Thailand	194	382,410	2,615	4,964,847
Total	5,440	11,244,312	10,773	23,282,406

[1] Less than 1 ton.

TABLE 14.—Tin[1] imported for consumption in the United States, by countries

[Bureau of the Census]

Country	1958		1959	
	Long tons	Value (thousands)	Long tons	Value (thousands)
Belgian Congo	564	$1,075	850	$1,684
Belgium-Luxembourg	3,005	6,269	705	1,571
Bolivia	148	285	325	711
Canada	---	---	(2)	(3)
Germany, West	43	88	40	87
Indonesia	---	---	200	438
Malaya and Singapore	23,325	47,652	22,404	50,181
Netherlands	7,292	15,279	2,820	6,198
Portugal	482	1,003	456	967
United Kingdom	6,290	12,973	15,693	34,829
Total	41,149	84,624	43,493	96,666

[1] Bars, blocks, pigs, grain, or granulated.
[2] Less than 1 ton.
[3] Less than $1,000.

TABLE 15.—Foreign trade of the United States in tinplate, taggers tin, and terneplate in various forms, in long tons

[Bureau of the Census]

Year	Tinplate, taggers tin, and terneplate		Tinplate circles, strips, cobbles, etc. (exports)	Terneplate clippings and scrap (exports)	Tinplate scrap	
	Imports	Exports			Imports	Exports
1950–54 (average)	1,401	[1] 536,562	10,639	58	40,684	2,216
1955	40	747,682	14,798	---	28,721	144
1956	586	648,517	21,858	10	29,137	3,377
1957	40	625,666	19,531	---	31,431	3,628
1958	51	331,813	15,728	(2)	32,824	(2)
1959	59,811	328,888	15,082	(2)	37,151	(2)

[1] Owing to changes in classifications, data for 1950–51 not strictly comparable.
[2] Beginning Jan. 1, 1958, not separately classified.

TABLE 16.—Foreign trade of the United States in miscellaneous tin, tin manufactures, and tin compounds

[Bureau of the Census]

Year	Miscellaneous tin and manufactures						Tin compounds	
	Imports			Exports			Imports (long tons)	Exports (long tons)
	Tinfoil, tin powder, flitters, metallics, tin and tinplate manufactures, n.s.p.f. (value) (thousands)	Dross, skimmings, scrap, residues, and tin alloys, n.s.p.f.		Tin cans, finished or unfinished		Tin scrap and other tin-bearing material, except tinplate scrap (value) (thousands)		
		Long tons	Value (thousands)	Long tons	Value (thousands)			
1950-54 (average)	[1] $484	5,027	$8,550	31,492	$13,056	[2] $2,224	17	77
1955	[1] 559	6,117	[1] 10,383	26,490	11,517	2,441	5	139
1956	[1] 605	5,073	[1] 9,430	30,502	13,245	2,324	10	167
1957	[1] 561	5,077	9,485	30,166	14,309	3,911	10	218
1958	610	3,208	5,771	35,849	18,322	992	11	(3)
1959	1,008	3,434	6,658	36,320	19,027	1,231	6	(3)

[1] Data known to be not comparable with other years.
[2] Owing to changes in classifications, data for 1950-51 not strictly comparable to later years.
[3] Beginning Jan. 1, 1958, not separately classified.

WORLD REVIEW

INTERNATIONAL TIN AGREEMENT

Tin control continued in 1959 under the International Tin Agreement. Progress was made in achieving stability in world prices and providing an adequate supply of tin. Export restrictions were gradually relaxed. Authority was extended to March 31, 1960, for the buffer-stock manager to operate on the market in the middle range at £780–£830 (97.50–103.75 cents a pound). The U.S.S.R. agreed to an annual tonnage limit on tin exports through 1960, and consumer-participants withdrew the emergency restrictions on tin imports from the U.S.S.R.

To meet increased demand for tin new supply was augmented by a substantial quantity from the buffer-stock manager. On February 27, 1959, announcement was made that tin acquired with the buffer-stock manager's special fund established January 28, 1958, had been entirely liquidated. Additional tin was sold from the main buffer stock and the strategic stockpile of the United Kingdom. None of the 3,000 tons of Canadian noncommercial-tin stocks was turned over to the buffer-stock manager for sale in 1959. Producer-participants shipped tin under agricultural surplus product barter transactions with the United States. The main buffer stock dropped from 23,325 long tons of tin on December 31, 1958, to 10,050 tons on December 31, 1959.

As the buffer stock approached 10,000 long tons, interpretation of article VII of the agreement became an issue. Uncertainty was related to the part which stated, "That no total permissible export amount shall become effective unless: (a) at least 10,000 tons of tin metal is held in the buffer stock."

The International Tin Council met four times. An understanding on U.S.S.R. tin exports was reached between the Head of the Trade Delegation of the U.S.S.R. in the United Kingdom and the Chairman of the International Tin Council. According to a press communique issued by the Council on January 26, Soviet Foreign Trade Organizations intend to consider 13,500 tons as the annual limit of Soviet tin exports. As a result, the United Kingdom, Netherlands, Denmark, and other consumer-participants under the International Tin Agreement removed the import restrictions imposed on U.S.S.R. tin in August 1958.

On June 26, the British Board of Trade, London, announced that sale would begin July 1, 1959, of 2,500 long tons of British stockpile tin no longer required for strategic purposes and that there was to be a further tonnage (2,417) for disposal later to complete that Government's liquidation of its strategic stockpile of tin. The tin was to be sold through the International Tin Council's buffer-stock manager.

On September 4, a committee began meetings to consider a working draft of a new tin agreement to supersede the current one which expires June 30, 1961. This draft was to be printed by mid-January 1960, preliminary to forwarding for discussion at a United Nations conference in New York, May 23, 1960.

At the 20th meeting, December 1–4, approval was given to a ninth control period (January–March 1960). The total permissible export amount was raised to 36,000 tons, or 93 percent of the total average export rate of the six producing countries during 1950–52.

Of the 10,000 tons of tin programed for U.S. Government acquisition by agricultural surplus barter transactions, up to December 31, 1959, a total of 7,850 tons exempt from export restrictions had been moved from the Belgian Congo and Ruanda-Urundi (700 tons), Bolivia (5,292 tons), and Thailand (1,858 tons). Up to December 31, 1959, the Council had approved barter arrangements for 9,234 long tons of tin—Bolivia, 6,000 tons; Thailand, 2,250 tons; and Belgian Congo and Ruanda-Urundi, 984 tons.

TABLE 17.—International Tin Agreement export control

Producing country	Percent allotted			
	(1)	(2)	(3)	(4)
Belgian Congo and Ruanda-Urundi	8.72	8.95	8.92	9.05
Bolivia	21.50	20.43	19.92	19.40
Indonesia	21.50	20.43	19.41	18.90
Malaya	36.61	37.50	37.50	37.75
Nigeria	5.38	5.34	5.90	6.10
Thailand	6.29	7.35	8.35	8.80
Total	100.00	100.00	100.00	100.00

Producing country	Export amount (by control periods), long tons							
	Dec. 15, 1957–Dec. 31, 1958				Jan. 1, 1959–Dec. 31, 1959			
	First [5]	Second [6]	Third [7]	Fourth [8]	Fifth [9]	Sixth [10]	Seventh [4]	Eighth [11]
Belgian Congo and Ruanda-Urundi	2,416	2,058	2,052	1,784	1,784	2,052	2,262	2,715
Bolivia	5,516	4,699	4,582	3,984	3,984	4,582	4,850	5,820
Indonesia	5,516	4,699	4,464	3,882	3,882	4,464	4,725	5,670
Malaya	10,125	8,625	8,625	7,500	7,500	8,624	9,438	11,325
Nigeria	1,442	1,228	1,357	1,180	1,180	1,357	1,525	1,830
Thailand	1,985	1,691	1,920	1,670	1,670	1,921	2,200	2,640
Total	27,000	23,000	23,000	20,000	20,000	23,000	25,000	30,000

[1] Established in text of 1953 International Tin Agreement, Geneva, Nov. 16–Dec. 9, 1953.
[2] Established at 6th meeting Oct. 23, 1957.
[3] July 1–Sept. 30, 1958. Fixed at 11th meeting April 29–May 1, 1958.
[4] Fixed at 18th meeting May 26–29, 1959. July 1–Sept. 30, 1959.
[5] Dec. 15, 1957–Mar. 31, 1958. Fixed at 8th meeting Dec. 4–5, 1957; and 9th, Jan. 22–24, 1958.
[6] April 1–June 30, 1958. Fixed at 9th meeting Jan. 22–24, 1958.
[7] July 1–Sept. 30, 1958. Fixed at 11th meeting April 29–May 1, 1958.
[8] Oct. 1–Dec. 31, 1958. Fixed at 13th meeting July 22–24, 1958.
[9] Jan. 1–Mar. 31, 1959. Fixed at 15th meeting Nov. 5–6, 1958.
[10] April 1–June 30, 1959. Fixed at 17th meeting Feb. 17–19, 1959.
[11] Oct. 1–Dec. 31, 1959. Fixed at 19th meeting Sept. 1–3, 1959.

TABLE 18.—International Tin Agreement exports in control periods[1] in long tons

Producing country	1957–58				1959			
	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth
Belgian Congo and Ruanda-Urundi	2,435	2,065	2,036	1,737	1,789	2,059	2,257	2,668
Bolivia	5,296	5,109	4,386	3,917	4,165	4,527	4,783	5,046
Indonesia	5,392	4,804	4,580	3,786	3,853	4,496	4,666	5,706
Malaya	10,704	7,999	8,555	7,609	7,458	8,535	9,449	11,421
Nigeria	1,455	1,245	1,337	1,147	1,182	1,359	1,524	1,833
Thailand	2,188	1,613	1,825	1,735	1,626	1,919	2,231	2,446
Total exports	27,470	22,835	22,719	19,931	20,073	22,895	24,910	29,120
Total permitted	27,000	23,000	23,000	20,000	20,000	23,000	25,000	30,000

[1] Figures represent exports reported in accordance with definitions as to point of export in the International Tin Agreement and are therefore different from standard trade statistics.

TABLE 19.—International Tin Agreement voting power of producing countries

Country	Vote [1]	Vote [2]	Vote [3]	Vote [4]
Belgian Congo and Ruanda-Urundi	90	92	92	93
Bolivia	213	203	198	193
Indonesia	213	203	193	188
Malaya	360	369	369	371
Nigeria	58	57	62	64
Thailand	66	76	86	91
Total	1,000	1,000	1,000	1,000

[1] Established in text of 1953 International Tin Agreement, Geneva, Nov. 16–Dec. 9, 1953.
[2] Established at 6th meeting Oct. 23, 1957, for period October 1957–June 1958.
[3] Reallocated, 12th meeting, June 17–18, for period July 1958–June 1959.
[4] International Tin Council, 1959 Statistical Yearbook, p. 9, for July 1959–June 1960.

TABLE 20.—International Tin Agreement voting power of consuming countries

Country	At 8th meeting, [1] 1957–58	At 12th meeting, [2] 1958–59	At 18th meeting, [3] 1959–60	Country	At 8th meeting, [1] 1957–58	At 12th meeting, [2] 1958–59	At 18th meeting, [3] 1959–60
Australia	29	29	32	Israel	7	7	7
Austria	13	13	13	Italy	58	57	58
Belgium	38	40	40	Korea [2]	----------	7	6
Canada	71	66	60	Netherlands	53	51	51
Denmark	86	83	73	Spain	13	12	11
Ecuador	(4)	(4)	(4)	Turkey	17	15	13
France	168	164	174	United Kingdom	372	388	401
India	75	68	61	Total	1,000	1,000	1,000

[1] December 4–5, 1957.
[2] June 17–20, 1958.
[3] May 26–29, 1959.
[4] Withdrew, November, 1957.

TABLE 21.—World mine production of tin (content of ore), by countries, in long tons [1]

[Compiled by Augusta W. Jann and Berenice B. Mitchell]

Country	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada	208	220	338	317	355	400
Mexico	409	605	500	473	544	376
United States	108	99	----------	----------	----------	50
Total	725	924	838	790	899	826
South America:						
Argentina	203	89	85	182	205	[2] 207
Bolivia (exports)	31,991	27,921	26,843	27,796	17,730	23,811
Brazil	196	146	175	293	[2] 400	[2] 400
Total	32,390	28,156	27,103	28,271	18,335	24,418
Europe:						
Czechoslovakia [3]	200	200	200	200	200	200
France	295	450	433	445	----------	----------
Germany, East	415	669	[2] 660	[2] 670	[2] 720	[2] 720
Portugal	1,254	1,445	1,169	1,127	1,249	991
Spain	922	822	550	491	467	[2] 485
U.S.S.R. [4] [5]	8,900	10,300	11,800	13,000	13,500	15,000
United Kingdom	935	1,034	1,044	1,028	1,087	1,252
Total [2] [5]	12,900	14,900	15,900	17,000	17,000	19,000
Asia:						
Burma	1,282	1,130	1,050	931	1,000	900
China [4]	8,000	18,000	20,000	23,000	23,000	26,000
Indonesia	33,555	33,368	30,053	27,723	23,201	21,616
Japan	568	896	926	949	1,108	993
Laos	134	253	254	274	301	294
Malaya, Federation of	57,697	61,244	62,295	59,293	38,458	37,525
Thailand	9,849	11,023	12,481	13,531	7,728	9,527
Total [2] [5]	111,100	125,900	127,100	125,700	94,800	96,900
Africa:						
Belgian Congo [6]	14,261	15,028	14,764	14,253	11,214	10,319
Cameroon, Republic of	79	85	85	71	75	68
Congo, Republic of	----------	----------	----------	----------	23	[2] 13
Morocco: Southern Zone	8	14	5	8	6	9
Niger, Republic of	80	47	56	50	61	57
Nigeria	8,252	8,158	9,067	9,534	6,200	5,541
Rhodesia and Nyasaland, Federation of	41	208	354	283	534	665
South-West Africa	181	357	475	636	161	5
Swaziland	35	27	29	25	15	5
Tanganyika (exports)	57	41	15	14	19	65
Uganda (exports)	118	68	33	40	41	36
Union of South Africa	1,003	1,283	1,442	1,463	1,416	1,272
Total	24,115	25,316	26,300	26,377	19,765	18,055
Oceania: Australia	1,730	2,017	2,078	1,952	2,237	2,163
World total (estimate)	183,000	197,200	199,300	200,100	153,000	161,400

---

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[2] Estimated by authors of the chapter and in a few instances from the Statistical Bulletin of the International Tin Council, London, England.

[3] Estimate, according to the 46th annual issue of Metal Statistics (Metallgesellschaft) through 1958.

[4] Estimated smelter production.

[5] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.

[6] Including Ruanda-Urundi.

TABLE 22.—World smelter production of tin, by countries, in long tons[1]

[Compiled by Augusta W. Jann and Berenice B. Mitchell]

Country	1950-54 (average)	1955	1956	1957	1958	1959
North America:						
Mexico	246	357	218	207	[2] 371	[2] 240
United States	30,549	22,329	17,631	1,564	[3] 5,440	[3] 10,773
Total	30,795	22,686	17,849	1,771	5,811	11,013
South America:						
Argentina	167	99	61	39	----------	----------
Bolivia (exports)	212	107	421	266	705	955
Brazil	554	1,184	1,544	1,401	629	[2] 600
Total	933	1,390	2,026	1,706	1,334	1,555
Europe:						
Belgium	9,775	10,432	9,716	9,869	8,723	5,945
Germany:						
East	430	605	[2] 600	[2] 600	[2] 600	[2] 600
West	524	280	683	955	646	1,010
Netherlands	25,062	26,566	28,197	29,259	17,098	9,592
Portugal	399	1,018	1,127	1,072	1,259	1,147
Spain	806	608	576	783	449	[2] 353
U.S.S.R.[2] [4]	8,900	10,300	11,800	13,000	13,500	15,000
United Kingdom	28,401	27,241	26,434	34,174	32,551	27,229
Total [2] [4]	74,300	77,100	79,100	89,700	74,800	60,900
Asia:						
China [2]	8,000	18,000	20,000	23,000	23,000	26,000
Indonesia	568	1,572	300	322	[2] 600	[2] 600
Japan	644	1,030	1,105	1,261	1,307	1,379
Malaya, Federation of	66,213	70,632	73,263	71,289	45,336	45,729
Total [2] [4]	75,400	91,200	94,700	95,900	70,200	73,700
Africa:						
Belgian Congo	2,838	3,034	2,772	3,105	2,642	3,291
Morocco: Southern Zone	5	8	[2] 12	[2] 12	[2] 12	[2] 12
Rhodesia and Nyasaland, Federation of	45	22	12	253	503	631
Union of South Africa	817	779	756	825	900	726
Total	3,705	3,843	3,552	4,195	4,057	4,660
Oceania: Australia	1,736	2,004	1,850	1,806	2,121	2,287
World total (estimate)	186,900	198,200	199,100	195,100	158,300	154,100

---

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[2] Estimated by authors of the chapter and in a few instances from the Statistical Bulletin of the International Tin Council, London, England.

[3] Imports in the United States of tin concentrates (tin content).

[4] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.

REVIEW BY COUNTRIES

Australia.—Tableland Tin Dredging, N.L., North Queensland, the leading tin producer, recovered 706 tons (629 in 1958) of tin concentrate. Ravenshoe Tin Dredging, Ltd., which commenced dredging in August 1957, produced 500 tons of concentrate in 1959 (400 in 1958).

Tin consumption was 3,585 long tons, against 3,190 tons in 1958; tinplate required 1,200 tons in 1959 and 1,050 tons in 1958. In the second full year of operation the Port Kembla mill produced 80,230 long tons of tinplate (68,000 in 1958), and the output of 8,000 tons in December approached capacity level. Tinplate production supplied 60 percent of domestic requirements. Most of the remainder was acquired from the United Kingdom. About 100 tons of secondary tin was recovered from tinplate scrap by A. G. Sims & Co. at plants in Sydney and Melbourne.

Belgian Congo.—Tin smelter output in Belgian Congo was the highest since 1948. Exports of tin-in-concentrate and metal were mostly to Belgium. The flow of Belgium smelter production shifted from the United States to France. In 1959, 700 tons of tin, exempt from export restrictions, was exported to the United States in exchange for surplus wheat. Permissible exports under the International Tin Agreement for 1959 were 8,813 long tons, whereas actual exports were 8,773 (reported for purposes of control at a point inland where delivery was made to a carrier near the mines).

Stocks of tin-in-concentrate at the mines and smelter increased from 2,920 long tons at the beginning to 3,850 tons at the end of 1959. During the same period stocks of tin metal at the smelter increased from 840 tons to 1,170 tons.

Bolivia.—Exports of tin-in-concentrate and ore totaled 23,810 tons valued at $52.8 million, an increase of 46 percent in value compared with 1958. Despite the gain the quantity was the smallest since 1934 except for 1958. Tin represented 77 percent of the gross value of Bolivian minerals exported in 1959. The International Tin Council approved arrangements for Bolivian barter exports of 6,000 tons of tin, not to be counted as exports for purposes of control. Through December 5,292 tons of barter tin had moved from Bolivia. This was scheduled to be shipped as concentrate to the United Kingdom for smelting and then as metal to the United States.

Stocks of tin-in-concentrate at South American ports and inland dropped from 4,870 long tons at the beginning to 1,528 tons at the end of 1959.

TABLE 23.—Tin production in Bolivia by nationalized mines, in long tons of contained tin

Mine	1957 [1]	1958 [1]	1959 [1]	Mine	1957 [1]	1958 [1]	1959 [1]
Caracoles	561	417	580	Ocuri	--------	--------	--------
Catavi	7,620	6,702	5,194	Oploca-Santa Ana	351	67	9
Chorolque	640	312	466	San Jose	1,352	1,023	813
Colavi	172	81	96	Santa Fe	712	548	628
Colquechaca	67	11	7	Tasna	748	321	312
Colquiri	4,083	3,447	3,509	Unificada	1,602	1,086	882
Huanuni	2,874	2,638	2,563	Viloco	174	139	186
Japo	110	85	90	Others	3	3	12
Monserrat	--------	--------	------				
Morococala	238	230	209	Total	21,307	17,110	15,556

[1] U.S. Embassy, La Paz, Bolivia, from data furnished by Corporacion Minera de Bolivia.

TABLE 24.—Tin exports from Bolivia by groups, in long tons of contained tin

[Departmento de Estadistica, Ministeno de Mines y Petroleo]

Group	1953	1954	1955	1956	1957	1958	1959
Corporation Minera de Bolivia [1]	30,108	24,776	23,417	22,478	22,032	13,852	17,590
Banco Minero:							
Medium mines	1,782	1,686	1,957	3,914	5,435	3,173	5,410
Small mines	2,761	2,166	2,440				
Smelter (tin metal)	174	196	107	449	329	705	811
Total	34,825	28,824	27,921	26,841	27,796	17,730	23,811

[1] Decree of Oct. 31, 1952, nationalized the major producers of tin, namely, Patino Mines & Enterprises Inc., Compagnie Aramayo de Mines en Bolivie, and Maurico Hochschild, S.A.M.I., included in this group.

TABLE 25.—Tin exports from Bolivia by destinations, in long tons of contained tin

[Departmento de Estadistica, Ministeno de Mines y Petroleo]

Destination	1957	1958	1959
Argentina	15	533	414
Brazil	254	----------	162
Chile	----------	----------	----------
Germany, West	1,034	602	1,126
Japan	----------	----------	4
Mexico	----------	----------	186
Netherlands	456	81	50
Peru	----------	----------	9
Switzerland	----------	----------	35
United Kingdom	25,035	15,874	15,804
United States	1,002	640	6,021
Total	27,796	17,730	23,811

Indonesia.—Tin output was the lowest since 1947. The islands of Banka, Billiton, and Singkep furnished 67, 28, and 5 percent, respectively, of the total.

Tin exports totaled 18,712 tons in 1959. Tin-in-concentrate exported was 18,427 tons; 473 tons went to the Netherlands; 8,215 to the United States; and 9,739 were shipped "London option," which trade channels indicated actually moved to the Netherlands for processing or for transshipment. (Imports of 213 tons of tin-in-concentrate by Brazil in 1959, with country of origin shown as the Netherlands, probably were Indonesian material shipped via the Netherlands). The remaining 285 tons was tin metal exported to Japan.

Tin-in-concentrate on hand was 5,886 long tons at the beginning and 7,170 at the end of 1959. Stocks of tin metal increased from 254 tons at the beginning to 1,116 tons at the end of 1959.

Malaya, Federation of.—Of the total mine production of 37,500 tons, 60 percent came from European mines (mostly dredges) and 40 percent from Asian mines (mostly by gravel pumps), including 2 percent from dulang washing. European mines produced 22,645 long tons (23,330 in 1958), and Asian 14,880 tons (15,130 in 1958). By methods of mining, the largest declines in tin production were 1,030 tons by dredging, 220 tons by dulang washing, and 120 by gravel pumps.

Gains over 1958 were shown for hydraulicking, underground mining (mainly European) and small workings (mainly Asian). The federal revenues received M$35.5 million in export duty on tin compared with M$29.6 million in 1958.

Active mines totaled 417 at the beginning compared with 483 at the end of 1959; dredges increased from 34 to 45; and gravel-pump units rose from 333 to 392. The labor force was 23,778 on December 31, 1959, against 23,153 on December 31, 1958.

Permitted exports of tin under the International Tin Agreement were 36,890 tons during 1959. The quantity allowed was about half the domestic "annual assessment" established at 72,700 tons. Tin-in-concentrate delivered to smelters was 36,863 tons (34,866 tons in 1958). Quota distribution was European 59 percent and Asian 41 percent (including dulang washing). Buffer stock contributions on 2.5 million piculs of tin concentrate collected during several periods beginning October 15, 1956, and terminating August 29, 1959, amounted to a net of M$55.4 million.

The principal world source of tin continued to be the large plants of the Eastern Smelting Co., Ltd., on the island of Penang and the Straits Trading Co., Ltd., at Pulau Brani, Singapore, and Butterworth, Province Wellesley. Concentrate treated was derived mostly from the Federation of Malaya and Thailand. Total tin-in-concentrate available for the Federation smelters was 45,570 tons (40,023 in 1958). Total tin-in-concentrate received by the Singapore smelter dropped to only 906 tons (6,774 tons in 1958). Total smelter production was 45,730 tons (45,340 in 1958). Exports of tin metal dropped in 1959 to the lowest since 1948. Of the total tonnage shipped, Penang accounted for 99 percent (84 percent in 1958) and Singapore 1 percent (16 percent in 1958).

Stocks of tin metal increased from 2,324 long tons at the beginning to 3,288 tons at the end of 1959. Tin-in-concentrate (including mine stocks) increased from 9,171 tons at the beginning to 11,851 at the end—the highest recorded.

TABLE 26.—Tin-metal exports from Malaya in long tons[1]

Destination	1958	1959	Destination	1958	1959
Argentina	773	899	Netherlands	707	231
Australia-New Zealand	1,466	1,530	Union of South Africa	671	134
Canada	842	1,020	United Kingdom	3,579	102
France	1,768	382	United States	19,686	22,845
India	4,427	3,617	Other countries	2,585	2,719
Italy	2,305	2,628			
Japan	7,004	8,566	Total	45,813	44,673

[1] Federation of Malaya, Department of Statistics, Monthly Statistical Bulletin: January 1960, p. 54.

TABLE 27.—Imports of tin-in-concentrate into Malaya, in long tons

Country of origin	1958	1959	Country of origin	1958	1959
Burma	1,306	1,365	Other countries	26	167
Laos and Viet-Nam	455	386			
Thailand	6,440	6,614	Total	8,227	8,532

Nigeria.—Nigeria produced 7,488 long tons of tin concentrate (8,423 in 1958) averaging 74 percent tin. The entire tin-in-concentrate exports, totaling 5,583 tons (5,627 in 1958), went to the United Kingdom. Stocks of tin-in-concentrate at mines dropped from 1,437 tons at the beginning to 1,076 tons at the end of 1959. Columbium was produced as a byproduct or coproduct of tin mining in Nigeria.

In the year ending March 31, 1959, Nigeria's largest tin producer—Amalgamated Tin Mines of Nigeria, Ltd.—reported treating 7.6 million cubic yards compared with 13.1 million in the preceding year. The value of the ground worked increased from 0.67 pound to 0.775 pound of cassiterite per yard.

The output (in long tons) was obtained by the following methods.

	Cassiterite	*Columbite*
Draglines with washing plants	772	82
Jig plants	528	184
Gravel pumps	484	21
Contractors	841	72
Mill tailing	2	---
	2,627	359

Rhodesia and Nyasaland, Federation of.—Tin production in Southern Rhodesia was the highest recorded. The principal producer was the Kamativi Tin Mines Ltd. (N. V. Billiton Maatschappij), near Dett, Bulawayo District. After successful testwork, the use of ammonium nitrate-fuel oil mixture as an explosive was reported as standard practice in opencast mining. About 18,000 tons was blasted on a single operation, and it was hoped that blasts will be increased to 30,000 tons during 1960. Mill production was smelted at the mine to produce refined tin, solder, and white metal by the Kamativi Smelting and Refining Co., Ltd., which also treated tin concentrate purchased from the smaller producers. A significant part of the refined tin output went to the Union of South Africa and the remainder for local industrial requirements.

Thailand.—Tin was the most important mineral resource of Thailand and ranked third as a major export, being exceeded in value only by rice and rubber. Tin-in-concentrate passed by the Customs Department of Thailand for payment of royalty was 8,222 tons in 1959. Shipments to the United States included 1,858 tons under surplus agricultural product barter transactions in exchange for tobacco. At the end of 1959, stocks of tin-in-concentrate in Thailand totaled 1,130 long tons (913 tons at mines and 217 tons in transit), whereas at the beginning of the year the quantity was 1,655 tons (1,317 tons at mines and 338 tons in transit).

TABLE 28.—Exports of tin-in-concentrate from Thailand, in long tons

Destination	1958	1959
Brazil	----------	1,062
Germany, West	7	9
Japan	22	43
Malaya	5,022	6,809
Mexico	----------	14
Netherlands	----------	10
United States	261	1,947
Other countries	7	----------
Total	5,319	9,894

United Kingdom.—Mine production of 1,250 long tons of tin was derived principally from 650 tons of black tin (65 percent) produced by Geevor Tin Mines, Ltd., and 885 tons (70 percent) by South Crofty, Ltd.

The United Kingdom ranked second as a world smelter of tin ore, as a consumer of pig tin, and as a producer of tinplate. Most of the tin concentrate treated was from Bolivia and Nigeria. Primary tin consumption was 21,000 long tons (20,000 in 1958), of which nearly half was for making tinplate. Tinplate production gained for the seventh consecutive year and totaled 1.07 million long tons, 7 percent more than 1958 (1,000,387 long tons) and the largest on record. Of the 1959 output, 63 percent was electrolytic and 37 percent hot-dipped. About 47 percent of the tinplate or 468,100 long tons was exported in 1959. Sharp decreases in shipments to Africa and Australia-New Zealand were more than offset by gains in exports to Europe, South America, United States, and unspecified destinations. The United States took 26,260 long tons, more than for any year in several decades, representing the largest increase in exports to any country in 1959.

Imports of tin metal, mainly from the U.S.S.R., dropped to 730 long tons (13,200 in 1958). The restrictions imposed on August 30, 1958, on tin imports from U.S.S.R. were withdrawn on January 26, 1959. Tin metal exports totaling 32,700 long tons (10,400 tons in 1958) were the highest since 1929, a little over half going to the United States in 1959.

Pig-tin stocks, the bulk under control of the buffer-stock manager, totaled 11,530 long tons at the end (19,050 at the beginning) of 1959. No tin metal was afloat to the United Kingdom at the end of 1959. Stocks of tin-in-concentrate were 2,300 tons at the beginning compared with 2,940 at the end of 1959. Yearend stocks of tin-in-concentrate afloat were 1,465 tons (1,885 at the beginning of 1959). British stockpile tin, 4,917 long tons, no longer needed for strategic purposes was released for sale through the International Tin Council's buffer-stock manager.

U.S.S.R.—The importance of tin from U.S.S.R. in world trade moderated. An understanding was reached between U.S.S.R. and the International Tin Council whereby U.S.S.R. would consider 13,500 tons as the annual limit of U.S.S.R. tin exports. Sales by U.S.S.R. were from either reexported Chinese tin (some of which was further refined) or exports of U.S.S.R. tin made possible by imports from China. U.S.S.R. imports from China were 19,000 long tons in 1958 and 16,000 (estimated) in 1959.

TABLE 29.—Tin metal shipments from Sino-Soviet Bloc, in long tons[1]

Source and destination	1958	1959
From U.S.S.R. to:		
Finland	268	----------
France	915	158
Germany, West	1,983	3,946
Iceland	----------	7
India	----------	344
Japan	473	315
Netherlands	7,434	6,320
Switzerland	466	67
United Arab Republic	410	----------
Uruguay	32	----------
United Kingdom	6,522	455
Total	18,503	11,612
From China to:		
Canada	----------	54
Finland	20	45
France	145	100
Germany, West	264	2,148
Hong Kong	1,136	90
India	312	200
Japan	110	----------
Netherlands	497	786
From China to—Continued		
Sweden	----------	67
Switzerland	92	250
United Arab Republic	266	----------
United Kingdom	560	21
Total	3,402	3,761
From Poland to:		
Austria	----------	20
France	127	----------
Germany, West	397	145
Netherlands	416	329
Sweden	----------	50
United Arab Republic	90	----------
United Kingdom	235	94
Total	1,265	638
From Hungary to:		
Netherlands	25	50
Grand total	23,195	16,061

[1] Statistical Bulletin of the International Tin Council.

TECHNOLOGY

The Federal Bureau of Mines published reports[10] describing studies on the volatilization of tin chloride and the codeposition of tin-nickel plate.

Cassiterite-bearing pegmatites, north of Brandberg, South-West Africa, were studied and described.[11] Although some of the mineralized dikes have been mined for cassiterite, the related eluvial and alluvial deposits, which are marginal, have yielded more cassiterite. It was concluded that the prospects were too low grade to be a source of tin in the forseeable future.

Mining of smaller alluvial tin deposits of Malaya is by the hydraulic method using vertically suspended, direct-driven gravel pumps to elevate the ore to a palong.[12] Advantages of the vertical gravel pumps are high output and low operating and maintenance cost. The usual ore pulp averages from 10 to 15 percent solids and is pumped a vertical height of 50 to 100 feet. Most of the pumps are manufactured in Malaya and use 150-, 200-, or 250-hp. electric motors.

It was reported that about 250 pounds of a 40-percent tin product was recovered from approximately 32,000 dry tons of tailing each day in the new byproduct plant of the Climax Molybdenum Co. which used a combination of spiral, flotation, table, and magnetic separation to recover tungsten, tin, and pyrite from the molybdenum flotation tailings.[13]

---

[10] Kershner, K. K., and Cochran, A. A., Volatilization of Tin Chloride From Bolivian Slimes: Bureau of Mines Rept. of Investigations 5459, 1959, 12 pp.
Campbell, T. T., and Abel, R., Codeposition of Tin-Nickel Plate From Organic and Mixed Aqueous-Organic Solvents: Bureau of Mines Rept. of Investigations 5482, 1959, 11 pp.

[11] Dennis, John G., Note on Some Cassiterite-Bearing Pegmatites Near Brandberg, South-West Africa: Econ. Geol., vol. 54, No. 6, September–October 1959, pp. 1115–1121.

[12] Walter, Leo, Vertical Gravel Pumps Do the Job: Rock Products, vol. 62, No. 6, June 1959, pp. 119, 122.

[13] Burk, Snell G., New Plant Recovers Tungsten, Tin, and Pyrite From Moly Flotation Tailing: Min. World, vol. 21, No. 12, November 1959, pp. 38–43.

It was announced that an aluminum-tin alloy bearing metal may reduce one of railroad's largest maintenance problems—hot-box damage.[14] In laboratory tests, aluminum-tin bearings proved superior to other materials, and it was planned to test the new alloy under operating conditions. Advantages over other bearing materials include ability to run cooler, resistance to corrosion without protective coatings, longer life, and, in many cases, lower costs.

Because of the successful use of low-tin-aluminum alloys for bearings instead of conventional materials, such as lead- and tin-based Babbitt metals and bronze, a new alloy containing 6.5 percent tin, 2.5 percent silicon, 1 percent copper, and the remainder aluminum was developed for solid bearing—those that do not require a backing material to give strength.[15] The desirable properties of the alloy—a high thermal conductivity, adaptability to normal misalinement, and ability to embed particles easily—make it suitable for heavy duty machinery such as rolling mills.

Internal and external corrosion of tin cans and methods for their control were listed and described.[16] Can corrosion may be caused by various factors such as contamination by the product, improper processing, or packaging, handling, and storage. Corrosive action of the product may be controlled through proper selection of material and may be modified by inhibitors, oxygen scavengers, products preparation, method of packaging, and handling and storage of the canned product.

Although several solders are satisfactory for joining copper and aluminum, one of the least expensive is a tin-zinc alloy.[17] This solder is resistant to corrosion and galvanic action, keeps a bright finish, and has a tensile strength of 8,000 p.s.i.

A comprehensive summary of research on tin and tin products, including detailed references, was published in an annual review.[18] Studies and results on such items as tinplate, cans, and packaging, hot tinning, solders and soldering practices, electrodeposition, bearings, bronze, tin chemicals, and basic research and alloy development were described.

Research by the Tin Research Institute in 1959 included studies on hot-tinning, tinplate, electrochemistry and corrosion, electroplating, tin in steel and cast iron, cobalt-tin, nickel-tin, and titanium-tin alloys, soldering fluxes, and miscellaneous tin compounds.[19]

---

[14] Light Metal Age, Aluminum Journal Bearings: Vol. 17, Nos. 7 and 8, August 1959, p. 22.

[15] Metallurgia (England), Aluminum-Tin Alloys for Bearings: Vol. 60, No. 362, December 1959, p. 267.

[16] Daly, J. J., Jr., Can Corrosion Problems: Corrosion, vol. 15, No. 11, November 1959, pp. 100–102, 104, 106.

[17] Iron Age, Low-Cost Solder Joins Al to Cu: Vol. 183, No. 11, Mar. 12, 1959, p. 131.

[18] MacIntosh, Robert M., Materials of Construction, Tin and Its Alloys: Ind. Eng. Chem., Chem. Eng. Revs., vol. 51, No. 9, pt. 2, September 1959, pp. 1223–1227.

[19] International Tin Research Council, Annual Report 1959: Tin Res. Inst., Greenford, England, 36 pp.

Titanium

By John W. Stamper[1]

◆

CONSUMPTION of ilmenite reached a new peak in 1959. Production of titanium pigments, which traditionally has used over 95 percent of the entire output of ilmenite concentrate, also was at a record high—23 percent above 1958. Increased production of welding rods coated with rutile accounted for a 9-percent rise in consumption of rutile, despite a drop in demand for rutile for making titanium metal.

Production and consumption of titanium ingot and output of mill products averaged about 15 percent higher than in 1958. Larger output of titanium ingot, despite slightly smaller consumption of sponge metal, reflected the industry's increasing ability to use more titanium scrap in melting operations. Cessation of government purchases of titanium sponge metal contributed to the decline in production of sponge.

World output of 1.9 million tons of ilmenite was the second highest on record. Increased production of rutile in the United States and the Union of South Africa accounted for the increase in world output of rutile, although production decreased in Australia, the principal source.

New titanium dioxide-producing facilities in the United States and foreign countries were completed, and additional expansion programs were announced to meet rising domestic and foreign demand for titanium pigments.

On October 2, 1959, the Office of Civil and Defense Mobilization removed titanium sponge metal from the List of Strategic and Critical Materials for Stockpiling.

DOMESTIC PRODUCTION

Concentrates.—Production of 635,000 tons of ilmenite was 13 percent above the 1958 output. The oversupply of rutile, which started early in 1956, continued in 1959. Nevertheless, both mine production and domestic shipments of rutile increased significantly over 1958.

Output of ilmenite was reported by the following companies: American Cyanamid Co., Piney River, Va.; E. I. du Pont de Nemours & Co., Starke and Lawtey, Fla.; Metal and Thermit Corp., Beaver Dam, Va.; National Lead Co., Tahawus, N.Y.; Titanium Alloy Manufacturing Division of National Lead Co., Skinner, Fla.; and The Florida Minerals Co., Wabasso, Fla. A small quantity of ilmenite, which accumulated during monazite dredging and processing operations from 1951 to 1955, was shipped from stockpiles at Boise, Idaho.

---

[1] Commodity specialist.

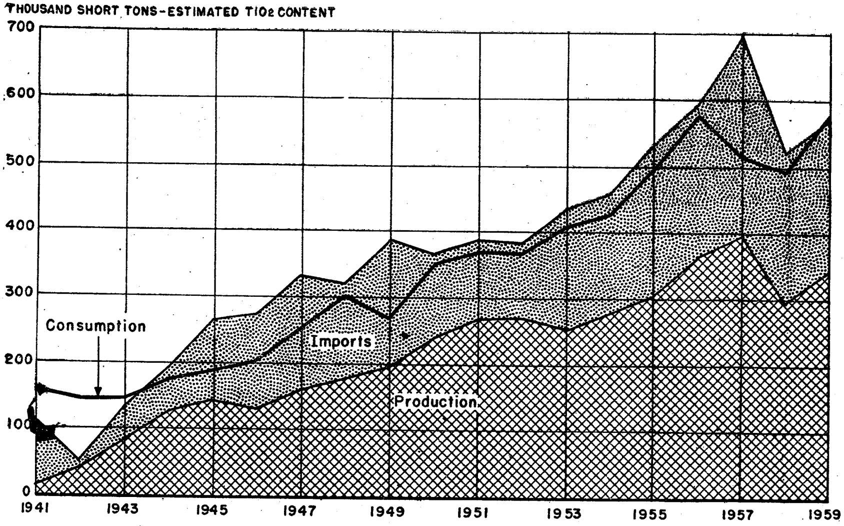

FIGURE 1.—Domestic production, imports, and consumption of ilmenite (includes titanium slag and a mixed product), 1941–59, in short tons.

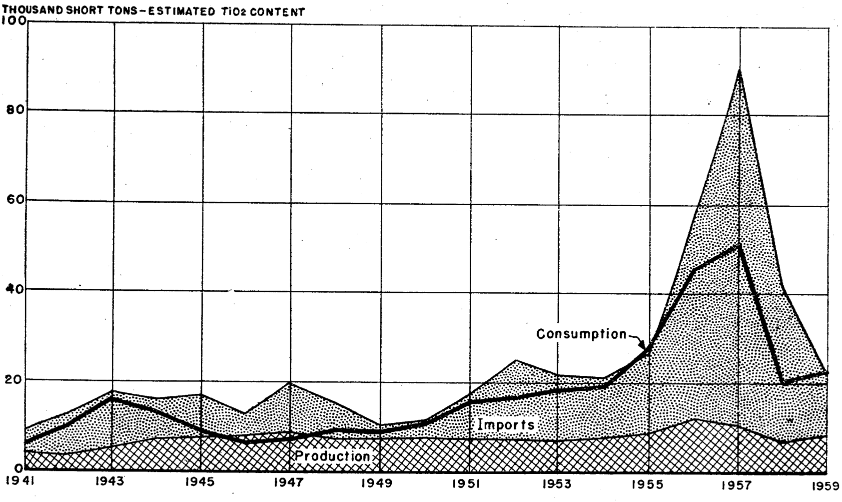

FIGURE 2.—Domestic production, imports, and consumption of rutile, 1941–59, in short tons.

Rutile producers were as follows: Metal and Thermit Corp., Beaver Dam, Va.; Titanium Alloy Manufacturing Division of National Lead Co., Skinner, Fla.; and The Florida Minerals Co., Wabasso, Fla.

Metal.—Production of titanium sponge metal was 3,900 tons compared with 4,600 tons in 1958. Activity in all segments of the titanium industry declined 50 to 75 percent in the third quarter of 1959 during the steel strike.

TABLE 1.—Salient titanium statistics

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Ilmenite concentrate: [1]						
Mine shipments____short tons__	505, 959	573, 192	735, 388	782, 975	565, 164	637, 263
Value____________(thousands)__	$7, 183	$10, 268	$14, 199	$21, 802	$11, 155	$12, 106
Imports [2]___________short tons__	230, 240	353, 351	359, 281	460, 353	348, 144	371, 687
Consumption [2]___________do____	754, 683	876, 403	1, 027, 645	957, 184	849, 005	1, 061, 076
Rutile Concentrate:						
Mine shipments__________do____	7, 650	9, 182	12, 065	10, 644	1, 863	8, 648
Value____________(thousands)__	$638	$1, 122	$1, 749	$1, 544	$210	$877
Imports____________short tons__	[3] 13, 317	19, 526	48, 906	84, 837	36, 563	23, 228
Consumption____________do____	17, 620	28, 762	46, 853	53, 393	21, 677	23, 573
Sponge metal:						
Production______________do____	1, 851	7, 398	14, 595	17, 249	4, 585	3, 898
Imports for consumption_do____	[4] 77	567	2, 048	3, 532	2, 073	1, 563
Consumption____________do____	[5] 2, 500	3, 979	10, 936	8, 221	4, 147	3, 953
Price Grade A-1, Dec. 31 per pound__	$4. 90	$3. 45	$2. 75	$2. 25	$1. 82	$1. 60
World:						
Ilmenite concentrate: Production [1] [2]_____________short tons__	1, 050, 200	1, 400, 400	1, 792, 000	1, 972, 300	1, 721, 900	1, 909, 100
Rutile concentrate: Production short tons__	46, 500	75, 700	122, 200	156, 200	103, 200	105, 200
Sponge metal: Production short tons__	[5] 7, 700	10, 500	19, 100	22, 300	7, 700	7, 900

[1] Includes a mixed product containing rutile, leucoxene, and altered ilmenite.
[2] Includes titanium slag.
[3] Includes 336 tons rutile content of zirconium ore as reported to the Bureau of Mines by importers.
[4] 1952–54 only.
[5] 1954 only. Data not available for previous years.

Commercial producers of titanium sponge were as follows: Union Carbide Metals Co., Division of Union Carbide & Carbon Corp., Ashtabula, Ohio; E. I. du Pont de Nemours & Co., Newport, Del.; Mallory-Sharon Metals Corp., Ashtabula, Ohio; and Titanium Metals Corp. of America (TMCA), Henderson, Nev. E. I. du Pont de Nemours & Co., and TMCA used magnesium to reduce titanium tetrachloride to titanium metal and Mallory-Sharon Metals Corp. and Union Carbide Metals Co. used sodium.

TABLE 2.—Production and mine shipments of titanium concentrates from domestic ores in the United States, in short tons

Year	Production (gross weight)	Shipments		
		Gross weight	TiO_2 content	Value
ILMENITE [1]				
1950–54 (average)________________	518, 830	505, 959	257, 460	$7, 183, 319
1955________________	583, 044	573, 192	297, 835	10, 267, 647
1956________________	684, 956	735, 388	386, 498	14, 198, 947
1957________________	757, 180	782, 975	407, 167	21, 801, 548
1958________________	563, 338	565. 164	297, 021	11, 154, 854
1959________________	634. 886	637, 263	342, 746	12, 105, 827
RUTILE				
1950–54 (average)________________	7, 217	7, 650	7, 132	637, 812
1955________________	8, 513	9, 182	8, 617	1, 122, 000
1956________________	11, 997	12, 065	11, 348	1, 748, 883
1957________________	10, 702	10, 644	10, 025	1, 543, 540
1958________________	7, 406	1, 863	1, 804	209, 872
1959________________	9, 466	8, 648	8, 148	876, 988

[1] Includes a mixed product containing rutile, leucoxene, and altered ilmenite.

Mallory-Sharon Metals Corp. announced that it had made an agreement with Bridgeport Brass Co. whereby the metallurgical knowledge, fabricating facilities, and commercial organization, as well as management resources of Bridgeport, will be made available to Mallory-Sharon. In exchange for benefits to be derived from the new association, Bridgeport was given an option to purchase an equal interest in Mallory-Sharon with P. R. Mallory Co., Sharon Steel Co., and National Distillers and Chemical Corp.

Titanium melters were: Harvey Aluminum, Inc., Torrance, Calif.; Mallory-Sharon Metals Corp., Niles, Ohio; Oregon Metallurgical Corp., Albany, Oreg.; Crucible Steel Co., Midland, Pa.; Republic Steel Corp., Massillon and Canton, Ohio; and TMCA, Henderson, Nev.

Oregon Metallurgical Corp. produced ingots and castings. The other companies produced and processed ingots into mill products such as sheet, strip, plate, forging billets, and bars. Harvey Aluminum, Inc., produced titanium castings in addition to other mill products. The Ladish Co., Cudahy, Wis., processed ingots into forged products.

Pigments.—The decline in production of titanium dioxide pigment, which started in 1956, was reversed in 1959. Production, on a gross-weight basis, reached a record high, 23 percent above 1958. Shipments increased 10 percent over 1958.

Titanium pigments were produced by the following companies: American Cyanamid Co., Piney River, Va., and Savannah, Ga.; The Glidden Co., Baltimore, Md.; E. I. du Pont de Nemours & Co., Edge Moor, Del., Baltimore, Md., and New Johnsonville, Tenn.; National Lead Co., St. Louis, Mo., and Sayreville, N.J.; and The New Jersey Zinc Co., Gloucester City, N.J.

In mid-1959, E. I. du Pont de Nemours and Co. began producing titanium pigments at its new 45,000-ton-per-year plant at New Johnsonville, Tenn. This is the first plant designed to produce titanium dioxide by the chloride process.

The Du Pont company announced agreements with foreign firms to build titanium dioxide plants in Mexico and West Germany. It was announced late in the year that The Glidden Co. would supply the technical assistance for a new titanium dioxide plant in the Netherlands which was being planned. Information on these agreements is given under the world review section.

Welding-Rod Coatings.—A total of 233,000 tons of welding rods containing titaniferous material in their coatings was produced. This

TABLE 3.—Titanium-metal data, in short tons

	1955	1956	1957	1958	1959
Sponge metal:					
Production	7,398	14,595	17,249	4,585	3,898
Imports for consumption	567	2,048	3,532	2,073	1,563
Industry stocks	854	3,000	2,800	1,000	1,100
Government stocks (DPA inventories)	6,647	9,316	19,821	22,463	22,474
Consumption	3,979	10,936	8,221	4,147	3,953
Scrap-metal consumption	1,353	2,033	1,743	1,336	1,690
Ingot:[1]					
Production	4,573	11,688	10,009	5,408	6,017
Consumption	4,442	10,860	10,428	4,971	5,964
Mill shape production	1,898	5,166	5,658	2,594	3,211

[1] Includes alloy constituents.

quantity was 11 percent above the tonnage of welding rods similarly coated in 1958.

Of the total output of welding rods, 37 percent contained rutile only; 23 percent, ilmenite only; 12 percent, a mixture of rutile and manufactured titanium dioxide only; 13 percent, manufactured titanium dioxide only; and 15 percent, slag only.

CONSUMPTION AND USES

Concentrates.—Owing to the increased demand for ilmenite for making titanium pigments, consumption reached a record high, increasing 25 percent over 1958. Consumption of titanium slag, which also is used in pigments, increased 22 percent over 1958. Consumption of rutile increased 9 percent, chiefly because the use of rutile in coatings for welding rods increased. Of the 24,000 tons of rutile used, 25 percent was used for metal; 61 percent was used in welding-rod coatings; and the remainder went into alloys, carbides, ceramics, fiberglass, and other items.

Metal.—Consumption of 4,000 tons of titanium sponge metal was slightly lower than in 1958. Titanium melters used nearly 600 pounds of scrap metal for each ton of titanium ingot produced, marking the second straight year that the percentage of scrap used in ingot pro-

TABLE 4.—Consumption of titanium concentrates in the United States, by products, in short tons

Product	Ilmenite[1]		Titanium slag		Rutile	
	Gross weight	Estimated TiO_2 content	Gross weight	Estimated TiO_2 content	Gross weight	Estimated TiO_2 content
1950–54 (average)	688,487	356,776	[2] 66,196	[2] 46,786	17,620	16,541
1955	741,450	401,146	134,953	94,522	28,762	27,192
1956	865,211	464,009	162,434	115,148	46,853	44,453
1957	840,719	434,077	116,465	82,545	53,393	50,870
1958						
Pigments (mfg. TiO_2)[3]	726,659	376,730	116,096	81,849	----------	----------
Titanium metal	(4)	(4)	(5)	(5)	7,878	7,525
Welding-rod coatings	666	394	937	680	11,001	10,384
Alloys and carbide	4,056	2,615	(5)	(5)	612	586
Ceramics	26	16	----------	----------	379	355
Fiberglass	----------	----------	----------	----------	867	845
Miscellaneous[6]	17	10	548	408	940	884
Total	731,424	379,765	117,581	82,937	21,677	20,579
1959						
Pigments (mfg. TiO_2)[3]	913,017	473,471	142,048	100,186	----------	----------
Titanium metal	(4)	(4)	(5)	(5)	6,001	5,721
Welding-rod coatings	794	470	860	614	14,687	13,819
Alloys and carbide	3,906	2,700	(5)	(5)	592	575
Ceramics	27	17	----------	----------	421	394
Fiberglass	----------	----------	----------	----------	992	968
Miscellaneous[6]	3	2	421	306	880	827
Total	917,747	476,660	143,329	101,106	23,573	22,304

[1] Includes a mixed product containing rutile, leucoxene, and altered ilmenite used to make pigments and metal.

[2] 1952–54 only.

[3] "Pigments" include all manufactured titanium dioxide.

[4] Included in "Pigments" to prevent disclosing individual company confidential data.

[5] Included in "Miscellaneous" to prevent disclosing individual company confidential data.

[6] Includes consumption for chemicals and experimental purposes.

duction has increased. Consumption of titanium mill products, using shipments as a gage, increased nearly 24 percent to 3,200 tons.

One large semifabricator reported that manned military aircraft continued to be the major market for titanium mill products; however, 15 percent of the metal shipped by the company was earmarked for use in missiles and an equal quantity for civilian application, chiefly in aircraft.[2]

Use of titanium in missiles stems chiefly from its combination of lightness and high strength. The use of titanium instead of steel for the fourth-stage motor casing of the Juno II rocket that placed Pioneer IV in orbit around the sun reportedly permitted an additional 2 pounds of payload, an increase of 20 percent.[3] Welded titanium rings, 74 inches in diameter, 2⅞ inches thick, and weighing 70.6 pounds, have been fabricated for use in the man-carrying space capsule scheduled for launching as part of the National Aeronautics and Space Administration's Project Mercury.[4] Another important use of titanium in missiles was for gas pressure vessels.

Although aircraft and missiles remained titanium's major markets, uses were developed in other fields. Chemical, petroleum, and food processing firms began to use titanium for heat exchangers, impellers, filters, condensers, coils, pressure vessels, valves, pumps, nozzles, reactors, and other equipment. Electronic uses in tubes, rectifiers, and computers were proposed.

The recently completed nickel-cobalt extraction facilities of Freeport Nickel Co. represent the largest application of titanium in the processing industries. The leaching plant at Moa Bay, Cuba, used approximately 37,000 pounds of titanium in heat exchangers, process piping, values, and reactor internals.[5] The purification plant at Port Nickel, La., used 8,000 pounds in processing equipment. The process, design problems, and material problems associated with the plants were discussed.[6]

Pigments.—Consumption of titanium pigments, using shipments as a gage, increased 10 percent over 1958. Consumption of pigments not separately classified in table 5 included use in ceramics, roofing, siding, gems, for titanium chemicals, and plastics.

STOCKS

Stocks of rutile, which have been increasing since 1955, continued to increase and at the end of 1959 represented over 3 years' supply at the 1959 rate of consumption. Titanium-slag stocks also increased but stocks of ilmenite decreased. Yearend stocks of titanium sponge held by producers, melters, and semifabricators totaled 1,000 tons, about the same as stocks at the end of 1958, and were enough for a 3 months' supply at the 1959 consumption rate. An additional 22,474 tons was held in the revolving sponge stockpile.

---

[2] Annual Report of the Allegheny Ludlum Steel Corporation, 1959, Titanium Metals Corporation of America, p. 14.

[3] Missiles and Rockets, Titanium, Plastic Rocket Cases Gain: Vol. 5, No. 42, Oct. 12, 1959, pp. 29–30, 32–33.

[4] Materials in Design Engineering, Largest Titanium Ring Used in Space Capsule: Vol. 50, No. 6, November 1959, pp. 209–210.

[5] Crucible Titanium Review, Titanium in Chemical and Marine Applications: Vol. 7, No. 4, November 1959, p. 2.

[6] Simons, S. C., Materials Selection and Design Problems in a Nickel-Cobalt Extraction Plant: Corrosion, vol. 15, No. 4, April 1959, pp. 55–99.

TABLE 5.—Distribution of titanium-pigment shipments, by industries, percent of total

Industry	1950-54 (average)	1955	1956	1957	1958	1959
Distribution by gross weight:						
Paints, varnishes, and lacquers	70.0	65.3	65.3	64.9	65.8	64.8
Paper	7.8	10.1	10.3	10.9	11.5	11.7
Floor coverings (linoleum and felt base)	4.6	4.6	4.2	4.1	5.0	4.9
Rubber	3.0	3.4	3.4	3.6	3.9	4.2
Coated fabrics and textiles (oilcloth, shade cloth, artificial leather, etc)	1.9	2.7	2.8	3.2	2.9	3.1
Printing ink	1.1	1.3	1.3	1.4	1.5	1.7
Other	11.6	12.6	12.7	11.9	9.4	9.6
Total	100.0	100.0	100.0	100.0	100.0	100.0
Distribution by titanium dioxide content:						
Paints, varnishes, and lacquers	61.8	58.4	58.3	57.7	59.1	58.2
Paper	11.3	13.5	13.6	14.2	15.2	15.1
Floor coverings (linoleum and felt base)	5.4	5.2	4.9	5.0	6.4	6.3
Rubber	3.9	4.4	4.4	4.6	5.1	5.4
Coated fabrics and textiles (oilcloth, shade cloth, artificial leather, etc)	2.6	3.4	3.6	4.1	3.7	3.9
Printing ink	1.6	1.7	1.8	1.9	1.9	2.2
Other	13.4	13.4	13.4	12.5	8.6	8.9
Total	100.0	100.0	100.0	100.0	100.0	100.0

Titanium sponge metal scrap held by melters and semifabricators decreased from 4,100 tons at the beginning of 1959 to 3,400 tons at the end of the year.

TABLE 6.—Stocks of titanium concentrates in the United States at the end of the year, in short tons

	Ilmenite		Titanium slag		Rutile	
	Gross weight	Estimated TiO_2 content	Gross weight	Estimated TiO_2 content	Gross weight	Estimated TiO_2 content
1958[1]						
Mine	35,938	16,622			5,626	5,240
Distributors	236	140			2,449	2,332
Consumers	758,370	388,695	153,494	108,275	61,298	58,262
Total stocks	794,544	405,457	153,494	108,275	69,373	65,834
1959						
Mine	33,561	15,560			6,444	6,047
Distributors	114	68			3,524	3,367
Consumers	679,527	351,784	155,011	109,507	66,422	63,081
Total stocks	713,202	367,412	155,011	109,507	76,390	72,495

[1] Revised figures.

PRICES

Concentrates.—The price quoted for ilmenite in E&MJ Metal and Mineral Markets remained unchanged in 1959 at $23 to $26 per long ton (59.5 percent TiO_2, f.o.b. Atlantic seaboard).

Rutile prices continued to decline. The price of rutile (94 percent TiO_2 f.o.b. Atlantic seaboard) at the beginning of 1959, quoted by E&MJ Metal and Mineral Markets, was $95 to $100 per short ton, and a nominal price of $85 per short ton was quoted from July 30 until the end of the year.

Manufactured Titanium Dioxide.—The prices of rutile and anatase grades of manufactured titanium dioxide pigment and calcium-rutile base titanium pigments were unchanged. The following prices were quoted in the Oil, Paint & Drug Reporter at the end of 1959:

	Price
Anatase, chalk-resistant, regular and ceramic, carlots, delivered, per pound	$0.25½
Less than carlots, delivered, per pound	.26½
Rutile, nonchalking, bags, carlots, delivered East, per pound	.27½
Less than carlots, delivered East, per pound	.28½
Titanium pigment, calcium-rutile base, 30 percent TiO_2, bags, carlots, delivered, per pound	.09⅜
Less than carlots, delivered, per pound	.09⅞

Metal.—Prices per pound quoted for titanium sponge metal during the year were as follows:

Grade:	*January 1, 1959 through July 15, 1959*	*July 16, 1959 through July 29, 1959*	*July 31, 1959 through Dec. 31, 1959*
A-1 [1]	[2] $1.62-1.82	$1.60-1.62	$1.60
A-2 [3]	1.70	1.50	1.50

[1] Maximum iron content 0.2 percent with Brinell hardness less than 125.

[2] Low price for Brinell hardness less than 100.

[3] Maximum iron content 0.45 percent with Brinell hardness less than 170.

The price of titanium mill products also declined. Prices per pound (f.o.b. mill, commercially pure grades, in lots of 10,000 pounds) were quoted as follows:

Product:	*January 1 through May 18, 1959*	*May 19 through December 31, 1959*
Sheet	$9.10-9.60	$7.75-8.50
Strip	8.50-9.00	7.25-8.00
Plate	6.00-6.75	5.25-6.00
Wire	6.50-7.00	5.55-6.05
Forging billets	3.80-4.35	3.20-3.70
Hot-rolled bars	5.10-5.50	4.00-4.50

Ferrotitanium.—The price of all grades of ferrotitanium quoted in E&MJ Metal and Mineral Markets remained unchanged. Nominal prices quoted were as follows:

	Price
Low-carbon: [1]	
Titanium, 40 percent; carbon, 0.10 percent maximum	$1.35
Titanium, 25 percent; carbon, 0.10 percent maximum	1.50
Medium-carbon: [2]	
Titanium, 17 to 21 percent; carbon, 3 to 5 percent	$290-295
High-carbon: [2]	
Titanium, 15 to 19 percent; carbon, 6 to 8 percent	$240-245

[1] Price per pound in 1-ton lots or more, lump (½ inch, plus), packed; f.o.b. destination Northeastern United States.

[2] Price per net ton, carload lots, lump, packed; f.o.b. destination Northeastern United States.

FOREIGN TRADE [7]

Imports.—The United States imported 372,000 short tons of ilmenite concentrates, including titanium slag from Canada. This was an increase of 7 percent over 1958. A significant decrease of ilmenite from

---

[7] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

India was more than offset by increases in imports from Canada and Australia. Material from Canada was virtually all titanium slag containing about 70 percent titanium dioxide.

As in the past, imports of rutile were virtually all from Australia and declined for the third straight year.

Imports for consumption of titanium metal were 1,563 tons, of which 1,412 tons was from Japan and included titanium metal imported under Commodity Credit Corporation surplus agricultural product barter agreements with that country. About 65 tons each came from Canada and the United Kingdom, and a small quantity came from West Germany. Part of the material from Canada and the United Kingdom was classified as scrap by the Bureau of the Census.

TABLE 7.—Titanium concentrates[1] imported for consumption in the United States, by countries, in short tons

[Bureau of the Census]

Country	1950–54 (average)	1955	1956	1957	1958	1959
ILMENITE						
Australia	54	-----	197	-----	22,736	47,317
Canada[2]	58,138	166,307	196,660	217,762	112,874	157,296
India	166,606	187,044	133,520	240,279	212,479	167,074
Malaya, Federation of	11	-----	28,864	2,279	-----	-----
Other countries	5,431	-----	40	33	55	-----
Grand total	230,240	353,351	359,281	460,353	348,144	371,687
Value	[3] $3,091,398	$7,031,060	[3] $9,197,835	[3] $10,316,853	$6,766,391	$7,991,208
RUTILE						
Australia	[4] 13,317	19,526	48,845	84,743	36,507	22,954
Other countries	-----	-----	61	94	56	274
Grand total	[4] 13,317	19,526	48,906	84,837	36,563	23,228
Value	$1,096,919	$1,984,431	$7,147,827	$11,843,295	$4,512,937	$2,943,258

[1] Classified as "ore" by Bureau of the Census.
[2] Chiefly titanium slag averaging about 70 percent TiO_2.
[3] Data known to be not comparable with other years.
[4] Includes 336 tons rutile content of zirconium ore as reported to the Bureau of Mines by importers.

Exports.—Exports of 36,000 tons of titanium dioxide and pigments were about the same as in 1958. Canada, as in the past, was the destination of most of the titanium pigment exported and received 18,000 tons, the same quantity as in 1958. Other countries that received 1,000 tons or more were as follows: Philippines, 2,600; Mexico, 2,400; Netherlands, 2,200; Belgium-Luxembourg, 1,700; Italy and France, 1,600; Cuba, 1,300; and Venezuela, 1,200.

Of the 4,700 tons of titanium concentrates exported in 1959, 2,900 tons went to Belgium-Luxembourg, 1,300 tons to Canada, and 230 tons to the United Kingdom. Small quantities were shipped to the following countries: Chile, Hong Kong, Mexico, Philippines, and West Germany.

Exports of 496 tons of titanium sponge and scrap were five times those in 1958. Of the total, the United Kingdom received 294 tons; West Germany, 90 tons; and Sweden, 61 tons. The remainder went to Austria, Canada, France, Italy, Japan, Netherlands, and Switzerland. Exports of titanium-metal products also increased significantly in 1959 to 499 tons. Most of the titanum products went to Canada, which received 483 tons. Cuba received 13 tons. Other countries receiving small quantities of mill products were France, Italy, Mexico, New Zealand, and West Germany. Canada received 238 tons of the 321 tons of ferroalloys exported in 1959. Italy received 57 tons, and Chile and Sweden received 12 and 9 tons, respectively. The remainder went to Austria, Belgium-Luxembourg, and Viet-Nam.

TABLE 8.—Exports of titanium products from the United States, by classes

[Bureau of the Census]

Year	Ores and concentrates		Metal and alloys in crude form and scrap[1]		Primary forms, n.e.c.[2]		Ferroalloys		Dioxide and pigments	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1950–54 (average)	829	$85,463	(3)	(3)	(4)	(4)	206	$65,546	42,224	$13,552,487
1955	1,143	193,752	10	$36,353	35	$1,211,311	245	65,091	54,353	18,332,995
1956	1,838	312,285	14	59,992	559	8,304,835	364	148,459	64,806	25,158,181
1957	2,019	276,472	71	77,629	779	9,404,232	367	130,046	52,960	19,687,188
1958	1,246	172,481	97	172,285	336	5,227,932	323	138,431	37,016	11,346,651
1959	4,656	289,507	496	543,104	499	5,161,074	321	145,611	36,282	10,558,287

[1] Beginning Jan. 1, 1955, classified as sponge and scrap.

[2] Beginning Jan. 1, 1955, classified as intermediate mill shapes and mill products, n.e.c.

[3] Not separately classified before 1952. 1952, 762 tons ($31,134); 1953, 2 tons ($11,858); 1954, 48 tons ($1,107,582).

[4] Not separately classified before 1952. 1952, 3 tons ($38,979); 1953, 31 tons ($798,077); 1954, 171 tons ($3,587,401).

WORLD REVIEW

The titanium industry of the free world was characterized by expansion of titanium dioxide productive capacity. New titanium dioxide plants were planned or under construction in Canada, Mexico, West Germany, and the Netherlands. Expansion of existing facilities was underway in the United Kingdom. As noted under "Domestic Production," initial output from a 45,000-ton-per-year plant started in the United States.

The United States continued to be the free world's principal source of ilmenite, and Australia again produced most of the world's rutile. World output of 1.9 million tons of ilmenite was the second highest recorded. Production of rutile also increased. A new titanium mine near Umgababa on the Natal coast of the Union of South Africa which began operation in 1958 significantly increased output of ilmenite and rutile in that country during 1958 and 1959.

NORTH AMERICA

Canada.—The Quebec Iron & Titanium Corp. (QIT) ilmenite-smelting plant at Sorel, Quebec, which had been closed since October 1958, was reopened in March 1959. Seven of the plant's eight furnaces operated, and production of titanium slag nearly equaled the record output in 1957. QIT, two-thirds owned by Kennecott Copper Corp. and one-third by New Jersey Zinc Co., exported virtually all of its titanium slag to the United States for use in making titanium pigments. The company stated that opening of new slag markets on the

TABLE 9.—World production of titanium concentrates (ilmenite and rutile), by countries,[1] in short tons [2]

[Compiled by Pearl J. Thompson and Berenice B. Mitchell]

Country [1]	1950–54 (average)	1955	1956	1957	1958	1959
Ilmenite:						
Australia (sales) [3]	408	600	4,787	79,694	78,730	[4] 86,900
Brazil	------	------	------	------	5,691	[4] 5,500
Canada [5]	68,515	164,249	220,885	269,690	161,312	247,858
Egypt	1,707	2,694	4,547	[4] 3,700	[4] 3,000	[4] 3,000
Finland	[6] 29,615	93,668	113,444	116,568	117,384	94,966
Gambia	[7] [8] 1,216	------	------	15,297	31,851	14,553
India	250,302	280,867	375,861	331,768	346,080	334,000
Japan [9]	[10] 2,166	5,097	9,634	9,055	3,837	3,445
Malaya, Federation of (exports)	36,158	60,340	136,837	102,742	83,806	81,593
Mexico	------	12	------	------	166	------
Mozambique	------	------	------	------	[8] 7,751	11,400
Norway	133,618	173,981	209,990	231,693	233,585	249,453
Portugal	409	866	679	388	506	[4] 440
Senegal	6,081	25,680	22,156	39,573	36,128	32,937
Spain	1,172	7,388	5,962	9,796	18,161	[4] 20,500
Thailand	------	------	386	2,039	922	[8] 440
Union of South Africa	[6] 6	1,917	1,855	3,118	29,611	87,232
United States [11]	518,830	583,044	684,956	757,180	563,338	634,886
World total ilmenite (estimate) [1] [2]	1,050,200	1,400,400	1,792,000	1,972,300	1,721,900	1,909,100
Rutile:						
Australia	39,024	66,767	108,434	144,372	93,325	[4] 91,900
Brazil	29	174	338	270	269	------
Cameroon Republic of	106	110	168	44	------	------
India	98	166	606	530	504	429
Norway	21	10	26	22	------	------
Senegal	[12] 7	------	650	243	1,157	------
Union of South Africa	------	------	------	32	552	3,381
United States	7,217	8,513	11,997	10,702	7,406	9,466
World total rutile (estimate) [1] [2]	46,500	75,700	122,200	156,200	103,200	105,200

[1] In addition to the countries listed, titanium concentrates are produced in U.S.S.R.; no estimate is included in the total.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Owing to high chromium content in the ore, sales are shown.

[4] Estimate.

[5] Beginning 1950, represents Ti slag containing about 70 percent TiO_2 and small quantities of "titanium ore."

[6] Average for 1953–54.

[7] Average for 1 year only, as 1954 was the first year of commercial production.

[8] Exports.

[9] Represents titanium slag.

[10] Average for 1952–54.

[11] Includes a mixed product containing ilmenite, leucoxene, and rutile.

[12] Average for 1951–54.

European Continent and in Britain was of particular significance, as this area has been traditionally supplied with ilmenite from Norway, Africa, and India.[8]

TABLE 10.—Quebec Iron & Titanium Corp. smelting operations, in short tons

	1950–54 [1] (average)	1955	1956	1957	1958	1959
Ore smelted	151,489	348,578	470,745	627,255	381,732	626,310
Titanium slag produced	65,753	162,784	218,575	258,920	161,312	243,700
Estimated TiO_2	46,470	117,042	157,374	186,422	116,150	175,464
Value of slag produced	$2,023,609	$5,192,810	$6,688,416	$9,740,570	$6,575,077	$8,363,320
Titanium slag shipped	62,329	157,378	213,742	262,879	105,622	(2)
Desulfurized iron produced	49,740	121,312	159,874	187,529	117,878	163,509

[1] Production began in October 1950.

[2] Data not available.

---

[8] Kennecott Copper Corporation, Forty-Fifth Annual Report, 1959, pp. 13–14.

It was reported that British Titan Products (Canada), Ltd., had purchased a site at Sorel and was planning to start construction of a $16-million titanium pigment plant early in 1960. About 17,000 tons of titanium slag per year is to be used as raw material. British Titan (Canada) is a subsidiary of British Titan Products Co., Ltd., the largest titanium pigment producer in England.

Mexico.—Mexico's first titanium dioxide pigment plant was under construction at Tampico, Tamaulipos. The plant is to be owned and operated by Pigmentos y Productos Quimicos, S.A. de C.V., a new company, owned 49 percent by Du Pont and 51 percent by private Mexican interests.[9] Operation of the plant, which will utilize titanium slag in the sulfate process, was to start in the first half of 1960. Reported capacity is 8,000 tons of titanium dioxide a year and plant costs about $2.8 million.

EUROPE

Germany, West.—Pigment-Chemie G.m.b.H., a new company, was formed to produce titanium dioxide pigment at Hamburg by E. I. du Pont de Nemours & Co. (U.S.A.) and Sachteleben A.G. fur Bergbau und Chemische Industries (West Germany).[10] Du Pont owns 26 percent of the new company and Sachtleben 74 percent. Production was scheduled to begin late in 1961. Cost of the new plant has been reported at $8.33 million and capacity estimated at 20,000 tons a year.

An article on the operation of the titanium dioxide pigment plant at Krefeld-Uerdingen by Farbenfabriken Bayer A.G.[11] reports the distribution of titanium dioxide consumption in Germany as follows: Lacquers and paints, 40 percent; linoleum and oilcloth, 11 percent; paper, 9 percent; porcelain enamel, 8 percent; textiles, 7 percent; rubber goods and cables, 6.5 percent; plastics and imitation leather, 6 percent; welding electrodes, 3.5 percent; and various other products, 9 percent.

Netherlands.—The Billiton Co., The Hague, and the Albatross Sulphuric Acid and Chemical Works, Utrecht, was reported to have agreed to form a new company for manufacturing titanium pigment. Plans are said to include construction of a plant in the Botlek area near Rotterdam with an initial capacity of 11,000 tons of titanium dioxide a year. Technical knowledge for the manufacturing process is to be supplied by The Glidden Co. (U.S.A.).[12]

United Kingdom.—Laporte Industries, Ltd., announced plans to increase annual titanium oxide productive capacity at the Stallingborough plant of its subsidiary, Laporte Titanium, Ltd., from 34,000 to 56,000 tons within 3 years. The additional output will become effective at intervals during the 3-year period. Late in August the larger of the two United Kingdom producers of titanium oxide, British Titan Products, Ltd., completed a 15,000-ton increase in the annual capacity of its Grimsby plant.

On completion of the Laporte plant expansion, total annual capacity of the United Kingdom's two producers was estimated at 170,000 tons.

---

[9] E. I. du Pont de Nemours & Co., Annual Report, 1959, p. 16.
[10] E. I. du Pont de Nemours & Co., Annual Report, 1959, pp. 16–17.
[11] Mining Magazine (London), vol. 102, No. 1, January 1960, pp. 22–24.
[12] Metal Bulletin (London), No. 4462, Jan. 15, 1960, p. 23.

Titanium sponge output at Wilton, North Yorkshire, by Imperial Chemical Industries, Ltd. (I.C.I.), is not available. However, production is estimated to have been about the same as in 1958, or about 1,300 tons.

ASIA

India.—Hopkins and Williams, Ltd., an ilmenite producer in the States of Kerala and Madras, closed its ilmenite processing plant at Manavalakurichi, Madras, early in 1959.[13] Virtually all of the ilmenite produced in India was from deposits in Quilon, Kerala, and was mined by the following companies: Travancore Minerals Private, Ltd., Hopkins and Williams, Ltd., and Associated Minerals Company, Ltd.

Japan.—Output of titanium slag declined to 2,800 short tons, only about three-fourths of the 1958 production. Hokuetsu Electric Chemical Industries Co. was the principal producer and accounted for over one-half of the total. Nisso Steel Manufacturing Co. and Morioka Electric Chemical Co. produced the remainder.

TABLE 11.—Titanium metal and titanium dioxide data, in Japan, in short tons

	1954	1955	1956	1957	1958	1959
Titanium metal:						
Production	673	1,378	2,768	3,393	1,812	2,730
Exports	473	1,229	2,783	2,734	1,962	1,982
Stocks, end of year	86	220	186	940	677	1,148
Titanium dioxide:						
Production	13,820	19,068	25,269	36,811	33,285	[1] 34,855
Exports	5,218	8,677	10,208	16,590	15,223	[1] 14,138
Stocks, end of year	882	538	1,174	2,490	2,754	[1] 950

[1] January–November only.

Production of titanium sponge metal increased 51 percent over the 1958 output to 2,700 short tons. Osaka Titanium Co., Ltd., and Toho Titanium Industry Co., Ltd., produced 1,400 and 1,300 tons, respectively. A small quantity was made by the Nippon Soda Co., Ltd. Most of the output by Osaka and Toho was exported to the United States to the Commodity Credit Corporation under surplus agricultural product barter agreements between these two producers and the U.S. Department of Agriculture.

Malaya.—Exports of ilmenite from Malaya decreased 3 percent.

TABLE 12.—Exports of ilmenite from Malaya, by countries of destination, in short tons[1]

[Compiled by Corra A. Barry]

Country	1955	1956	1957	1958	1959
Australia	-----	7,316	2,240	-----	-----
Belgium	112	-----	7,030	2,856	11,223
France	3,371	3,388	3,047	7,280	8,812
Italy	425	134	392	90	345
Japan	33,799	57,896	38,478	28,443	46,310
Netherlands	30	1,232	560	-----	-----
United Kingdom	22,518	34,048	50,960	45,103	14,903
United States	-----	32,683	-----	-----	-----
Other countries	85	140	35	34	-----
Total	60,340	136,837	102,742	83,806	81,593

[1] Compiled from Customs Returns of Malaya.

---

[13] U.S. Consulate General, Madras, India, State Department Dispatch 526: May 15, 1959.

AFRICA

Senegal.—Ilmenite, rutile, and zircon were mined by Société Minière Gaziello & Cie. Most of the output was exported to France to Fabriques de Produits Chimique de Thann et de Mulhouse and Le Produits de Titane du Havre, the principal stockholders of Gaziello.[14]

Union of South Africa.—Separation and concentration of ilmenite, rutile, and zircon at the Umgababa Minerals, Ltd., mine near Durban were described in detail.[15] Geology of the beach sand deposit also was described.

Egypt.—The General Ilmenite Co. (State owned) continued development of mining and processing facilities to exploit the high-grade ilmenite deposit at Abu Ghalaga in the Eastern Desert. The company reportedly planned to start production late in 1960.[16] The deposit at Abu Ghalaga has been described.[17]

OCEANIA

Australia.—Concentrating and separating plants at Yoganup and Capel being built by Westralian Oil, Ltd., were described briefly.[18] Heavy minerals in deposits in the Yoganup and Capel areas near Bunbury, Western Australia, are to be concentrated at Yoganup and separated at Capel. Annual capacity at Yoganup was to be 100,000 tons of concentrate; after separation at Capel, this concentrate would yield 60,000 tons of ilmenite, 11,000 tons of leucoxene, and 6,000 tons of a mixed product containing both ilmenite and leucoxene. Monazite and zircon, totaling 13,000 tons, would make up the remainder.

TABLE 13.—Exports of rutile concentrate from Australia, by countries of destination, in short tons [1] [2]

[Compiled by Corra A. Barry]

Country	1955	1956	1957	1958	1959 [3]
Belgium	2,700	4,797	4,114	2,532	(4)
France	3,485	4,599	4,620	5,459	(4)
Germany, West	4,573	4,042	5,964	4,114	(4)
Italy	2,154	3,433	3,644	3,293	(4)
Japan	2,118	2,335	4,232	2,920	(4)
Netherlands	8,687	9,968	11,056	10,579	8,110
Sweden	3,093	3,591	3,938	3,687	(4)
United Kingdom	13,702	13,993	12,345	13,026	7,747
United States	23,798	51,754	79,086	29,365	17,711
Other countries	2,539	2,161	4,339	9,714	32,273
Total	66,849	100,673	133,338	84,689	65,841

[1] Compiled from Customs Returns of Australia.
[2] This table incorporates some revisions.
[3] January through September, inclusive.
[4] Data not separately recorded.

---

[14] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 2, February 1960, pp. 27–28.

[15] Cairns, I. F., and Langton, G., The Development and Commissioning of the Heavy Minerals Separation Plant at Umgababa—South Coast, Natal: Jour. of the South African Inst. of Min. and Met., vol. 60, No. 4, November 1959, pp. 139–172.

[16] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 3, March 1960, pp. 36–37.

[17] Amin, M. S., The Ilmenite Deposit of Abu Ghalaga, Egypt: Econ. Geol., vol. 49, No. 1, January–February 1954, pp. 77–87.

[18] Mining Magazine (London), vol. 102, No. 1, January 1960, pp. 36–37.

TABLE 14.—Exports of ilmenite concentrate from Australia, by countries of destination, in short tons[1]

[Compiled by Corra A. Barry]

Country	1954-55 [2]	1955-56 [2]	1956-57 [2]	1957-58 [2]	1958-59 [2]
Belgium-Luxembourg	---	---	1,335	3,228	---
France	---	---	621	223	10,037
Japan	(3)	(3)	16,373	16,668	10,862
Netherlands	---	---	134	3,360	---
United Kingdom	---	---	---	20,447	7,285
United States	---	---	---	22,736	23,490
Other countries	414	426	---	---	93
Total	414	426	18,463	66,662	51,767

[1] Compiled from Customs Returns of Australia.
[2] Years ending June 30.
[3] Data not available.

TECHNOLOGY

The Federal Bureau of Mines published reports on several phases of its titanium research program.

Data on the metallurgical thermochemistry of titanium were given.[19] The selection of data was discussed as well as the application of this data to metallurgical reactions involved in chlorinating rutile and ilmenite; reducing titanium tetrachloride with magnesium, sodium, and hydrogen; reducing titanium tetrabromide and titanium tetraiodide with hydrogen; the disproportionation of titanium halides; the calcium reduction of titanium oxides; and the reduction of ilmenite with carbon.

Coastal deposits of titanium minerals in the Middle Atlantic States were investigated.[20]

Improvements in the Bureau's fused salt, electrolytic process for recovering high-purity titanium metal were reported.[21] The efficiency of the process was improved by increasing the depth of the bath and the size of the cathode. The metal deposit was distributed evenly on the cathode at all immersion depths, and the metal quality was not impaired by deep bath deposition.

Another improvement in the electrorefining process, resulting from the use of an internally heated cell, was described.[22] This research established the practicability of the internal heater in fused salt titanium electrorefining as a means of lowering the total power requirements in the process. No deleterious effect on the bath or metal process was detected as the result of using internal heating.

A study of the effects of impurities (oxygen, nitrogen, carbon, and iron) on the hardness of electrolytically refined titanium metal was published.[23] Nitrogen affected hardness more than the other impurities investigated, but all added elements caused the hardness to

---

[19] Kelly, K. K., and Mah, Alla D., Metallurgical Thermochemistry of Titanium: Bureau of Mines Rept. of Investigations 5490, 1959, 48 pp.

[20] Kuster, W. V., Titanium Minerals in the Heavy Sand Deposits of Asateague Island, Md.: Bureau of Mines Rept. of Investigations 5512, 1959, 22 pp.

[21] Baker, D. H., Jr., and Nettle, J. R., Titanium Electrorefining: Cathode Studies and Deep Bath Deposition: Bureau of Mines Rept. of Investigations 5481, 1959, 11 pp.

[22] Leone, O. Q., Nettle, J. R., and Baker, D. H., Jr., Electrorefining Titanium, Using an Internally Heated Cell: Bureau of Mines Rept. of Investigations 5494, 1959, 20 pp.

[23] Haver, F. P., and Baker, D. H., Jr., Effects of Common Impurities on Hardness of Electrolytically Refined Titanium Metal: Bureau of Mines Rept. of Investigations 5546, 1959, 7 pp.

increase as a straight-line function of impurity concentration up to the limit of their maximum solid solubility.

Technique and equipment used for hardness testing of titanium metal was reported.[24] Detailed descriptions were given of the methods used in preparing test samples for chemical analysis and hardness testing. The melting of the buttons and reading of the Brinell-hardness impressions were described. Engineering drawings of the equipment were presented.

A report describing studies on air-cooled crucibles for cold-mold arc melting of reactive metals such as titanium showed that a copper crucible, with longitudinal, integral-type fins and with an outer jacket to confine the airstream, appears to be the best general design for air-cooled operation.[25]

A theory on the reduction of titanium tetrachloride by sodium was advanced by Bureau scientists who proposed that the reaction between sodium and titanium tetrachloride is heterogenous between two separate phases. One phase consists of sodium dissolved in sodium chloride and another of the lower chlorides of titanium dissolved in sodium chloride.[26] Theoretical and experimental evidence indicated that the reduction reaction is stepwise, the final reduction between the phase boundary being electrochemical in nature.

Low-temperature chlorination studies by the Bureau on a titanium concentrate obtained as a byproduct in extracting alumina from Arkansas bauxite ore were described.[27] The concentrate contains columbium associated with manganilmenite. Through a system of column packings of carbides of titanium and calcium, columbium was recovered from the chloride vapors by selective condensation of its pentachloride. Nearly colorless titanium tetrachloride was obtained by passing the crude vapors through rock salt and activated charcoal.

Several articles reviewed many aspects of titanium metal technology from ore beneficiation to production of the metal and its alloys.[28]

The aging response in the temperature range of 800° F. of the nominal alloys Ti-8Mn, Ti-8Mn-2Al, Ti-4Mn-4Al, Ti-6Al-4V, and Ti-4Fe were studied to follow their transformation behavior in relation to mechanical properties after aging.[29] Hardness, tensile, and X-ray diffraction data were compiled to follow the aging of these alloys.

Electrodeposition of smooth and adherent coatings of titanium metal on a steel cathode in a fused potassium iodide-potassium fluoride

---

[24] Baker, D. H., Jr., Hardness Testing of Titanium Sponge: Equipment and Procedure: Bureau of Mines Rept. of Investigations 5440, 1959, 18 pp.

[25] Kirk, M. M., Magnusson, P. C., and Schmidt, G. L., Air-Cooled Crucibles for Cold-Mold Arc Melting: Bureau of Mines Rept. of Investigations 5443, 1959, 23 pp.

[26] Henrie, T. A., and Baker, D. H., Jr., A Theory on the Reduction of Titanium Chlorides by Metallic Sodium: International Symposium on the Physical Chemistry of Process Metallurgy, April 27–May 1, 1959, Pittsburgh, Pa.

[27] Nieberlein, V. A., Separation of Chloride Vapors During Ilmenite Chlorination: Bureau of Mines Rept. of Investigations 5602, 1960, 11 pp.

[28] Kroll, W. J., The Present State of Titanium Extractive Metallurgy: Trans. Met. Soc. of AIME, vol. 215, No. 4, August 1959, pp. 546–553.

Bomberger, Howard B., Titanium: Ind. Eng. Chem., vol. 51, No. 9, pt. 2, September 1959, pp. 1228–1230.

Journal of Metals, What's Happening to Titanium Alloys?: Vol. 11, No. 1, January 1959, pp. 29–32.

[29] Griest, A. J., Doig, J. R., and Frost, P. D., Correlation of Transformation Behavior with Mechanical Properties of Several Titanium-Base Alloys: Met. Soc. of AIME, vol. 215, No. 4, August 1959, pp. 627–632.

bath was described.[30] The procedure involves use of a heated cathode several hundred degrees hotter than the bath, which was maintained at 700° to 775° C., and a soluble titanium anode. Decomposition voltages for several cell conditions were determined, and the mechanism of the electrolytic reactions was discussed.

Commercially pure titanium was evaluated and compared with zirconium and other metals and alloys in a wide variety of corrosive chemical plant exposures.[31] Titanium was found to corrode little or not at all in wet chlorine gas, hypochlorous acid, sodium and calcium hypochlorite, sodium and potassium chlorides, sea water, and many solutions containing chlorine.

---

[30] Journal of the Electrochemical Society, Electrodeposition of Adherent Titanium Coatings on Induction Heated Cathodes in Fused Salts: Vol. 106, No. 5, May 1959, pp. 428–433.

[31] Gegner, P. J., and Wilson, W. L., The Corrosion Resistance of Titanium and Zirconium in Chemical Plant Exposures: Corrosion, vol. 15, No. 7, July 1959, pp. 19–28.

Tungsten

By R. W. Holliday [1] and Mary J. Burke [2]

DOMESTIC consumption of tungsten concentrate in 1959 nearly doubled. However, imports declined because deliveries to the Government stockpile had been virtually completed by the end of 1958.

Mine production in the United States continued far below capacity, although prices in the last quarter were the highest since mid-1957. Limited increases in output were reported in some areas of the world. A new chemical processing plant increased South Korean productive capacity, and there was evidence of increasing exports from Iron Curtain countries.

LEGISLATION AND GOVERNMENT PROGRAMS

The General Services Administration (GSA) negotiated a contract with the domestic industry to produce approximately 900,000 pounds of tungsten carbide powder from Government-owned concentrate. Acquisition of tungsten concentrate for the Government stockpile from domestic sources had been suspended in December 1956. Acquisition from foreign producers had been terminated over the past several years in accordance with the terms of individual long-term contract agreements negotiated before 1953. Final delivery was made on the last of these contracts early in 1959.

Import duties on various scrap metals were suspended, but import duties on tungsten scrap continued without change.

TABLE 1.—Salient tungsten ore and concentrate statistics

(Thousand pounds of contained tungsten)

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Mine production	7,907	15,833	14,761	8,032	(1)	(1)
Mine shipments	7,993	15,619	14,027	5,254	3,605	3,473
General imports	17,009	20,789	21,857	14,186	6,873	6,248
Imports for consumption	18,438	20,700	20,860	14,018	6,542	5,435
Consumption	7,682	8,967	9,061	8,544	5,320	9,835
Stocks:						
Producers	276	523	1,477	4,326	(1)	(1)
Consumers and dealers	4,045	3,502	2,980	4,103	4,670	3,196
Total	4,321	4,025	4,457	8,429	(1)	(1)
World: Production	62,966	78,802	78,898	64,717	52,820	54,105

[1] Figure withheld to avoid disclosing individual company confidential data.

---

[1] Commodity specialist.

[2] Statistical assistant.

DOMESTIC PRODUCTION

Two producers supplied most of the domestic output of tungsten in 1959 although five other producers also reported production. Shipments from stocks or from current production were reported by 10 firms. Plans were announced to resume operations at two additional mines in 1960.

In Inyo County, Calif., the Pine Creek mine and mill of Union Carbide Nuclear Co. produced scheelite concentrate from ores containing other marketable minerals, principally molybdenite. In Lake County, Colo., the Climax Molybdenum Co., Division of American Metal Climax, Inc., produced byproduct huebnerite from molybdenum ore.

The Minerals Engineering Co. began stripping operations in September, preparatory to mining at the Calvert mine in Beaverhead County, Mont. The Tungsten Mining Corp., subsidiary of Howe Sound Co. announced plans to reopen the Hamme mine in Vance County, N.C.

CONSUMPTION AND USES

More tungsten concentrate was consumed in 1959 than in any previous peacetime year, as shown in figure 1. The large consumption during World War II was due to expanded requirements for tungsten in tool steel and armor. Increased consumption during the Korean war was due largely to the requirements for armor-piercing projectile cores of tungsten carbide.

In 1959 tungsten consumption increased in all the major use categories. Compared with 1958, consumption of tungsten in high-speed and other alloy steels increased 79 percent, in high-temperature and other nonferrous alloys 288 percent, in pure-metal uses 72 percent, and in carbides 68 percent.

Data in table 4 include consumption of imported ferrotungsten, other imported products, and scrap. In 1959, steel plants consumed 32 percent of the total, nonferrous alloys nearly 14 percent, and pure-metal uses 15 percent. The nonferrous alloys include cutting and wear-resistant alloys, high-temperature, and other superalloys, alloy

TABLE 2.—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
1950–54 (average)	8,398	503,866	7,993	$29,499	$58.55	$3.69
1955	16,412	984,711	15,619	60,841	61.79	3.90
1956	14,737	884,323	14,027	51,201	57.90	3.65
1957	5,520	331,208	5,254	[3] 8,186	24.72	1.56
1958	3,788	227,255	3,605	3,991	17.56	1.11
1959	3,649	218,927	3,473	4,502	20.56	1.30

[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 (W).

[3] Estimated.

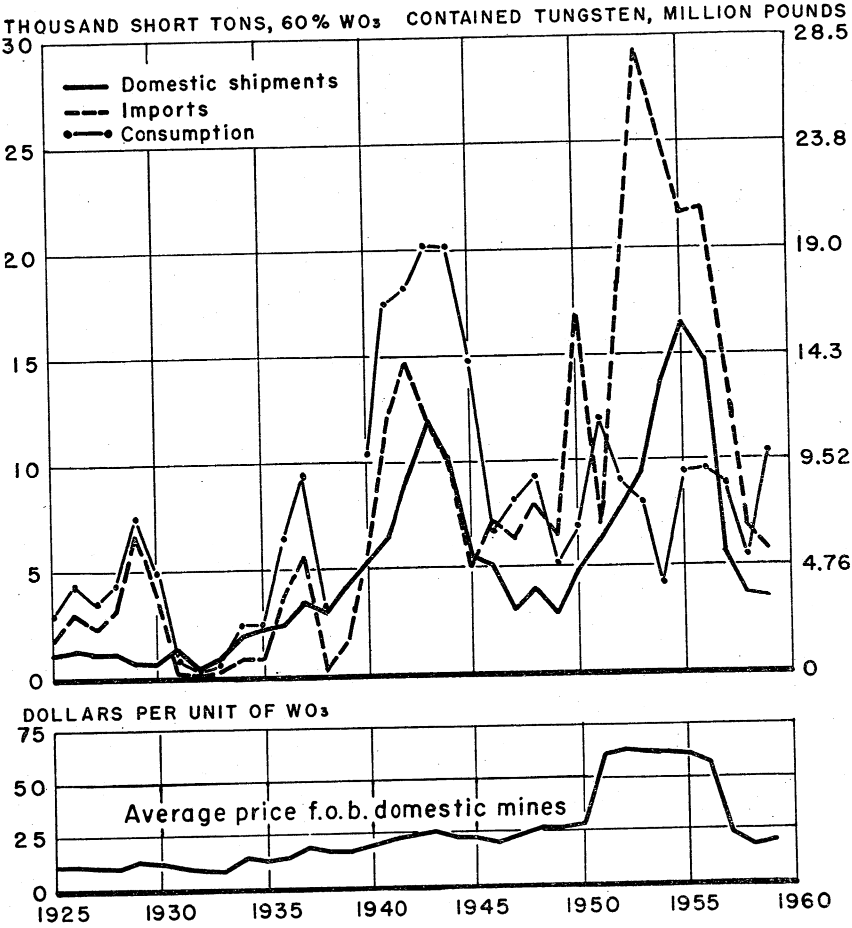

FIGURE 1.—Domestic shipments, imports, consumption, and average price of tungsten ore and concentrate, 1925–59.

welding rods, and electrical contact and resistance alloys. The pure-metal uses include wire, rod, and sheet used in electrical and electronic applications, as well as various shaped parts produced by powder-metallurgy techniques.

Cemented tungsten carbides accounted for 27 percent of total consumption and cast carbides for 10 percent. The cast carbides were used chiefly in hardfacing but also in shaped pieces such as nozzles and dies. The plasma jet process gained importance as a method of applying tungsten carbide coatings.

The largest use of cemented tungsten carbides was in metal-shaping tools and rock bits. However, a continuing trend toward their use as materials of construction was noted. High resistance to bending or deformation, exceptional hardness, and wear resistance are properties favoring their use for machine and equipment components. Improved quality control, lower prices, and increased knowledge of

TABLE 3.—Distribution of tungsten concentrate consumed

	Tungsten content (thousand pounds)		Short tons (60 percent WO_3)		Percent of total	
	1958	1959	1958	1959	1958	1959
Manufacturers of steel ingots and ferrotungsten	1,393	2,993	1,464	3,145	26	30
Manufacturers of hydrogen-reduced metal powder	2,274	4,810	2,389	5,054	43	49
Manufacturers of carbon-reduced metal powder and tungsten chemicals and consumption by firms making several products	1,653	2,032	1,737	2,135	31	21
Total	5,320	9,835	5,590	10,334	100	100

properties have also contributed to a wider application of cemented carbides.

Tungsten and tungsten-base alloys were used increasingly in rockets and missiles as larger billets and shapes became available. In addition, the knowledge of properties and fabricating techniques acquired in developing rocket and missile parts assured their wider use in fields such as chemistry, metallurgy, and power generation, where high-temperature capabilities are needed.

In 1959, new facilities for processing concentrate were established in Western States. The Union Carbide Nuclear Co., a division of Union Carbide Corp., began producing ammonium paratungstate at the Pine Creek mine near Bishop, Calif. The Salt Lake Tungsten

TABLE 4.—Consumption of tungsten products by end uses, in 1959

(Thousand pounds of contained tungsten)

	Ferrotungsten, melting base, self-reducing tungsten, tungsten sponge mix, etc.	Carbon-reduced tungsten powder [1]	Hydrogen-reduced tungsten powder [2]	Tungsten carbide powder [3]	Chemicals	Scheelite (natural or synthetic)	Scrap	Other	Total
Steel:									
High speed	771	20	--------	--------	--------	1,073	222	------	2,086
Hot work and other tool	325	24	--------	--------	--------	156	66	------	571
Alloy (other than tool)[4]	175	14	2	--------	--------	196	78	------	465
High-temperature nonferrous alloys [5]	85	13	17	--------	--------	82	278	5	480
Other nonferrous alloys [6]	10	14	155	45	411	1	215	9	860
Tungsten metal:									
Wire, rod, and sheet	----------	--------	1,333	--------	--------	--------	------	------	1,333
Other	----------	--------	164	--------	--------	--------	------	------	164
Carbides:									
Cemented or sintered	----------	22	3	2,630	--------	--------	------	------	2,655
Other (including cast or fused)	----------	662	213	5	--------	--------	105	------	985
Chemicals [7]	----------	--------	--------	--------	151	--------	------	------	151
Total	1,366	769	1,887	2,680	562	1,508	964	14	9,750
Stocks at consumers' plants, Dec. 31, 1959	305	81	153	84	60	--------	198	3	884

[1] Includes tungsten-metal pellets that may be hydrogen or carbon reduced or scrap.
[2] Does not include quantities consumed in making tungsten carbide powder.
[3] Includes crystalline carbide powder and carbide powder made from hydrogen-reduced metal powder.
[4] Includes steel-mill rolls, stainless, and other alloy steels.
[5] Includes cutting and wear-resistant alloys.
[6] Includes diamond-drill-bit matrices, electrical contact points, and welding rods.
[7] Includes fluorescent powders, pigments, and color compounds.

Co., Salt Lake City, Utah, also announced production of ammonium paratungstate from concentrate from the Calvert mine in Beaverhead County, Mont.; the company and mine are operated by Minerals Engineering Co., Grand Junction, Colo. The Nevada Scheelite Division of Kennametal, Inc., continued production of crystalline tungsten carbide at its Leonard mine near Fallon, Nev. The operation, begun in the last half of 1958, utilized a direct process for converting scheelite to tungsten carbide.

STOCKS

Stocks of concentrate held by consumers and dealers declined 32 percent. Figures on stocks held at the yearend by producers were not available for publication. Stocks of tungsten concentrate in the national stockpile exceeded minimum and long-term objectives.

PRICES AND SPECIFICATIONS

Prices of foreign concentrate increased about 50 percent in the last quarter compared with the first three quarters of 1959. The published price for domestic concentrate was $20–$22 in January and $22–$24 at yearend.

E&MJ Metal and Mineral Markets quoted the price of tungsten-metal powder (98.8 percent in 1,000-pound lots) at $3.05–$3.20 per pound in January and $2.75–$2.90 per pound for the rest of the year. The price of hydrogen-reduced tungsten-metal powder (99.99 percent) was $3.33–$3.80 from January 1 until June 29. Thereafter, prices were quoted at $3.10–$4.00, and one company listed the following size and price relationships:

Range of Fisher number, microns:	*Price per pound*
0.70–0.99	$4.00
1.00–1.99	3.20
2.00–5.99	3.10
6.00–18.50	3.25

TABLE 5.—Prices of tungsten concentrate in 1959 [1]

	Foreign ore per short-ton unit of WO_3, 65-percent basis, c.i.f. U.S. ports, duty extra		London market, per long-ton unit of WO_3 wolfram
	Wolfram	Scheelite	
Jan. 1	$12–$12.75	$12–$12.75	95s.–100s.
Feb. 5	12	12	90s.–95s.
Mar. 5	10.75–11.25	10.75–11.25	84s.–89s.
Apr. 2	10.75–11.25	10.75–11.25	84s.–89s.
May 7	11.25–11.50	11.25–11.50	89s.–94s.
June 4	12.50–13	12.50–13	98½s.–103½s.
July 2	12.50–13	12.50–13	96½s.–101½s.
Aug. 6	12–12.25	12–12.25	94½s.–99½s.
Sept. 3	14.50–15.00	14.50–15.00	105s.–110s.
Oct. 1	17.50	17.50	[2] 140s.
Nov. 5	16	16	[2] 225s.
Dec. 3	18.25	18.25	150s.
Average price	13.00	13.00	
Duty	7.93	7.93	
Average price duty paid	20.93	20.93	

---

[1] Published price quotations from E&MJ Metal and Mineral Markets.

[2] Nominal.

Effective December 28, the quoted price range increased to $3.25–$4.25. The price of ferrotungsten (contained tungsten) remained at $2.15 per pound throughout the year (in lots of 5,000 pounds or more, ¼-inch lump, packed; f.o.b. destination, continental United States, 70–80 percent W).

FOREIGN TRADE [2a]

General imports of tungsten contained in concentrate totaled 6,248,364 pounds valued at $4,739,935. Comparable totals for 1958 were 6,873,000 pounds valued at $12,114,210. The large decrease in value was due chiefly to the difference between the open-market price in 1959 and the price of Government-stockpile acquisitions obtained in 1958 under long-term contracts.

About 65 percent of the total imports in 1959 came from Portugal, Republic of Korea, Bolivia, Australia, Burma, and Peru, in order of importance. The remaining 35 percent came from 10 other countries.

TABLE 6.—Tungsten ore and concentrate imported for consumption in the United States, by countries

(Thousand pounds and thousand dollars)

[Bureau of the Census]

Country	1958			1959		
	Gross weight	Tungsten content	Value	Gross weight	Tungsten content	Value
North America:						
Canada	1,185	680	$2,161			
Mexico	4	2	1	52	28	$49
Total	1,189	682	2,162	52	28	49
South America:						
Argentina	1,178	586	1,580			
Bolivia [1]	856	367	236	1,337	735	442
Brazil	4,595	2,609	2,628	1,957	1,144	1,136
Chile [1]	57	25	16			
Peru [1]	1,591	928	2,635	555	311	210
Uruguay				8	3	5
Total	8,277	4,515	7,095	3,857	2,193	1,793
Europe:						
Germany, West				87	46	23
Netherlands	40	21	17	115	66	76
Portugal	42	23	14	1,409	780	647
Spain				102	53	32
Sweden				98	54	30
Total	82	44	31	1,811	999	808
Asia:						
Burma	90	49	35	357	195	132
Hong Kong	(2)	(2)	(2)	22	13	7
Korea, Republic of	673	370	254	1,431	798	428
Malaya, Federation of	56	31	21	186	105	113
Singapore	22	12	8			
Thailand	45	25	20	189	105	134
Total	886	487	338	2,185	1,216	814
Africa: Belgian Congo	22	12	7	559	314	219
Oceania: Australia	1,549	802	2,327	1,223	685	552
Grand total	12,005	6,542	11,960	9,687	5,435	4,235

[1] Imports shown from Chile probably were mined in Bolivia or Peru and shipped from a port in Chile.
[2] Less than 1,000.

[2a] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 7.—Ferrotungsten imported for consumption in the United States, by countries

(Thousand pounds and thousand dollars)

[Bureau of the Census]

Country	1958			1959		
	Gross weight	Tungsten content	Value	Gross weight	Tungsten content	Value
Europe:						
Austria	46	37	$41	190	150	$148
France	----------	----------	----------	27	22	29
Germany, West	----------	----------	----------	48	38	37
Netherlands	----------	----------	----------	12	10	9
Portugal	48	39	34	62	50	49
Sweden	22	19	14	160	136	117
United Kingdom	56	46	45	159	127	137
Total	172	141	134	658	533	526
Oceania: Australia	22	18	20	----------	----------	----------
Grand total	194	159	154	658	533	526

Imports of tungsten metal, tungsten carbide, and combinations containing tungsten or tungsten carbide in lumps, grains, or powder contained 196,053 pounds of tungsten valued at $425,494. Imports of ferrochromium tungsten, chromium tungsten, chromium-cobalt tungsten, tungsten-nickel, and other alloys not specifically provided for contained 93,963 pounds of tungsten valued at $104,913. No imports of tungstic acid and other compounds of tungsten were reported. Table 8 gives semifabricated forms imported.

Exports and reexports of tungsten concentrate were 1,171 and 195,261 pounds, gross weight, respectively, valued at $4,950 and $118,600. Exports of ferrotungsten were 76,589 pounds, gross weight, and reexports were 11,218 pounds.

Exports of tungsten powder totaled 158,638 pounds valued at $917,427. Exports of tungsten metal and alloys in crude form and scrap were 336,454 pounds, gross weight, valued at $147,900; reexports were 251 pounds valued at $800.

Exports of semifabricated forms were 42,559 pounds gross weight valued at $934,946.

TABLE 8.—Tungsten or tungsten carbide forms imported for consumption in the United States

[Bureau of the Census]

Year	Ingots, shot, bars, or scrap		Wire, sheets, or other forms, n.s.p.f.		Total	
	Gross weight (pounds)	Value	Gross weight (pounds)	Value	Gross weight (pounds)	Value
1950-54 (average)	233,039	$409,645	800	[1] $8,217	233,839	[1] $417,862
1955	353,928	693,494	102,169	[1] 310,523	456,097	[1] 1,004,017
1956	485,583	840,271	168,103	578,328	653,686	1,418,599
1957	66,717	[1] 130,139	190,413	[1] 483,195	257,130	[1] 613,334
1958	53,299	57,543	196,190	348,179	249,489	405,722
1959	258,051	199,464	193,061	367,324	451,112	566,788

[1] Data known to be not comparable with other years.

WORLD REVIEW

Production curtailment in most areas of the free world, 1957–59, resulted in a considerable reduction of producers' stocks by the end of 1959. These stocks, accumulated after termination of U.S. stockpile contracts, were largely responsible for the very low prices since mid-1957. Increased prices during the last quarter of 1959 appeared to be more closely related to costs of production. Large stocks still were held by the Governments of the United States, United Kingdom, and Argentina and, presumably, by the Governments of China and the U.S.S.R.

NORTH AMERICA

Canada.—A large scheelite deposit was discovered in the Northwest Territory near the Yukon border and 150 miles north of Watson Lake in the McKenzie Mountain Range. Limited drilling reportedly indicated more than 1 million tons of open-pit ore averaging about 2.18 percent WO_3. Canada Tungsten Mining Corporation, Ltd. was formed by a group including Leitch Gold Mines, Ltd., Highland-Bell, Ltd., Area Mines, Ltd., Dome Mines, Ltd., and Ventures, Ltd., to conduct development work. Tungsten deposits and the tungsten industry of Canada through 1953 were reviewed.[3]

Mexico.—Tungsten mining was resumed on a limited scale following the price increase of the last quarter of 1959. All exports were shipped to the United States.

SOUTH AMERICA

Argentina.—The Government agency, Comite de Comercializacion de Minerales (Cocomine), purchased concentrate at prices above the market and stockpiled most of it for future sale under more favorable market conditions. Effective March 1, 1959, the official purchase price was increased from about $23 per short-ton unit to about $31 (from 115 to 155 pesos a kilogram for tungsten concentrate on a basis of 65 percent WO_3), but the increase in price did not apply to quantities exceeding the 1958 deliveries of individual producers.

Bolivia.—Tungsten production in the nationalized mines decreased nearly 20 percent compared with 1958. Production data from privately owned mines were not available, but exports increased slightly.

Brazil.—Exports to the United States decreased more than 50 percent from 1958, but substantial sales of concentrate to Japanese firms in the last quarter were reported in the Brazilian press.

Peru.—The only firm producing tungsten, Fermin Malaga Santolalla e Hijos, continued to operate at a reduced rate. Exports to the United States decreased about 65 percent and production about 35 percent compared with 1958. A government decree, issued February 11, 1959, suspended collection of the 4-percent tax on tungsten exports.

Venezuela.—No tungsten was produced in 1959, but evidence of tungsten mineralization in the Roscio district of the State of Bolivar was reported. Decree 507, of January 9, 1959, set this district aside, for 2 years, as a government-reserved area for exploration and exploitation of tungsten.

---

[3] Little, H. W., Tungsten Deposits of Canada: Geol. Survey of Canada, Econ. Geol. Series, No. 17, 1959, 251 pp.

TABLE 9.—World production of tungsten ore and concentrate (60-percent WO_3 basis), by countries, in short tons [1]

[Compiled by Pearl J. Thompson and Berenice B. Mitchell]

Country	1950–54 (average)	1955	1956	1957	1958	1959
North America:						
Canada	1,066	1,618	1,893	1,602	575	----------
Mexico	454	626	628	294	8	138
United States (shipments)	8,398	16,412	14,737	5,520	3,788	3,649
Total	9,918	18,656	17,258	7,416	4,371	3,787
South America:						
Argentina	528	1,213	1,293	1,441	1,127	[2] 830
Bolivia (exports)	3,788	5,935	5,255	4,809	2,457	2,671
Brazil (exports)	1,606	1,410	2,017	2,304	2,596	1,609
Peru	715	893	1,242	1,215	922	610
Total	6,637	9,451	9,807	9,769	7,102	5,720
Europe:						
Austria	----------	----------	----------	140	146	148
Finland	49	146	74	----------	163	42
France	1,004	1,520	1,348	1,091	1,082	924
Italy	17	30	30	20	10	7
Portugal	4,982	5,122	5,506	4,756	2,109	2,610
Spain	2,437	1,728	1,354	1,319	1,301	896
Sweden	437	510	504	557	660	[2] 660
U.S.S.R. [2]	8,300	8,300	8,300	8,300	8,300	8,300
United Kingdom	75	80	68	55	2	----------
Yugoslavia	[2] [3] 120	[2] 120	83	90	99	108
Total [2]	17,420	17,600	17,300	16,300	13,900	13,700
Asia:						
Burma [4]	1,758	2,927	2,982	2,873	1,667	1,182
China [2]	18,300	19,800	19,800	16,500	16,500	19,800
Hong Kong	[5] 85	28	30	42	46	47
India	10	----------	2	2	----------	1
Japan	481	990	1,200	1,144	881	1,446
Korea:						
North [2]	1,410	2,055	2,190	2,665	3,300	4,400
Republic of	4,090	3,757	4,472	4,567	3,597	3,761
Malaya, Federation of	93	138	117	63	57	24
Thailand	1,565	1,367	1,411	1,080	725	553
Total [2]	27,800	31,100	32,200	28,950	26,800	31,210
Africa:						
Algeria	[5] 28	----------	----------	----------	----------	----------
Belgian Congo [4] [6]	1,073	1,733	2,142	1,914	1,479	1,209
Morocco: Southern zone	20	----------	3	----------	----------	----------
Nigeria	15	3	4	----------	----------	----------
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	298	245	287	180	103	41
South-West Africa [4]	141	283	388	278	64	2
Tanganyika (exports)	13	10	7	----------	----------	----------
Uganda (exports)	195	187	193	224	31	14
Union of South Africa	341	708	330	290	61	42
United Arab Republic (Egypt Region)	10	21	----------	----------	----------	----------
Total	2,134	3,190	3,354	2,886	1,738	1,308
Oceania:						
Australia	2,210	2,765	2,954	2,629	1,587	[2] 1,125
New Zealand	42	[2] 33	33	36	3	----------
Total	2,252	2,798	2,987	2,665	1,590	[2] 1,125
World total (estimate)	66,160	82,800	82,900	68,000	55,500	56,850

---

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included.

[2] Estimate.

[3] Average for 1953–54.

[4] Including WO_3 in tin-tungsten concentrates.

[5] Average for 1951–54.

[6] Including Ruanda-Urundi.

EUROPE

Austria.—A small tonnage of tungsten was mined in Austria; of more significance to the industry was the processing of tungsten, particularly production of large (8- by 8-inch) tungsten ingots by powder metallurgy techniques at the Metallwerk Plansee in Reutte, Tyrol, Austria.

Portugal.—Production increased slightly in Portugal compared with 1958. One company, Beralt Tin and Wolfram, Ltd., reported that a considerable part of its stocks had been sold and that its production had been increased in the last quarter.

U.S.S.R.—Shipments of tungsten concentrate to the European market, especially to France, Austria, West Germany, and the United Kingdom, were reported.[4] Export of wolfram concentrate to West Germany was scheduled at 1,650 short tons in 1960, compared with 1,320 tons in 1959.

United Kingdom.—The United Kingdom Board of Trade, through its agent, British Tungsten, Ltd., began selling stockpiled concentrate in September for the first time since June 1957. Sales were limited to minimize their effect on the market.

ASIA

Burma.—Tungsten production decreased nearly 30 percent. Little, if any, ore came from the Mawchi mine which, before World War II, was one of the world's largest producers.

China.—Although little data were available on the tungsten production of China, it is known that a very large productive capacity existed. Undoubtedly the increased production of steel resulted in additional domestic use of tungsten.

Korea, Republic of.—The new synthetic scheelite refinery of Korea Tungsten Mining Co. began operating about mid-1959.[5] The $3 million plant was designed to produce high-purity scheelite, to increase recovery of tungsten, and to permit recovery of valuable byproduct constituents. The company, a Government agency, operated the Sangdong and Dalsong mines which produced 90 percent or more of the South Korean tungsten output. By December, stocks of concentrate at the Government-operated mines were reduced to about one-third the quantity on hand at the beginning of the year.

Thailand.—In response to price increases, tungsten production in the last half of 1959 increased about 10 percent compared with the first half. Despite this increase, the rate of production remained relatively low.

AFRICA

More than 90 percent of all tungsten ore produced in Africa came from the Belgian Congo.

OCEANIA

Australia.—King Island Scheelite, Ltd., planned to resume production of tungsten concentrate on a limited scale in 1960 for the first time since August 1958. Exports to the United States were slightly less than in 1958.

---

[4] Metal Bulletin, Russia and the Tungsten Market: Mar. 15, 1960, pp. 11–12.

[5] Mining World, Synthetic Scheelite From Korea: Vol. 21, No. 11, October 1959, p. 41.

TECHNOLOGY

Significant improvements in fabricating techniques were reported in 1959. Improvement in ductility and oxidation resistance and development of new tungsten-base alloys continued as major research objectives.

Several firms announced the installation of facilities for producing and shaping larger billets of tungsten and tungsten-base alloys. Powder metallurgy methods, electron-beam melting, and arc melting all were used to produce billets for machining, forging, extruding, or rolling. Slip casting, spinning, and plasma-jet spraying gained importance during the year. These and other fabricating methods were described.[6]

The Bureau of Mines developed a method for producing extremely pure tungsten by hydrogen reduction of gaseous tungsten hexafluoride.[7] The method appeared promising also as a means of making complicated shapes and protective coatings. Other Bureau research was on the production of tungsten metal directly from scheelite by fused-salt electrolysis.[8]

It was estimated that $2.6 million is spent annually on tungsten research in the United States and that about 40 percent of this total is provided by sponsoring Government agencies.[9] An article reviewed Government-sponsored research, as reported during a conference at Duke University, May 20 and 21.[10] The conference was under the auspices of the Office of Ordnance Research, U.S. Army, in cooperation with nine other agencies. In another article the current status of tungsten technology was compared with that of other refractory metals.[11]

To overcome the problems of room-temperature brittleness, and oxidation at temperatures above 2,000° F., research was conducted on a wide range of subjects including alloy development, properties, methods of increasing purity, methods of working, and protective coatings.

Tantalum-tungsten, tungsten-molybdenum, and many other tungsten-alloy combinations were investigated for use in high-temperature applications such as missiles and rockets.[12] Reports describing in-

---

[6] Barth, V. D., The Fabrication of Tungsten: Battelle Memorial Inst., DMIC Rept. 115, Aug. 14, 1959, 55 pp.

[7] Nieberlein, V. A., and Kenworthy, H., High-Purity Tungsten by Fluoride Reduction: Bureau of Mines Rept. of Investigations 5539, 1959, 12 pp.

[8] Zadra, J. B., and Gomes, J. M., Electrowinning Tungsten and Associated Molybdenum from Scheelite: Bureau of Mines Rept. of Investigations 5554, 1959, 23 pp.

[9] Austin, W. W., What's New in Tungsten Research: Metal Progress, vol. 76, No. 6, December 1959, pp. 71–75.

[10] Tietz, T. E., Current Research on Tungsten: Jour. Metals, vol. 11, No. 11, November 1959, pp. 763–764.

[11] Jaffee, R. I., A Brief Review of Refractory Metals: Battelle Memorial Inst., DMIC Memo. 40, Dec. 3, 1959, 34 pp.

[12] Chemical and Engineering News, Tantalum, Tungsten Fill Hot Needs: Vol. 37, No. 42, Oct. 19, 1959, pp. 52–55.

Thielemann, R. H., High Temperature Tantalum Base Alloys: U.S. Patent 2,877,112, Mar. 10, 1959.

Braun, H., Keiffer, R., and Sedlatschek, K., Tungsten Alloys of High Melting Point: Jour. Less Common Metals, vol. 1, No. 1, 1959, pp. 19–33.

vestigations of certain properties and methods for testing these properties were published.[13]

An article describing research on the use of tungsten disulfide as a lubricant,[14] a tungsten bibliography,[15] and a report on the determination of interstitial gases[16] were also published.

Little activity was noted in the field of exploration. Instead, the emphasis was on extractive technology to facilitate recovery of values from low-grade ore.

A new 32,000-ton-per-day byproduct plant to recover tungsten, tin, and pyrite at the Climax, Colo., molybdenum mine of Climax Division, American Metal Climax, Inc., was described.[17] Another report outlined the problems to be solved in recovering tungsten commercially from the brines of Searles Lake in California.[18] This lake is estimated to contain 170 million pounds of WO_3, or nearly as much as the total known U.S. reserve of ore that can be mined at foreseeable prices. However, the WO_3 concentration is only about 70 parts per million.

Tungsten deposits in New Mexico and four counties of Arizona were described in Bureau publications,[19] and a geochemical technique was given for tungsten prospecting.[20]

A comprehensive review of tungsten milling methods, used in the 1955–56 period of high production, was published.[21] Flowsheets, reagents, and process descriptions were included.

---

[13] Tietz, T. E., Wilcox, B. A., and Wilson, J. W., Mechanical Properties and Oxidation Resistance of Certain Refractory Metals: Stanford Research Inst., Tech. Rept. to Dept. of the Navy, Bureau of Aeronautics, Contract Noas 58–366–d, Jan. 30, 1959, pp. 164–186.

Schwartzberg, F. R., Ogden, H. R., and Jaffee, R. I., Ductile-Brittle Transition in the Refractory Metals: Battelle Memorial Inst., DMIC Rept. 114, June 25, 1959, pp. 44–50.

Moon, Donald P., and Simmons, Ward F., Methods for Conducting Short-Time Tensile, Creep, and Creep-Rupture Tests Under Conditions of Rapid Heating: Battelle Memorial Inst., DMIC Rept. 121, Dec. 28, 1959, 38 pp.

[14] Lavik, M. T., Gross, G. E., and Vaughn, G. W., Investigation of the Mechanism of Tungsten Disulfide Lubrication in Vacuum: Lubrication Eng., vol. 15, No. 6, June 1959, pp. 246–249, 264.

[15] Sylvania Electric Products, Inc., Bibliography of Tungsten References: 1959, 44 pp.

[16] Fagel, J. E., Smith, H. A., and Witbeck, R. F., Determination of Oxygen, Hydrogen, and Nitrogen in Refractory Metals: Anal. Chem., vol. 31, No. 6, June 1959, pp. 1115–1116.

[17] Burk, Snell G., New Plant Recovers Tungsten, Tin and Pyrite from Moly Flotation Tailing: Min. World, vol. 21, No. 12, November 1959, pp. 38–43.

[18] Carpenter, L. G., and Garrett, D. E., Tungsten in Searles Lake: Min. Eng., vol. 11, No. 3, March 1959, pp. 301–303.

[19] Dale, V. B., and McKinney, W. A., Tungsten Deposits of New Mexico: Bureau of Mines Rept. of Investigations 5517, 1959, 72 pp.

Dale, V. B., Tungsten Deposits of Yuma, Maricopa, Pinal, and Graham Counties, Ariz.: Bureau of Mines Rept. of Investigations 5516, 1959, 68 pp.

[20] Theobald, P. K., Jr., and Thompson, C. E., Geochemical Prospecting with Heavy-Mineral Concentrates Used to Locate a Tungsten Deposit: Geol. Survey Circ. 411, 1959, 13 pp.

[21] Zadra, J. B., Milling and Processing Tungsten: Bureau of Mines Inf. Circ. 7912, 1959, 120 pp.

Uranium

By James Paone[1]

⁂

URANIUM-ore production in 1959 was the highest in history. Domestically, over 1,000 mines produced nearly 7 million tons of ore valued at $141 million. The ore was processed by 24 mills and yielded 16,390 tons of concentrate valued at $300 million.

Free-world uranium production totaled over 43,000 tons of U_3O_8 (uranium oxide), as compared with about 36,000 tons in 1958, and 23,000 tons in 1957. Mine and mill production of uranium increased in nearly every uranium-producing country. The United States was the leading producer, followed by Canada and the Union of South Africa.

Uranium was used chiefly for military applications, but peaceful uses of the commodity were being investigated and developed. A total of 18 civilian power reactors were in operation, under construction, or under development in the United States by the end of the year. The first nuclear-powered merchant ship was launched, and 37 nuclear submarines and 3 nuclear naval vessels were in operation, under construction, or authorized. Small reactors were being built for remote military locations.

The United States broadened its cooperation in sharing data about peaceful uses of atomic energy with foreign countries in 1959 through agreements with European Atomic Energy Community (Euratom), the International Atomic Energy Agency (IAEA), the Inter-American Nuclear Energy Commission, and the Organization for European Economic Cooperation (OEEC).

LEGISLATION AND GOVERNMENT REGULATIONS

The modified uranium-purchase program, announced by the Atomic Energy Commission (AEC) November 24, 1958, made provision for purchasing appropriate quantities of U_3O_8 in acceptable concentrates at the established price of $8 per pound; production and delivery would be made during April 1, 1962, to December 31, 1966. The provision was applicable only to reserves developed before November 24, 1958. AEC stated that it would make contracts to purchase concentrates from reserves developed after November 24, 1958, only so far as required, and only on such terms and conditions and at such prices as the AEC may decide upon from time to time.

A suitable market for independent ores has been provided in contracts between AEC and milling companies covering the purchase of

---

[1] Commodity specialist.

uranium concentrates. Contracts stipulating delivery of ore before April 1, 1962, require the milling company to pay prices for ore that are no less favorable to the seller, than are the established prices in the Domestic Uranium Program Circular 5, Revised. New contracts or renegotiated contracts require that the ore treated shall be produced from specified properties at specified rates.

The AEC filed notice May 18 with the Federal Register, fixing August 1, 1959, as the final date, for those who wished to be considered in negotiations for uranium concentrate procurement for the 1962–66 period, to submit data about ore reserves developed by November 24, 1958. On August 14 the deadline was extended to October 1, 1959, for those who could reasonably justify need for such an extension.

No exploration contracts for uranium properties were made by Office of Minerals Exploration (OME). Uranium exploration contracts under Defense Minerals Exploration Administration, predecessor of OME, totaled $7 million—of which the Government advanced $3.86 million.

DOMESTIC PRODUCTION

Mine Production.—Uranium-ore production in the United States reached a new high in 1959, totaling 6.9 million dry tons valued at $141 million, a 33-percent increase over 5.2 million tons valued at $116 million mined in 1958. The United States regained first place among free-world producers. Producing States in order of value of mine production were New Mexico, Utah, Colorado, Wyoming, Arizona, Washington, Oregon, Alaska, South Dakota, Nevada, Montana, Idaho, California, New Jersey, and Texas. New Jersey production was a test shipment and is excluded from table 1.

Bonus payments to mine operators for initial production from mining properties were $15.8 million from inception of the program in March 1951 through December 31, 1959. May 14, AEC published a notice in the Federal Register (F.R., title 10, pt. 60, sec. 60.6) modifying Domestic Uranium Program Circular 6. The notice permitted orderly termination of the initial production program March 31, 1960 (its expiration date). Although no bonus will be paid for ores delivered after March 31, 1960, additional time will be given uranium producers to file applications for certification and bonus payments on prior deliveries.

TABLE 1.—Uranium mine production in 1959

State	Short tons	Average grade, percent U_3O_8	U_3O_8, pounds	Total value f.o.b. mine (thousands)
Alaska, California, Idaho, Montana, Texas	14,354	0.67	193,827	$888
Arizona	253,390	.30	1,513,409	6,309
Colorado	1,044,089	.26	5,489,347	22,471
New Mexico	3,269,826	.21	13,658,906	53,463
Nevada, Washington, Oregon	232,298	.16	790,501	2,617
South Dakota	45,734	.19	171,449	606
Utah	1,210,654	.36	8,600,316	37,310
Wyoming	864,582	.25	4,337,433	17,686
Total	6,934,927		34,755,188	141,350

Mill Production.—Uranium-concentrate production in 1959 totaled 16,390 tons of U_3O_8 valued at about $300 million. This represents a 30-percent increase over 12,560 tons of U_3O_8, valued at $238 million, produced in 1958.

Concentrate was produced by 24 operating mills. The AEC-owned uranium mill at Monticello, Utah, was shut down in December; however, the AEC ore-buying station was to stay open until arrangements could be made with private mills in the area to buy roscoelite and carnotite ores from mine operators desiring to ship such ores to Monticello as provided by Circular 5, Revised. Also, during the year, existing contracts between AEC and certain mills were changed as follows: The Anaconda Co., Grants, N. Mex., and Uranium Reduction Co., Moab, Utah, extended to December 31, 1966; Gunnison Mining Co., Gunnison, Colo., and Kerr-McGee Oil Industries, Inc., Shiprock, N. Mex., modified and extended to December 31, 1962, and June 30, 1965, respectively.

TABLE 2.—Uranium processing plants, December 31, 1959

Company—mill location	Percent of total	Present contract terminates	Tons of ore per day	Estimated cost of mill (thousands)
ARIZONA	1.3			
Rare Metals Corp. of America, Tuba City		Mar. 31, 1962	300	$3,600
COLORADO	17.1			
Climax Uranium Co., Grand Junction		July 31, 1960	330	3,088
Cotter Corp., Canon City [1]		Feb. 28, 1965	200	1,800
Gunnison Mining Co., Gunnison		Mar. 31, 1962	200	2,025
Trace Elements Corp., Maybell		do	300	2,208
Union Carbide Nuclear Co., Rifle		do	1,000	8,500
Union Carbide Nuclear Co., Uravan		do	1,000	5,000
Vanadium Corp. of America, Durango		do	750	813
NEW MEXICO	47.9			
The Anaconda Co., Bluewater		do	3,000	19,358
Homestake-New Mexico Partners, Grants		do	750	5,325
Homestake-Sapin Partners, Grants		June 30, 1963	1,500	9,000
Kermac Nuclear Fuels Corp., Grants		Dec. 31, 1966	3,300	16,000
Kerr-McGee Oil Industries, Inc., Shiprock		June 30, 1965	300	3,161
Phillips Petroleum Co., Grants		Dec. 31, 1966	1,725	9,500
OREGON	.9			
Lakeview Mining Co., Lakeview		Nov. 30, 1963	210	2,600
SOUTH DAKOTA	1.8			
Mines Development, Inc., Edgemont		Mar. 31, 1962	400	1,900
UTAH [2]	14.0			
Texas-Zinc Minerals Co., Mexican Hat		Dec. 31, 1966	1,000	7,000
Uranium Reduction Co., Moab		Mar. 31, 1962	1,500	11,172
Vitro Chemical Co., Salt Lake City		do	600	5,500
WASHINGTON	1.8			
Dawn Mining Co., Ford		do	400	3,100
WYOMING	15.2			
Federal-Radorock-Gas Hills Partners, Gas Hills		Dec. 31, 1966	522	3,370
Globe Mining Co., Natrona County [1]		do	492	3,100
Lucky Mc Uranium Corp., Gas Hills		Mar. 31, 1962	980	6,900
Susquehanna-Western, Inc., Riverton		Nov. 30, 1963	500	3,500
Western Nuclear Corp., Split Rock		Mar. 31, 1962	845	4,300
Total	100.0		22,104	141,820

---

[1] Under construction.

[2] AEC-owned mill at Monticello shut down in December.

AEC negotiated for new mills in North Dakota, South Dakota, Nevada, southeast Texas, Wyoming, and the Colorado Front Range. This action was in keeping with the limited-expansion program announced April 2, 1958, providing an ore market in certain areas with developed reserves but either an inadequate market or none at all. As a result of negotiations, AEC and five firms agreed upon specific additional milling capacity for mills in Wyoming and the Colorado Front Range as follows:

TABLE 3.—Authorized additional milling capacity by AEC, tons per day

	Former rate	Added rate	New rate
WYOMING			
Lucky Mc Uranium Corp., Fremont County	833	147	980
Western Nuclear Corp., Split Rock	444	401	845
Federal-Radorock-Gas Hills Partners, Fremont County [1]		522	522
Globe Mining Co., Riverton [2]		492	492
Total	1,277	1,562	2,839
COLORADO FRONT RANGE			
Cotter Corp., Canon City, Colo	[3] 50	150	200

[1] Formerly Federal Uranium Corp.
[2] Subsidiary of Union Carbide Nuclear Co.
[3] Pilot plant.

NOTE: Resulting from reappraisal of ore supply at several mills in Wyoming, adjustment was made in capacity of Lucky Mc mill; and Susquehanna-Western, Inc. (formerly Fremont Minerals, Inc.), Riverton, Wyo., postponed its plans for added capacity.

Several firms that had expressed interest in building uranium mills in southeast Texas, Nevada, and the North Dakota-South Dakota lignite area did not reach agreements with AEC. Columbia-Southern Chemical Corp. and others reportedly continued to negotiate with AEC for a mill in southeast Texas at yearend.[2] Owing to technical and economic problems, no action was taken during the year by interested firms to provide milling facilities for Nevada or for the North Dakota-South Dakota area.

Domestic uranium-concentrate procurement from fiscal year 1943 through fiscal year 1959 was over 45,000 tons of U_3O_8; foreign procurement during this period totaled 80,750 tons. The slight peaks in figure 1 for fiscal years 1954 and 1958 indicate beginning deliveries from South Africa and Canada, respectively.

Concentrate receipts from domestic sources in 1959 constituted about 45 percent of the total procurement; they are expected to exceed receipts from foreign sources in fiscal year 1961. From the beginning of the atomic-energy program to July 1, 1955, 83 percent of uranium purchased by the United States came from foreign sources. Between July 1, 1955, and June 30, 1962, 47 percent of AEC uranium purchases will be from domestic sources and 53 percent from foreign. From June 30, 1962, through December 31, 1966, 84 percent of the uranium that AEC is now committed to buy will come from domestic sources.

Refinery Production.—Three feed-materials plants refined uranium concentrates from foreign and domestic sources. Two refineries were Government-owned plants operated under AEC contracts, and one was

---

[2] Engineering and Mining Journal, vol. 160, No. 7, July 1959, p. 124.

TABLE 4.—United States uranium ore and concentrate data, fiscal years 1943–59

Fiscal year	Estimated ore reserves[1] (million short tons)[2]	Ore production		Concentrate procurement (short tons U_3O_8)		Purchases of domestic concentrate		Processing plant investment (thousands)[2]
		Quantity (thousand short tons)	Grade, percent U_3O_8	Domestic origin	Foreign origin	Total cost (millions)	Average cost per pound U_3O_8	
1943–47 inclusive	----------	----------	----------	1,440	10,150	----------	----------	----------
1948	[3] 1.0	54.0	0.31	110	1,960	$1.7	$7.14	$4,200
1949	1.0	89.0	.27	120	1,960	2.0	8.53	6,500
1950	[4] 2.0	230.0	.31	320	2,740	5.8	8.92	7,700
1951	2.0	290.0	.32	630	3,050	12.8	10.01	8,000
1952	3.0	390.0	.32	830	2,830	18.4	11.19	8,300
1953	5.0	610.0	.31	990	1,910	24.2	12.30	11,800
1954	10.0	914.0	.32	1,450	3,240	35.6	12.25	25,400
1955	27.0	1,306.0	.30	2,140	3,800	53.6	12.51	44,300
1956	63.0	2,185.0	.28	4,200	6,240	97.8	11.63	72,100
1957	78.0	3,303.0	.28	7,580	8,580	159.6	10.53	126,800
1958	82.5	4,416.0	.27	10,244	16,132	196.0	9.57	156,200
1959	[4] 88.9	6,117.0	.26	15,162	18,164	280.5	9.25	----------
Total	----------	19,904.0	----------	45,216	80,756	888.0	10.14	----------

[1] Yearend unless otherwise noted.
[2] Figures are cumulative for each year.
[3] January.
[4] July.

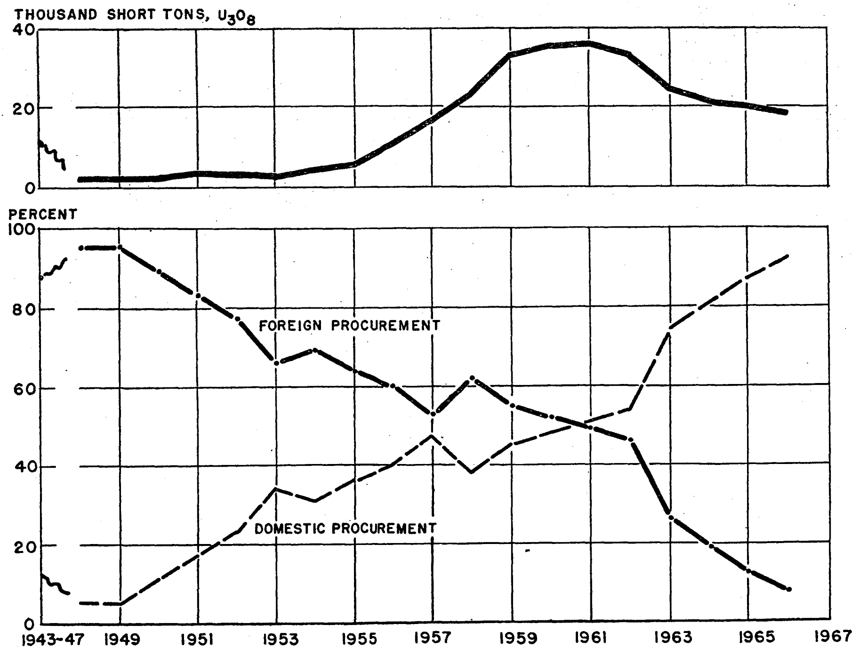

FIGURE 1.—Domestic and foreign U_3O_8 procurement, 1943–67.

privately owned. The operators and locations were as follows: Mallinckrodt Chemical Works, Weldon Spring, Mo.; National Lead Co. of Ohio, Fernald, Ohio; and Allied Chemical Corp. (privately owned), Metropolis, Ill.

TABLE 5.—Employment in domestic uranium mills, fiscal years 1948–59

Fiscal year	Number of employees	Fiscal year	Number of employees
1948	650	1954	1,619
1949	740	1955	1,840
1950	750	1956	2,059
1951	800	1957	2,413
1952	1,020	1958	2,857
1953	1,350	1959	3,185

The original Mallinckrodt plant, replaced by the Weldon Spring plant and placed in a standby condition in June 1958, was being dismantled.

The uranium hexafluoride (UF_6) plant at Metropolis, Ill., owned and operated by the Allied Chemical Corp., began operation in April. The plant converted uranium oxide in concentrates furnished by AEC to UF_6, feed material for the gaseous diffusion plants that concentrate the uranium 235 isotope. This refinery differs from the other two in that it uses a direct fluorination process. The process resulted primarily from research at Argonne National Laboratory on the use of fluid-bed equipment in the uranium feed-materials program.

Firms producing uranium fuel materials commercially included: Davison Chemical Co., of W. R. Grace & Co., Erwin, Tenn.; M&C Nuclear, Inc., Attleboro, Mass.; Mallinckrodt Nuclear Corp., subsidiary of Mallinckrodt Chemical Works, Hematite, Mo.; National Lead Co., Fernald, Ohio; Nuclear Materials and Equipment Corp., Apollo, Pa.; Spencer Chemical Co., Kansas City, Mo.; Vanadium Corporation of America, New York, N.Y.; Var-Lac-Oid Chemical Co., New York, N.Y.; and Vitro Engineering Co., New York, N.Y.

Production of Fissionable Material.—Enriched uranium (U^{235}) was produced in three Government-owned gaseous diffusion plants operated by private industry. They were: Union Carbide Nuclear Co., Oak Ridge, Tenn.; Union Carbide Nuclear Co., Paducah, Ky.; and Goodyear Atomic Corp., Portsmouth, Ohio. Cost of producing nuclear material, excluding cost of raw material, was $713 million in fiscal year 1959; although this was a reduction of $37 million from 1958, the quantity of material produced increased.

Plutonium and related reactor products, intended primarily for use in weapons, were produced by General Electric Co., at the Hanford Works, Hanford, Wash., and by E. I. du Pont de Nemours & Co., Inc., at the Savannah River plant, Aiken, S.C.

Nuclear Fuel Processing.—AEC announced October 15 that it would accept from reactor operators irradiated fuels in unprocessed form, and that it would make financial settlements to provide for reprocessing the spent fuel elements until such services become commercially available. Irradiated fuels would be received for processing at the following AEC facilities: Chemical Processing Plant, National Reactor Testing Station, Idaho; Oak Ridge National Laboratory, Oak Ridge, Tenn.; Savannah River plant, Aiken, S.C.; and Hanford Works, Richland, Wash.

Assignments of fuel elements from specific reactors to the appropriate site were made during the year.

CONSUMPTION AND USES

Uranium was used in AEC programs chiefly as material for weapons production and as fuel for nuclear reactors.

Production Reactors.—Plutonium produced in eight graphite-type production reactors in Hanford, Wash., and in five heavy water-type reactors in Savannah River, S.C., was delivered to the weapons stockpile. In May a contract was awarded to Kaiser Engineers of Oakland, Calif., for construction of the New Production Reactor (NPR) at Hanford, Wash. In contrast to existing reactors the NPR will employ secondary cooling, in which the cooling water is converted to steam for possible production of power at a later date.

Nonmilitary Power Reactors.—A total of 18 civilian stationary power reactors were under construction or development by the end of the year; 2 were operable, 6 were being built, and 10 were planned.

The Shippingport reactor, the first large-scale, nuclear-power producer, was shut down in October for planned replacement of fuel elements; alterations to increase the electrical output from 60,000 135,000 kw. were under consideration. The Dresden reactor went critical in October and reached full power in early 1960. Other large-scale reactors were nearing completion, and some were being planned.

The AEC civilian nuclear-power program was enlarged in 1959 by authorization of several new reactor projects, including an experimental organic-cooled reactor and an experimental prototype, gas-cooled reactor. Also authorized were a boiling-water prototype reactor, two undesignated intermediate-size reactors, and an experimental low-temperature-process heat reactor.

The world's first nuclear-powered merchant ship, the Nuclear Ship *Savannah*, was launched in July. The 595-foot, 22,000-ton vessel is the world's second atomic-powered surface ship; the first was a nuclear-powered icebreaker launched by the U.S.S.R. in 1958.

The economics of atomic powerplants, compared with present-day, conventional powerplants was the subject of several conferences and papers.

The AEC boiling-water reactor at Argonne National Laboratory was undergoing modification that would permit operation at a higher power level; operation was not expected until April 1960. The Sodium Reactor Experiment at Santa Susana was also shut down in October for replacement of a faulty fuel element. Operation with a new core loading was expected in late spring 1960. The Vallecitos boiling-water reactor increased thermal output from 20 to 30 megawatts. Data obtained from the Vallecitos reactor were used in support of the 180,000-kw. Dresden nuclear-power station, the largest all-nuclear-power station announced in the United States. Modifications involving fuel handling, building, and support facilities to the organic-moderated reactor experiment (OMRE) were made in support of the larger Piqua organic-moderated reactor. Aqueous fuel systems were investigated by experiments with the homogeneous reactor experiment (HRE-2) and with the Los Alamos power experiment (LAPRE-2). Research on breeder reactors continued with operation of the experimental-breeder reactor (EBR-1) and the Argonne fast-source reactor (AFSR).

TABLE 6.—Power reactors and reactor experiments operable or under construction, 1959

Designation and operator	Date critical	Type	Capacity (kw.)	Location
OPERATING				
Dresden Nuclear Power Station (Commonwealth Edison Co.)	1959	Boiling water	180,000	Morris, Ill.
Shippingport Atomic Power Station (AEC and Duquesne Light Co.)	1957	Pressurized water	60,000	Shippingport, Pa.
Experimental Boiling Water Reactor (AEC).	1956	Boiling water	4,500	Lemont, Ill.
Vallecitos Boiling Water Reactor (General Electric Co. and Pacific Gas & Electric Co.).	1957	do	5,000	Pleasanton, Calif.
Sodium Reactor Experiment (AEC and Southern California Edison Co.).	1957	Sodium graphite	6,000	Santa Susana, Calif.
Organic Moderated Reactor Experiment (AEC).	1957	Organic moderated	None	Arco, Idaho.[1]
Homogeneous Reactor Experiment No. 2 (AEC).	1957	Aqueous homogeneous	300	Oak Ridge, Tenn.
Experimental Breeder Reactor No. 1.	1957	Fast breeder	150	Arco, Idaho.[1]
Los Alamos Molten Plutonium Reactor Experiment (AEC).	1959	Fast-molten plutonium, sodium-cooled.	None	Los Alamos, N. Mex.
Stationary Medium Power Plant No. 1 (Formerly APPR-1) (Army).	1957	Pressurized water	1,855	Fort Belvoir, Va.
UNDER CONSTRUCTION				
Experimental Breeder Reactor No. 2.	1960	Fast breeder	16,500	Arco, Idaho.[1]
Consolidated Edison Thorium Reactor.	1960	Pressurized water	151,000	Indian Point, N.Y.
Enrico Fermi Atomic Power Plant (Power Reactor Development Co.)	1960	Fast breeder	90,000	Lagoona Beach, Mich.
Yankee Atomic Electric Co	1960	Pressurized water	110,000	Rowe, Mass.
AEC and Rural Cooperative Power Association.	1961	Boiling water	22,000	Elk River, Minn.
Hallam Nuclear Power Facility (AEC and Consumers Public Power District).	1962	Sodium graphite	75,000	Hallam, Nebr.
AEC & City of Piqua, Ohio	1961	Organic moderated	11,400	Piqua, Ohio.
Boiling Reactor Experiment No. 5	1961	Light water	2,000	Arco, Idaho.[1]
Stationary MediumPower Plant No. 1A (Army).	1960	Pressurized water	1,700	Fort Greely, Alaska.
Portable Medium Power Plant No. 1 (AF-AEC).	1961	do	1,000	Sundance, Wyo.
Portable Medium Power Plant No. 2 A (Army).	1961	do	1,500	Arctic location.

[1] National Reactor Testing Station.

Military Reactors.—At the end of the year, the U.S. Navy had 37 nuclear submarines and 3 nuclear surface ships in operation, under construction, or authorized. Naval vessels operating in 1959 were the submarines *Nautilus*, *Skate*, *Swordfish*, *Sargo*, *Skipjack*, *Seadragon*, *Triton*, *Halibut*, and *George Washington*. Submarines *Scorpion*, *Patrick Henry*, *Theodore Roosevelt* and *Robert E. Lee* and the guided-missile cruiser, *Long Beach*, were launched; 19 submarines were under construction and the *Seawolf* powerplant was being converted from a sodium-cooled to a pressurized-water nuclear reactor. Also being built were the aircraft carrier, *Enterprise*, to be powered by eight reactors and the guided-missile destroyer, *Bainbridge*, with two reactors. The submarine *Triton* and the cruiser *Long Beach* each have two reactors.

The Army reactor program continued development of compact, lightweight, power and heat reactors capable of being set up rapidly at minimum cost in remote military installations. A total of 10 prototypes, experiments, and field plants were operable in 1959, 5 were being built and 13 were planned; 3 units formerly operated were dismantled. In addition, three military research and test reactors were operable, four were being built, and three were planned.

Designation of the Army Package Power Reactor (APPR–1) Fort Belvoir, Va., was changed to Stationary Medium powerplant No. 1 (SM–1). The SM–1 was shut down in March to permit visual inspection and metallurgical examination of its components. The Army and AEC were building a reactor SM–1A similar to the SM–1, at Fort Greely, Alaska, and a Portable Medium powerplant (PM–2A) at an undisclosed Arctic location. The Air Force and AEC were building a Portable Medium powerplant (PM–1) at Sundance, Wyo. The Army and Air Force reactors are designed to produce space heat as well as electricity.

A contract to perform design and engineering studies on reactors for remote overseas installations was awarded to Kaiser Engineers, Oakland, Calif.

The AEC continued work on nuclear powerplants for both manned aircraft and unmanned space vehicles.

Research and Test Reactors.—Four general test reactors, Materials Testing Reactor and Engineering Test Reactor, at Arco, Idaho, General Electric Co. Testing Reactor, Pleasanton, Calif., and the Westinghouse Testing Reactor, Waltz Mill, Pa., were operable. National Aeronautics and Space Agency completed a general test reactor at Sandusky, Ohio. In addition 53 civilian research and training reactors and 10 specialized test reactors were operable in the United States on December 31, 1959; 47 were under construction, and 12 were planned.

Radioisotopes.—Uses of radioisotopes continued to increase. Shipments from AEC laboratories totaled over 245,000 curies, compared with 228,000 curies in 1958 and 166,000 curies in 1957. Because of price reductions, gross income from radioisotope sales by the AEC declined from $2.6 million in 1958 to $2.4 million in 1959. Total quantity of radioisotopes shipped since the isotope distribution program began in 1946 was nearly 860,000 curies.

Many shipments from AEC laboratories were to commercial firms which reprocessed the isotopes to supply tracers, industrial radiography, and gaging sources, as well as labeled pharmaceuticals for medical applications. About 5,500 organizations and individuals in the United States possessed byproduct-material licenses, a 26-percent increase over the total for 1958 and 62 percent over 1957. Of licensed users of radioisotopes in 1959, 42 percent were medical, 30 percent industrial, 21 percent research and development, and 7 percent others.

A special report on radioisotopes by the AEC was prepared for publication early in 1960.[3]

A catalog to aid the users of isotopes was prepared during the year.[4]

Weapons.—Production of nuclear weapons continued under Presidential direction. Emphasis for research and development of nu-

---

[3] Atomic Energy Commission, Radioisotopes in Science and Industry: January 1960, 176 pp.

[4] Atomic Energy Commission, Special Sources of Information on Isotopes: TID–4563 (2d Rev.) Tech. Inf. Service Extension, Oak Ridge, Tenn., Jan. 1, 1960, 54 pp.

clear weapons was on smaller, immediately ready, and more rugged weapons for use in advanced-weapons systems. A new $5.9-million facility for support of the weapons function of the E. O. Lawrence Radiation Laboratory (Livermore Branch) was occupied in 1959. No nuclear-explosion tests were made during the year.

As part of the program on detection of the seismic effects resulting from nuclear explosions, the first of a series of nonnuclear high-explosive tests was detonated in December in the Carey Company salt mine near Winnfield, La.

Other Uses.—Civil uses of nuclear explosives under the Plowshare Program, such as mining, excavating, and producing of power and isotopes, continued to be studied.

Research, chiefly by Government agencies, was initiated on possible uses of depleted uranium. Vitro Manufacturing Co., Pittsburgh, Pa., a division of Vitro Corp. of America, announced the use of uranium in production of brilliant yellow, orange, and green glazes.[5]

PRICES AND SPECIFICATIONS

Uranium Ore and Concentrate.—Purchase prices for uranium ore established by AEC remained in effect during 1959. Minimum base prices for ores of various types and grades were guaranteed under AEC Domestic Uranium Program Circular 5 (revised), which expires March 31, 1962; initial production bonus on the first 5 tons of U_3O_8 sold from an eligible mining property was guaranteed under Circular 6, which expired March 31, 1960. Haulage and mine-development allowances remained in effect. Circulars 5 (revised) and 6 were published in the Uranium and Radium chapter of the 1954 Minerals Yearbook and in Part 60, Title 10, Code of Federal Regulations.

Average prices paid by AEC for domestic uranium concentrate from fiscal years 1948 through 1959 are shown in table 3. Average price paid for this period was $10.14 per pound of U_3O_8. A rise in concentrate price from 1948 to 1955 was attributed to increase in ore price and an amortization factor involved in construction of new mills. Improved metallurgical processes and larger milling operations beginning in 1956 resulted in lower unit costs for concentrate. From April 1, 1962, to December 31, 1966, the AEC established a base price of $8 per pound of U_3O_8 contained in concentrates meeting specifications.

Uranium Metal.—Price of natural uranium metal made available by AEC to qualified and licensed buyers remained at $40 per kilogram.

Special Nuclear Materials.—Charges for U^{235} in the form of UF_6, in varying degrees of enrichment ranged from $5.62 per gram of contained U^{235} for material with 0.72 percent U^{235} weight fraction to $17.07 for material with 90 percent U^{235} weight fraction.

Base charges for plutonium and U^{233} remained at $12 and $15 per gram, respectively; in each instance the annual lease charge was 4 percent of the base charge.

Depleted Uranium.—Prices for depleted uranium furnished by AEC as UF_6, f.o.b., Paducah, Ky., varied from $5 per kilogram of uranium,

---

[5] Ceramic Age, vol. 73, No. 1, January 1959, p. 41.

assaying 0.0036 and lower weight fraction of U^{235}, to \$38.45 per kilogram assaying 0.0070 weight fraction.

Radioisotopes.—Adjustments in AEC prices for certain isotopes were made during the year. Carbon 14 was reduced to \$13 per millicurie from its former price of \$22 to \$28 per millicurie; chlorine 36 per microcurie, \$0.50, reduced from \$1; thallium 204 per millicurie, \$1, reduced from \$5; iridium 193 (sources) per curie, \$6, reduced from \$15; calcium 45 per millicurie, \$6.50, increased from \$5; copper 64 per millicurie, \$0.80, reduced from \$0.60; gold 198 per millicurie, \$0.06, increased from \$0.02; iron 59 per millicurie, \$30 reduced from \$50; sodium 24 per millicurie, \$7, increased from \$2; yttrium 90 per millicurie, \$3, increased from \$2; and iodine 131 per millicurie, \$0.30, reduced from \$0.40.

Uranium Concentrate Specifications.—Specifications shown in the uranium chapter of Minerals Yearbook for 1958 remained in effect.

FOREIGN TRADE

Uranium from foreign sources supplied over 52 percent of the Nation's requirements in 1959, as compared with 60 percent in 1958. Deliveries to the United States during 1959 totaled 18,120 tons of contained U_3O_8; of this quantity, 13,680 tons was imported from Canada and the rest from Australia, Belgian Congo, Portugal, and Union of South Africa under contracts of the Combined Development Agency. (See fig. 1.)

To encourage foreign trade in the nuclear-power industry, AEC announced in February a deferred-payment arrangement for power-reactor fuel supplied to non-Euratom countries. This policy would apply to projects whose combined electrical-generation capacity did not exceed 500 megawatts and was intended to reduce the initial capital cost of purchasing nuclear-fuel inventories. By the end of the year, U.S. manufacturers had built or were building 38 research reactors for foreign countries. In addition domestic firms were building three power reactors in foreign locations, one each in Belgium, The Federal Republic of Germany, and Italy. The value of research reactors authorized for export during 1959 was estimated at \$54 million.

The AEC contracted to sell to Belgium a total of 10 kilograms of uranium enriched to nearly 20 percent U^{235}. Cost of the material to be used in a research reactor in the Belgian Congo is approximately \$32,000. Mallinckrodt Nuclear Corp. agreed to manufacture and supply uranium metal for a British submarine, the HMS *Dreadnought*. This event marked the first commercial transaction in the free world of uranium metal for nuclear military propulsion; Mallinckrodt also contracted to deliver 20,000 pounds of uranium dioxide (UO_2) to General Electric Co. for conversion to pellet form. The uranium pellets were to be used to fuel the 15,000-kw. reactor under construction at Kahl, West Germany.

WORLD REVIEW

Total free-world production of uranium was over 43,000 tons of uranium oxide; the North American continent supplied about 75 percent of output. Nearly every uranium-producing country mined a greater quantity in 1959 than in 1958. Total production of uranium in 1959 increased 20 percent over production in 1958 and 85 percent above that in 1957. Over 65 uranium mills were processing about 125,000 tons of ore per day.

IAEA increased its number of members States from 69 to 70 during the year. Agreements between IAEA and the United States, United Kingdom, and the U.S.S.R. came into effect; these provided for the transfer to IAEA of quantities of nuclear materials which were to be used in meeting requests from member States. In the first fuel transaction agreed upon, Canada donated about 3 tons of natural uranium to IAEA for sale to Japan at $35.50 per kg. IAEA received 74 requests for technical assistance from 24 countries and sent approximately 30 experts to member States for periods ranging from 3 months to 1 year.

TABLE 7.—Free-world production of uranium oxide (U_3O_8), by countries,[1] in short tons [2]

[Compiled by Augusta W. Jann]

	1956	1957	1958	1959
North America:				
Canada	2,280	6,635	13,400	15,910
United States	6,000	8,640	12,560	16,390
South America:				
Argentina [3]	20	20	25	25
Colombia [3]	----------	----------	----------	3
Europe:				
Finland [3]	----------	----------	----------	20
France [3]	----------	465	865	1,000
Germany, West [3]	----------	----------	----------	3
Sweden	6	10	10	[3] 10
Africa:				
Belgian Congo [3]	1,300	1,300	2,300	2,300
Madagascar [3]	----------	70	95	100
Rhodesia and Nyasaland, Federation of	----------	25	50	[3] 35
Union of South Africa	4,365	5,700	6,245	6,445
Oceania:				
Australia [3]	300	400	700	1,000
Free-world total (estimate) [1] [2]	14,470	23,470	36,450	43,450

[1] In addition to countries listed, uranium is also known to have been produced in Italy, Japan, Morocco Mozambique, Portugal, and Spain, but production data are not available. An estimate for these countries has been included in the world total. Colombia, Finland, West Germany, Belgian Congo, and Rhodesia do not produce concentrate; figures are based on ore production. Statistics for France are converted from metal production data.

[2] This table incorporates several revisions of data published in previous Uranium chapters. Data do not add to the exact total shown because of rounding where estimated figures are included in total.

[3] Estimate.

NORTH AMERICA

Canada.—Canadian-uranium production totaled 15,904 tons of U_3O_8 valued at $325 million, compared with 13,482 tons valued at $280 million in 1958, and its value exceeded that of any other metal in 1959. Nearly all production was exported under existing contracts (expiring March 1962 and March 1963) with the United States and the United Kingdom. The United States and the United Kingdom decided on November 6 to drop their options on Canadian potential production from 1963 to 1966. As a result of this decision, the Canadian Government announced a change in policy with respect to the supply of uranium under existing contracts. Arrangements were made by Eldorado Mining and Refining, Ltd. of Canada, the

Government purchasing agent, with the U.S. Atomic Energy Commission (AEC) and the United Kingdom Atomic Energy Authority (AEA), to allow a stretchout of uranium deliveries to December 31, 1966.

To implement the stretchout of Canadian production, transfers of uranium-sales contracts between the Canadian companies now in production would be permitted, and Eldorado established the principal technical conditions governing acquisition of the undelivered portion of a special-price contract by any producer:

1. Deliveries to Eldorado by the acquiring producer will continue at a rate no greater than its present contract rate.
2. The basic price for any uranium acquired will be the price, or prices, in the contract from which it is acquired.
3. Except for uranium that bears a U.S. price of $8 per pound, Eldorado will offer advance payments of $2.50 per pound of U_3O_8 in respect of each pound of uranium deferred. The advance payments will be made about the same time as delivery of the uranium would have been made, had there been no deferment. The advances were made possible by similar advances to Eldorado by AEC and AEA. In addition, AEA offered to make an additional advance payment of $1.50 per pound on any portion up to 16 million pounds of the amount covered by existing contracts, which can be deferred into January 1965 through November 1966.
4. Specifications for uranium concentrates to be delivered under the new arrangements will differ slightly from those in existing contracts.
5. All uranium delivered under the new arrangements must be derived from mining claims or properties (or areas, for a producer that operates a custom mill), which are specifically referred to in the existing special-price contracts under which deliveries have been made to Eldorado.

In accordance with a longstanding agreement with Eldorado Mining and Refining, Ltd. of Canada, AEC amended its contracts to procure additional amounts of U_3O_8 in concentrates before March 31, 1962, from certain Canadian producers. These amendments, which do not represent new commitments to procure uranium concentrates from Canada, provide for amounts from producers listed as follows:

Producer	Thousand pounds U_3O_8
Gunnar Mines, Ltd	4,500
Pronto Uranium Mines, Ltd	1,508
Algom Uranium Mines, Ltd	2,456
Bicroft Uranium Mines, Ltd	260

The price per pound U_3O_8, Gunnar Mines, in Can $8.75; for Pronto Algom, and Bicroft mines, US $8.

Uranium sales under the Government's program, which permits sales of up to 2,500 pounds of uranium to any country not having a bilateral agreement, were made to Japan, Italy, and Norway. Bilateral agreements for uranium procurement were made with Japan, West Germany, Switzerland, Belgium, France, the Netherlands, Luxembourg, and Italy.

At the end of the year, 19 uranium mines and 17 mills were in operation; 3 mines and 2 mills curtailed operations.

A 20,000-kw. reactor being built jointly by Atomic Energy of Canada, Ltd., The Hydro-Electric Power Commission of Ontario, and General Electric Company, Ltd., was expected to begin operation in 1961. The reactor is a prototype for a 200,000 kw. nuclear powerplant scheduled for completion by 1965. Canada had three reactors in operation and three being planned or under construction.

TABLE 8.—Canadian uranium mines and mills[1]

Company and area	First production	Milling capacity, tons a day	Ore reserves, all categories, thousand tons	Grade, percent U_3O_8
BANCROFT AREA, ONTARIO				
Bicroft Uranium Mines, Ltd	Nov. 1956	1,400	1,500	0.095
Canadian Dyno Mines, Ltd	May 1958	1,400	2,250	.08
Faraday Uranium Mines, Ltd	Apr. 1957	1,600	2,000	.09
Greyhawk Uranium Mines, Ltd.[2]	Sept. 1957	(3)	200	.065
BLIND RIVER, ONTARIO				
Algom Uranium Mines, Ltd.:				
Nordic mine	Jan. 1957	3,700	12,040	.11
Quirke mine	Sept. 1956	3,000	15,510	.124
Can-Met Explorations, Ltd	Oct. 1957	3,000	8,360	.092
Consolidated Denison Mines, Ltd	Sept. 1957	6,000	136,785	.139
Milliken Lake Uranium Mines, Ltd	Mar. 1958	3,100	6,130	.099
Northspan Uranium Mines, Ltd.:				
Lacnor mine	Sept. 1957	4,800	9,770	.096
Panel mine	Mar. 1958	3,100	7,840	.11
Spanish American mine[2]	Mar. 1958	2,000	8,000	.10
Pronto Uranium Mines, Ltd	Oct. 1955	1,500	1,810	.128
Stanleigh Uranium Mining Corp., Ltd	Mar. 1958	3,300	12,060	.093
Stanrock Uranium Mines, Ltd	Mar. 1958	3,300	9,080	.10
BEAVERLODGE LAKE AREA, SASKATCHEWAN				
Cayzor Athabaska Mines, Ltd	May 1957	(3)	250	.30
Eldorado Mining and Refining, Ltd	Apr. 1953	2,000	3,500	.22
Gunnar Mines, Ltd	Sept. 1955	2,000	3,000	.185
Lake Cinch Mines, Ltd	May 1957	(3)	200	.324
Lorado Uranium Mines, Ltd	May 1957	750	----------	----------
Rix-Athabasca Uranium Mines, Ltd	Apr. 1954	(3)	50	.21
NORTHWEST TERRITORIES				
Eldorado Mining and Refining, Ltd. (Port Radium, Great Bear Lake).	1942	300	100	.58
Rayrock Mines, Ltd.[2] (Marian River Area)	June 1957	150	nil	----------

[1] Purchase contracts with Eldorado listed in Uranium chapter, Minerals Yearbook 1957.

[2] Spanish American mine, Greyhawk Uranium Mines, Ltd., and Rayrock Mines, Ltd., ceased operations in 1959.

[3] No mill.

Note: Total reserves for all mines have not been published, but it is estimated that an additional 88 million tons grading 0.10 percent of possible or inferred ore can be added to the total of those in the table, giving a grand total of 327,465,624 tons averaging 0.12 percent U_3O_8.

A comprehensive report, including history, geology, reserves, and production of the uranium mines and mills in Canada was published.[6]

Northwest Territories.—Uranium reserves at Eldorado's Port Radium mine, only 30 miles south of the Arctic Circle, were becoming exhausted, and based on the current rate of production would be depleted by the end of 1960. Rayrock Mines, Ltd., depleted its uranium reserve during the year, and the mine was shut down July 31.

Ontario.—Principal uranium mining area in Canada was the Blind River area, also known as the Elliot Lake district. Algom Uranium Mines, Ltd., increased the efficiency of milling operations at both the Nordic and the Quirke mills. A major reorganization was being planned for its uranium interests by the Rio Tinto Mining Co. Under the planned merger, Algom Uranium Mines, Milliken Lake Uranium Mines, Pronto Uranium Mines, and Northspan Uranium

---

[6] Griffith, J. W., A Survey of the Uranium Industry in Canada: Department of Mines and Tech. Surveys, Ottawa, November 1959, 94 pp.

Mines would consolidate into a new firm, The Rio Algom Mine, Ltd. Under the Eldorado contracts of the four companies, it was estimated that about 34.4 million pounds of uranium concentrates were still to be delivered at the end of 1959. Proved and probable ore reserves of Rio Algom were estimated at 47.3 million tons, averaging 2.31 pounds of U_3O_8 per ton, or a total content of over 100 million pounds.

Can-Met Explorations, Ltd., achieved a recovery rate of 93 percent at its acid-leach, ion-exchange mill. Consolidated Denison Mines, Ltd., continued to operate the largest uranium mill in the world. The acid-leach, ion-exchange, precipitation-process mill was operating near its capacity of 6,000 tons of ore per day. The reserve at Consolidated Denison was considered to be the largest of any uranium mine in the world. Northspan Uranium Mines, Ltd., ceased production from the Spanish American mine in February, and the mine was put on a care-and-maintenance basis because the other two mines, Lacnor and Panel, owned by Northspan were capable of producing sufficient quantities of uranium oxide to meet the firm's contract requirements. Pronto Uranium Mines, Ltd., a Rio Tinto subsidiary, was expected to exhaust its reserves early in 1962. Stanleigh Uranium Mining Corp., Ltd., finished delivering 23 percent of the concentrate called for under its contract by mid-1959. Sale of the remainder of Stanleigh's contract with Eldorado, or an attempt to acquire other contracts, was being considered.

The Bancroft area of southeastern Ontario had three producing mines with plants capable of treating 4,000 tons of ore a day. Bicroft Uranium Mines, Ltd., in addition to deliveries to Eldorado, stockpiled uranium concentrate for possible private sales. Canadian Dyno Mines, Ltd., and Faraday Uranium Mines, Ltd., continued deliveries of concentrate as scheduled. Faraday increased its mine production to offset the loss of ore from Greyhawk Uranium Mines, Ltd., which closed in April owing to a lack of funds to mine ore of acceptable grade.

Saskatchewan.—Uranium production in Saskatchewan was from the Beaverlodge area near the north shore of Lake Athabasca. Gunnar Mines, Ltd., expected to extract 60 percent of the ore from the Gunnar mine by open pit and 40 percent through a 1,243-foot shaft. Eldorado Mining and Refining, Ltd., of Canada the Crown corporation wholly owned by the Government, continued mining operations through the Ace, Fay, and Verna shafts. Eldorado operated the only alkaline leach mill in Canada; however, it also had a sulfuric acid circuit to treat sulfide ores. Lorado Uranium Mines, Ltd., in addition to treating ore from its own mine, treated custom ores from Cayzor Athabaska Uranium Mines, Ltd., Lake Cinch Mines, Ltd., Rix-Athabasca Uranium Mines, Ltd., and about nine smaller operations.

Mexico.—National Nuclear Energy Commission officials reported that 8,000 tons of radioactive ores were discovered in the State of Chihuahua, 2,000 tons in Sonora, and smaller deposits at other places in Queretaro and Durango.

Uranium has been found in 10 separate areas in the State of Chihuahua however, only 2 deposits were large enough to exploit commercially. The first deposit, in the Sierra de Gomez about 12 miles northeast of the town of Aldama, yielded 2,100 tons of uranium ore in 1958. Of this quantity, 700 tons was shipped to a pilot plant in Mexico City for concentrating. The remaining 1,400 tons of ore was stockpiled in Chihuahua. Of the ore mined, 1,800 tons contained 0.6 to 0.8 percent U_3O_8. The second deposit, recently discovered, is near the Boquilla Chica del Peguis, about 25 miles northwest of the town of Ojinaga. All of the deposits in the State occur in limestone formations.

Press reports stating that the Government is planning to erect a concentrating plant in Chihuahua have been confirmed by the Government; however, a final decision cannot be made until the size and quality of the deposits have been determined.

SOUTH AMERICA

Argentina.—National Atomic Energy Commission continued exploration for and development of uranium deposits. While uranium has been found in numerous and widely separated areas, no significant discoveries were made. Output of uranium ore in 1956 was 6,380 tons with an average grade of 0.249 percent U_3O_8; in 1957 it was 7,340 tons at 0.258 percent U_3O_8; and in 1958 it was 6,130 tons at 0.37 percent U_3O_8. A uranium mine, La Primera, in Rohueco, in the Province of Neuquen was formally opened.[7]

Brazil.—Prospecting was done by the National Nuclear Energy Commission and by other State organizations in the States of Ceara, Rio Grande do Norte, Paraiba, Pernambuco, Bahia, Minas Gerais, Mato Grosso, Santa Catarina, and Rio Grande do Sul. Brazil continued to purchase domestically mined uraniferous ores and by early 1959 had acquired over 10,000 tons of uranium raw materials. Efforts were directed toward extraction of caldasite in the Pocos de Caldas area.[8]

The National Nuclear Energy Commission planned to invite bids early in 1960 on construction of an atomic reactor in south-central Brazil with assistance of IAEA.

Chile.—An organized program of uranium prospecting began in Chile early in 1958 when two geologists from the U.S. AEC assigned to the Instituto de Investigeciones Geologicas, equivalent of the U.S. Geological Survey, carried out several field investigations. No significant discoveries of radioactive minerals were made.[9]

The Sociedad de Minerals Radioactivos, a Government agency, was reportedly undertaking development of six uranium deposits.

Colombia.—Compania Minera de Uranio began commercial production of uranium ore and was expected to export as much as 50 tons of uranium a month for refining in the United States.

EUROPE

The European Atomic Energy Community (Euratom) and the United States agreed in February to cooperate in a joint nuclear-power program. The major objective was to be installation in the

---

[7] Mining Journal (London), vol. 254, No. 6493, Jan. 29, 1960, p. 136.

[8] Talbert, G. E., Preliminary Report on the Uraniferous Zirconium Deposits of the Pocos de Caldas Plateau, Brazil: Engenharia Mineracao E Metalurgia, vol. 27, No. 161, May 1958, pp. 265–269.

[9] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 4, October 1959, p. 38.

Euratom countries (Belgium, France, The Federal Republic of Germany, Italy, Luxembourg, and The Netherlands) of approximately 1 million kw. of nuclear electric power within the next 3 to 5 years, using advanced types of reactors developed in the United States.

Other organizations fostering the development of nuclear power in Europe were OEEC and IAEA.

Belgium.—First delivery of uranium oxides was made to the United States by Société Genérale Métallurgique de Hoboken from ores supplied by Union Minière du Haut Katanga. The Hoboken plant has an annual production capacity of 600 tons of uranium oxide and 150 tons of uranium metal. Belgium Congo deposits had a potential output of 800 to 1,000 tons of uranium a year. The Centre d'Etudes Nucleaires de Mol continued to operate its natural uranium, graphite-moderated research reactor. Also, the Centre continued to construct a high-flux reactor for testing materials and a pressurized-water reactor with a planned output of 11,500 kw. It was reported that Belgium was considering construction of four nuclear-power stations by the end of 1967 with a total electrical capacity of 550 mw.[10]

Czechoslovakia.—Discovery of uranium deposits were reported in eastern Bohemia and northeast of Moravia, at Jihlava.[11] The high-grade uranium deposits in western Czechoslovakia were probably significant contributors to the uranium program of Soviet Russia. Designs for a second reactor having an output of 2,500 kw. were completed. Construction was continued on the first reactor situated in the village of Bohunice.

Finland.—Open-pit uranium mining began on the isthmus between lakes Pielisjarvi and Hoytiainen in northern Karelia. The Finnish ore was shipped to Sweden for treatment. A uranium concentrating plant with a capacity of 100,000 tons of ore per year was under construction in Finland. The plant will use an acid-leach circuit to produce a concentrate with uranium content of 30 percent and be modified later to produce a 60-percent concentrate. The ore ranges from 0.2 to 0.3 percent U_3O_8; initial production rate from the mine is expected to be 30,000 tons of ore a year.

France.—France became the leading producer of uranium in Western Europe. Four ore-treatment plants produced a 60-percent U_3O_8 concentrate, which was shipped to two plants that produce uranium metal. The two plants produced 750 tons of uranium metal in 1959 and were expected to yield as much as 1,200 tons by 1961. In addition to the Le Bouchet plant, which was installed in 1946, a plant near Narbonne at Malvesi, started producing uranium metal in 1959. Although reserves of uranium were said to be sufficient to meet the needs of the nuclear-energy program, France continued to explore for radioactive minerals in France and in the countries of the French community, where a large number of areas seemed promising.[12]

The Marcoule plutonium-production center, which began operations in 1958, continued to separate chemically the plutonium produced in three large graphite-moderated reactors (G1, G2, and G3). Each reactor is charged with 100 tons of natural uranium. About 220 pounds of plutonium was converted annually from the natural ura-

---

[10] Atomic World, Nuclear Energy in Belgium: Vol. 10, No. 3, March 1959, p. 105.

[11] Mining Journal (London), vol. 253, No. 6483, Nov. 20, 1959, p. 513.

[12] Commissariat a l'Energie Atomique, 1945–1960, A Report: January 1960, 73 pp.

nium. The three Marcoule reactors were capable of supplying 50,000 kw. of power.

Electricité de France, the French national power company, was building two power reactors at Avoine, near Chinon, in the Loire valley. The first reactor (EDF1), with a capacity of 65,000 kw., was to be operable by the end of 1960; the second reactor (EDF2), with a capacity of 175,000 kw. was to begin operation late in 1961. A third reactor (EDF3), with 300,000 kw., was scheduled for completion in 1963. The principal objective of the French atomic-energy program is approximately 1 million kw. of nuclear-produced electricity in 1965–66 and 8 million kw. by 1975, at which time nuclear-produced electrical power should represent one-fourth of all electricity produced.

Also under construction in France during the year was a plant for isotopic separation of U^{235}. The plant at Pierrelatte, near Donzere-Mondragon, would produce enriched uranium for reactor use. A pilot plant for isotopic separation of uranium has been in operation since 1957.

A nuclear research center was being constructed at Cadarache; other large nuclear research centers were at Saclay, Fontenay-aux-Roses, and Grenoble. The French AEC employed over 12,000 persons in 1959, compared with 10,700 in 1958 and 9,100 in 1957. During the year it was expected that the 1960 French-AEC program would involve a budget of about $200 million.

Among other atomic-energy developments, the French AEC was preparing several plutonium-type weapons for testing in the Sahara Desert early in 1960.

Germany, East.—Production of uranium ore in East Germany was about 200 tons. The ore was mined by Wismut Corporation, a firm jointly-owned by East Germany and the U.S.S.R. The research reactor near Dresden continued to operate, and radioisotopes for industrial and medical uses were imported from the U.S.S.R.

Germany, West.—Exploration for uranium was accelerated. Although some 15 to 20 firms were engaged in uranium prospecting, only one, the Hanover company, Gewerkschaft Brunhilde, mined uranium ore.

Main uranium areas within West Germany were the Saar-Nahe area, the German-Czech border, and sedimentary areas of Franconia. Uranium has been found in brown coal deposits of Schwandorf in the Upper Palatinate.[13]

The Degussa Company of Frankfort announced an agreement with Mallinckrodt Chemical Works, of St. Louis, whereby Degussa would be sole sales agent in Continental Europe for the United States firm.[14] A research and materials-testing reactor were under construction, and a power reactor was planned.

Hungary.—Uranium deposits were discovered in the Mecsek Mountains in southern Hungary. In March the first Hungarian atomic reactor became critical. The research reactor was constructed with aid from the U.S.S.R.

---

[13] Mining Journal (London), vol. 253, No. 6480, Oct. 30, 1959, p. 414.

[14] Chemical Trade Journal and Chemical Engineer (London), vol. 144, No. 3741, Feb. 13, 1959, p. 380.

Italy.—The Societa Mineraria e Chemica per l'Uranio, a State agency, produced about 900 pounds of uranium concentrate with a content of 75 percent U_3O_8. It was expected that mining of deposits in the Piedmont region would yield about 85 tons of 75-percent U_3O_8 concentrates in 1960; with production from the Eastern Alps, Italian uranium concentrate output by the middle of 1961 was expected to reach over 250 tons of concentrate annually.

Several Italian firms were planning to build a 165,000-kw. power reactor, the largest nuclear powerplant to be built for a private company in Europe.

An American-made, AGN-201 nuclear-research reactor was purchased during the year by the Technical Institute of Palermo, University Engineering College. A research reactor was to be built at the University of Pisa.

Netherlands.—A cooperative agreement in the field of atomic energy was made between The Netherlands Reactor Center (R.C.N.) and the Norwegian Institute for Atomenergi (I.F.A.). Thin beds containing uranium were reportedly discovered at a depth of 100 to 125 feet in the Province of Overijssel, Holland.[15]

Poland.—Poland continued to export uranium to the U.S.S.R. However, in the development of an atomic energy program, Poland was planning to produce uranium metal for its nuclear reactors within 5 years; meanwhile, Soviet fuel elements would be used in power reactors.[16]

Portugal.—Uranium ore mined at the Urgeicera mine was sold to the Combined Development Agency, purchasing agency for the United States and the United Kingdom. Exploration for uranium deposits continued, and production of uranium metal was planned.

Spain.—Uranium was produced in the Monesterio district where uranium occurs in granite. Preliminary exploration disclosed uranium minerals in Sierra Albarrana, the Santuario-Cardena region, and in the Provinces of Salamanca, Zamora, Cacerco, and Badajoz. Uranium reserves of Spain were not well known but reports estimated the reserve at 1,500 tons of metal.[17] The first uranium-ore treatment plant started during the year and was expected to treat 200 tons of ore per day in 1960. Two other plants were planned.

Sweden.—Uranium production was estimated at 10 tons of U_3O_8, the same as in 1958 and 1957.

The large shale deposits of the Narke and Vastergotland region contain 0.02 to 0.03 percent U_3O_8. AB Atomenergi, in conjunction with Sweden's Geological Survey, is investigating areas in Sweden believed to contain uranium in higher concentration. Shale deposits in Billingen field near Stenstorp, Skaraborg county, are the richest found thus far.

After prolonged consideration, the Swedish government approved plans in June for constructing a uranium extraction and refining plant at Ranstad, by AB Atomenergi. Construction of the plant, Urangruvan Ranstadsverket, is expected to begin in 1960 and be completed in 1964. The plant is designed to produce 120 tons of

---

[15] Mining Journal (London), vol. 252, No. 6441, Jan. 30, 1959, p. 122.

[16] Billig, W., [The Prospects for the Development of Nuclear Energy in Poland]: Przeglad Techniczny (Warsaw), Jan. 7, 1959, pp. 7–9.

[17] Engineering and Mining Journal, vol. 160, No. 7, July 1959, p. 148.

uranium metal annually, using ore from the shale deposits at Billingen.

Sweden's present uranium-refinery capacity, about 10 tons annually, is inadequate for its civilian nuclear-power program. It is estimated that Sweden's uranium-metal requirements for reactor fuel rods will increase to about 20 tons annually in 1960, 75 tons in 1965, and 200 tons thereafter.[18]

Turkey.—Promising districts for uranium were studied by the Mineral Research and Exploration Institute of Turkey (M.T.A.). The Turkish Government planned to install its first atomic reactor near Lake Kucuk Cekmece, 15 miles west of Istanbul. The swimming-pool-type reactor was to be built by an American firm and will be used to produce radioisotopes.

U.S.S.R.—The U.S.S.R. has not published information about internal uranium reserves or production. However, uranium ores were probably mined from the Angara Shield and the Ukhta areas in North Russia, from near Lake Biakal in Southern Siberia, from the Kamchatki area in Northwest Russia, and in the Ferghana region of Central Asian Republics.

Production of uranium concentrate from internal sources was probably between 8,000 and 10,000 tons of U_3O_8. About 2,000 tons of U_3O_8 may have been imported from China, East Germany, Czechoslovakia, Rumania, Bulgaria, and Hungary.

Since the advent of the atomic age the U.S.S.R. has claimed discovery of several new uranium-bearing minerals including hydronasturan; urgets; nenadkevite, a uranium silicate; and lermontovite, a uranium phosphate mineral. Sources of the discoveries were not released. During the year Soviet Union published a book on prospecting for uranium[19] and one on the geology of uranium.[20]

In the field of mining and processing uranium ores, the U.S.S.R. published at least three books.[21] The Soviet Union continued its program on hydrometallurgical processes for the production of uranium from uranium raw materials with principal attention directed to conversion of uranium concentrates to pure salts and metallic uranium. Soviet scientists were successful in developing plutonium oxide as a fuel. The use of plutonium oxide minimizes the problems of radiation damage to metallic fuels in a reactor.

Visiting AEC officials noted that the Soviets were building only half the number of reactors originally planned. A summary of nuclear-power stations in the U.S.S.R. included: Two in operation, Obninsk Station of the Academy of Sciences, 5,000 kw.; Siberian Station, 600,000 kw. (first section of 100,000 kw.); three under construction, Beloyarsk Station, 400,000 kw.; Voronezh Station, 420,000 kw.; Ul'yanovsk Station, 50,000 kw.; and one being planned, Leningrad Station, 420,000 kw.

---

[18] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 5, November 1959, pp. 30–31.

[19] Surozkskiy, D. Ya., [Methods of Prospecting for, Surveying, and Assaying of Industrial Occurrences of Uranium]: Atomizdat (Moscow), 1959, 25 pp.

[20] Konstantinov, M. N., [Geology of Uranium]: Atomizdat (Moscow), 1959, 5 pp.

[21] Petrov, G. I., and others, [Methods of the Geologico—Geophisical (Radiometric) Servicing of Uranium Mines]: Atomizdat (Moscow), 1959, 12 pp.

Galkin, N. P., Mayorov, A. A., and Vergatin, U. D., [Technology of the Conversion of Uranium Concentrates]: Atomizdat (Moscow), 1959, 12 pp.

Nevskiy, B. V., [Conversion of Uranium Ores]; Atomizdat (Moscow), 1959, 12 pp.

A comprehensive report on historical and technical development of the U.S.S.R. nuclear-energy programs was published.[22]

Soviet Russia continued development programs on nuclear propulsion for marine, land, and air use, and on peaceful uses of nuclear explosives at the new atomic cities at Dubna, Obninsk, Irkutsk, Yakutsk, Alma-Ato, one unnamed near Novosibirsk, possibly at Akademgrad, and others.

United Kingdom.—Reconnaissance surveys for uranium by the Atomic Energy Division of the U.K. Geological Survey were nearly completed. Although 70 new occurrences were found, only one was economic.

The United Kingdom's potential sources of radioactive minerals were reviewed.[23]

AEA announced that a second full-sized nuclear plant, at Chapel Cross, Scotland, would be delivering its rated capacity of 140,000 kw. into the national grid by the end of the year. This reactor is a duplicate of the first full-scale nuclear powerplant at Calder Hall. Other British power reactors being built at Bradwell, Berkeley, Hunterston, and Hinkley Point, are expected to have a total output of 1.4 million kw. by 1962.

Construction of Britain's first nuclear submarine, the *Dreadnought*, was started in 1959.

AEA was reported to have about 100 grams of protactinium, which probably represents most of the world's stock of this rare radioactive element. Although protactinium has been known for years, it is difficult to isolate and accumulate in significant quantities.

ASIA

Burma.—Geologists continued to search for uranium ore in Burma. The Burmese Government, a member of IAEA, initiated a nuclear-research center primarily for handling radioisotopes.[24]

Ceylon.—Ceylon's Ministry of Industries was expected to begin a 2- to 5-year program of exploring for radioactive minerals. The geologic structure of Ceylon was said to be favorable to the discovery of uranium. Uranium was expected to be found in central and southern Ceylon where the Precambrian rocks are similar to those found in Madagascar.

China.—Specimens of different uranium ores and samples of uranium compounds and metal were exhibited in 1958 in Peking, but no indication was given as to either the location or size of the country's uranium reserve. There are believed to be important uranium deposits in Sinkiang. Uranium exploration was being conducted on a large scale in 1959. In many areas peasants provided with pocket beta-gamma radiometers were taking part in the search for deposits.[25]

China's first experimental reactor of the heavy water type became critical in 1958. The reactor was built with assistance from the Soviet Union to promote development of nuclear energy in China.

---

[22] Kramish, Arnold, Atomic Energy in the Soviet Union: Stanford University Press, 1959, 323 pp.

[23] Bowie, S. H. V., The Uranium and Thorium Resources of the Commonwealth: Jour. Roy. Soc. of Arts, vol. 107, No. 5038, September 1959, pp. 704–718.

[24] Mining Journal (London), vol. 253, No. 6482, Nov. 13, 1959, p. 482.

[25] Chemical and Process Engineering, Atomic Energy in China: Vol. 40, No. 11, November 1959, pp. 397–404.

India.—The first Asian plant to produce nuclear-grade uranium was India's Atomic Energy Establishment at Trombay near Bombay. In January the plant made its first pure uranium ingot from uranium contained in monazite sands. A uranium mill which could process about 500 tons of uranium ore daily, was planned for the Bihar area. The mill was expected to be in operation by 1962.

In Umra near Udiapur (Rajasthan) several uraniferous pegmatite deposits, having an aggregate length of nearly 600 feet and thickness of 2 to 3 feet have been partly developed. The ore is the richest discovered in India so far; of the 600 tons already mined the average grade is 0.5 percent U_3O_8. Mineralogy of the ore is being investigated; those already identified include uraninite, clarkeite, kasolite, uranophane, johannite, zippeite, metatorbernite, and autunite.

The total ore reserves from the outcrop of Jaduguda (Bihar), verified to a depth of 1,000 feet, amount to 1.84 million long tons of 0.064-percent U_3O_8. Further extensions of the ore body in depth and in lateral directions were being proved by drilling; a production of 500 tons a day was being planned.

At Keruadungri (Bihar), nearly 1.1 million tons of ore containing 0.05 to 0.04 percent U_3O_8 has been indicated by drilling, and a shaft has been sunk to reach the ore body at a depth of 120 feet. As the ore is low-grade, mining it full scale is not contemplated in the near future.

India's second reactor was started during the year. A third reactor, purchased from Canada, was expected to be operational in 1960.

Israel.—A shipment of 6,500 grams of uranium, enriched to 90 percent of isotope U^{235}, was received in Haifa in March 1959. In addition, the uranium shipment was accompanied by neutron sources, consisting of several grams of plutonium mixed with beryllium, to be used for activating the uranium. It is estimated that the uranium will last for about 2 years as fuel.

Japan.—Japan produced about 66 pounds of uranium from a 3-ton-per-day pilot plant.

A 3-year program of prospecting for uranium deposits over an area of 80,000 km.^{2} in Japan was completed.

Results have established that the Ningyotogo mine, on the border between the Tottoni and Okayama Prefectures, in western Japan, contains the richest deposit, estimated to be about 1.5 million tons. Other major deposits include those at Kurayoshie mine, Tottori Prefecture, and the Iwai and Nodatamagawa mines, Iwata Prefecture.

The Government granted subsidies both to private bodies engaged in prospecting for uranium deposits and those engaged in manufacturing necessary equipment.[26]

A promising uranium discovery north of Lake Tazawa in Akita Prefecture was said to compare favorably with that of Ningyo Pass, Tottori Prefecture. The uranium find, contained in breccia of Tertiary age, is believed to be from 0.4 percent to 0.64 percent; the Ningyo Pass deposit averages about 0.05 percent.[27]

Japanese Atomic Fuel Corporation was reported to have contracted for purchase of 6 tons of uranium concentrate from Gunnar Mines,

---

[26] Mining Journal (London), vol. 253, No. 6482, Nov. 13, 1959, p. 473.

[27] Mining World, vol. 22, No. 1, January 1960, p. 71.

Ltd., of Canada; 3 tons of natural uranium was purchased from IAEA at $35.50 per kilogram of uranium.

The Japanese Atomic Power Company announced that it would begin negotiations with a British firm for the purchase of a 150-electrical-megawatt nuclear reactor.

Malaya.—Reports compiled by air and ground teams exploring for uranium in Malaya indicate that radioactive minerals exist only in scattered surface deposits, none of economic value.[28]

Pakistan.—Pakistan Geological Survey teams exploring for iron-ore deposits reported the discovery of uranium deposits in the Chitial region of West Pakistan.

AFRICA

Belgian Congo.—Uranium production in 1959 was 2,315 tons. Belgian Congo continued to supply uranium to the United States, Great Britain, and Belgium, principally from the famous Shinkolobwe mine.

Egypt.—Uranium ore found in an area 90 km. west of Cairo contained 0.3 percent U_3O_8, and a detailed aerial-radiometric survey of the district was undertaken. Lower grade deposits were found in the Eastern Desert.

Discovery of a uranium deposit about halfway between Cairo and Alexandria was announced. The uranium is associated with sandstone and occurs in percentages of 0.3 to 0.4 U_3O_8. The deposit extends for a few kilometers on the surface but the depth is unknown.[29]

Gabon Republic (*formerly part of French Equatorial Africa*).—About 20 million tons of uranium ore are estimated to be in the Mounana deposits. This reportedly will provide 4,000 to 5,000 tons of 10- to 20-percent uranium. An ore-treatment plant scheduled for completion in 1961 was under construction, and concentrates are to be sent to France for further processing.

Madagascar.—Production of uranium during 1959 was about 600 tons, averaging nearly 18 percent U_3O_8. The product was shipped to Bouchet plant in France, which is equipped to treat the uranothorite from Madagascar.

Rhodesia and Nyasaland, Federation of.—It was reported that the Rhokana Corp. mine in the Mindola area had been depleted and was to close in July. Total production to the end of June was 110 tons of uranium concentrate. A report on Southern Nyasaland radioactive minerals was published.[30]

Union of South Africa.—During 1959 uranium production reached slightly over the 6,200 tons of U_3O_8 agreed upon with Combined Development Agency to be the annual ceiling for purchasing until 1966. Efforts to market additional quantities of uranium were unsuccessful.

An organization, Atomic Research Fund, was formed in the Union of South Africa. The purpose of the organization—composed of uranium producers, electrical power producers, and others—is to develop uses for uranium and a reactor program in the Union.

---

[28] Mining Newsletter (Philippines), vol. 10, No. 6, July–August 1959, p. 248.

[29] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 3, March 1960, p. 37.

[30] Bosazza, V. L., Radioactive Minerals in Southern Nyasaland: Mines Magazine (London), vol. 101, No. 2, August 1959, pp. 49–55.

OCEANIA

Australia.—Uranium concentrate production in 1959 was estimated at 1,100 tons, compared with 650 tons in 1958, and 500 tons in 1957. Major uranium-producing areas were Rum Jungle, Mary Kathleen, and South Alligator River.

Exploration by the Australian Government resulted in the discovery of pitchblende at Radium Hill, where the complex uranium-bearing ores contain the low-grade radioactive mineral davidite.[31]

A new company, Queensland Mines Ltd., has been formed to produce uranium from two deposits near Mt. Isa, Queensland. The largest deposit has an estimated reserve of 800,000 tons. A pilot plant purchased by Factor's Ltd., was expected to begin operating under direction of the Mining Department (Brisbane University) in August 1959.

An unproved deposit, the Skal, about 26 miles from Mt. Isa, was reported to contain an estimated 200,000 tons of ore.[32]

The policy of the Commonwealth Government was modified to permit Australian uranium producers to export a total of 2,500 pounds of uranium oxide to any one country, but individual sales would be limited to 250 pounds. Previously, exports could be made only to the United States and Great Britain.

Uranium mining and milling methods used at the Mary Kathleen mine in the Cloncurry-Mt. Isa district of Queensland were described.[33]

Davidite, a principal uranium-ore mineral of Australia, was described during the year.[34]

New Zealand.—A New Zealand firm was expected to begin extensive prospecting for uranium in the Bullock Creek area, between Westport and Punakaiki, on the South Island's west coast. Exploration of the Paparoa uranium province continued.

TABLE 9.—United States uranium ore reserves, Dec. 31, 1957–59 [1]

(Million tons)

State	Dec. 31, 1957		Dec. 31, 1958		Dec. 31, 1959	
	Quantity	Grade, percent U_3O_8	Quantity	Grade, percent U_3O_8	Quantity	Grade, percent U_3O_8
New Mexico	53.3	0.26	54.9	0.26	55.7	0.26
Wyoming	9.2	.26	11.5	.31	15.8	.34
Utah	5.7	.37	5.6	.35	5.3	.23
Colorado	4.1	.29	4.4	.30	4.5	.30
Arizona	1.4	.32	1.4	.34	1.2	.35
Washington, Oregon, Nevada	1.9	.23	2.3	.24	1.9	.21
North Dakota, South Dakota	.6	.25	.6	.26	.6	.27
Other states (Texas, California, Montana, Idaho, Alaska)	1.8	.23	1.8	.23	1.1	.24
Total	78.0	.27	82.5	.27	86.1	.28

[1] In addition to reserves in place, ore was stockpiled at mills or AEC buying stations to balance ore production with mill requirements and to assure a balanced millfeed. The stockpile contained 2,000,000 tons with a grade of 0.28-percent U_3O_8 in December 1957, 1,750,000 tons of the same grade in December 1958, and 1,300,000 tons at 0.33-percent U_3O_8 in December 1959.

---

[31] Mining Journal (London), vol. 252, No. 6450, Apr. 3, 1959, p. 371.

[32] Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 3, September 1959, p. 27.

[33] Nelson, A., The Mary Kathleen Uranium Project: Mine and Quarry Eng. (London), vol. 26, No. 2, February 1960, pp. 46–54.

[34] Whittle, A. W. G., The Nature of Davidite: Econ. Geol., vol. 54, No. 1, January–February 1959, pp. 64–81.

WORLD RESERVES

Known free-world reserves of uranium totaled 1 million tons of U_3O_8; assumed additional reserves, based on geologic estimates, also totaled 1 million tons according to a report of AEC.[35] Assuming aggressive exploration and considering geologic data and discovery experience, AEC indicated that possibly 2 million tons more of U_3O_8 could be found within the next 4 decades.

Free-world-uranium reserves are shown in the 1958 Yearbook in table 7, page 1123. Tables 4, 8, and 9 of this chapter contain reserve data.

Development of ore bodies by private companies continued at a high level. The ore reserve increased 3.6 million tons during a period when 6.9 million tons was mined. In addition, there was approximately 1.3 million tons of ore in government and private stockpiles at the end of the year.

TECHNOLOGY

Exploration.—Exploration and development drilling by private companies had its first substantial decrease since the uranium program was started in 1948. Exploration methods and techniques used in Canada were discussed.[36]

Mining.—Domestically the room-and-pillar method was most widely used in larger underground mines, and one mine was using a caving panel-retreat method that would permit nearly 100-percent recovery of uranium ore. Open-pit mines were being developed in Wyoming. Canadian underground mines were employing open-stope and room-and-pillar methods and track and trackless haulage for transporting ore.

Uranium mining in relatively inaccessible areas where ore is extracted profitably by contract mining, using small working crews and

TABLE 10.—Government and private exploratory and development drilling for uranium, 1948–58, in thousand feet

Year	AEC drilling	Other Government drilling	Total Government drilling	Private drilling
1948	----------	130	130	80
1949	70	223	293	120
1950	156	212	368	410
1951	354	374	728	700
1952	482	580	1,062	600
1953	600	715	1,315	2,700
1954	613	497	1,110	3,500
1955	316	213	529	5,500
1956	14	26	40	8,750
1957	----------	----------	----------	9,200
1958	----------	----------	----------	7,300
Total	2,605	2,970	5,575	38,860

---

[35] Atomic Energy Commission, An Analysis of the Current and Long-Term Availability of Uranium and Thorium Raw Materials: TID-8201, Office of Technical Services, Washington, D.C., July 1959, 7 pp.

[36] Canadian Mining Journal, Symposium on Canadian Exploration Techniques: Vol. 80, No. 4, April 1959, pp. 122–128.

varied techniques, was described.[37] Many mines that were closed because they were considered to be depleted were rehabilitated and operating profitably under contract agreements with large companies. Mines producing only 50 to 100 tons of ore a month are operated by two or three men.

Some mines, particularly in the Uravan area of the Colorado Plateau, have development drifts 20 to 60 feet beneath the ore horizon to permit nearly complete extraction of ore. Others were being developed with haulage drifts nearer, and sometimes within, the ore horizon.

Uranium mining costs in Colorado were higher than at some mines in New Mexico, Wyoming, and Utah, because the ore bodies were smaller, more erratic, and discontinuous.

Open-pit mining operations in Wyoming were described.[38] In the Gas Hills area the open pit operations range in size from 300 by 100 feet to 1,200 by 100 feet. The Lucky Mc pits, when completed and connected, will cover an area about 8,000 feet long and 600 feet wide, averaging close to 200 feet in depth. Average overall stripping ratio of the Gas Hills area was about 20 to 1; some ratios approached 30 to 1. Stripping operations at Midnite mine (Dawn Mining Co.) on the Spokane Indian Reservation were described.[39]

Development of underground mines in the Ambrosia Lake area was nearing completion. Excess groundwater flow into the workings required the use of special techniques of ground and water control. Some shaft-sinking operations employed chemical gels to inhibit waterflow when excessive quantities were encountered. Ground- control problems were encountered in development headings driven in shale, which swelled as water originating from the orebody was absorbed.

Concern over presence of radon and its radioactive decay products in the air of uranium mines has stemmed largely from reported experience in certain European mining areas, where ores containing radioactive materials are extracted. The situation in the United States and Europe is not exactly parallel; European orebodies contain a variety of elements, some potentially harmful, that are not associated with the uranium ores now produced in the United States. However, the problem of adequate ventilation was being given more attention by industry and State and Federal agencies.

Milling.—Extensive extractive metallurgical research directed toward improvement of uranium processing was noted in nearly every uranium-producing country. Significant developments were made in each phase of uranium recovery operations.[40]

In grinding operations, mills in the Canadian Bancroft area were using partial autogenous grinding circuits. Minus-½- to ⅜-inch feed was rod-milled in an open circuit; the discharge went to a classifier in closed circuit with a pebble mill, which delivered a product with 50- to 60-percent minus-200-mesh. The pebble mills leave less iron in the circuit than rod mills; iron is detrimental in product

---

[37] Borden, J. R., Mining on the Plateau: Min. Cong. Jour., vol. 45, No. 10, October 1959, pp. 94–96.

[38] Quine, A. V., Uranium Mining in Wyoming: Min. Cong. Jour., vol. 45, No. 8, August 1959, pp. 79–81.

[39] Sheldon, R. F., Midnite Mine Geology and Development: Min. Eng., vol. 11, No. 5, May 1959, pp. 531–534.

[40] Lennemann, W. L., and McGinley, F. E., Advances in Uranium Ore Processing: Min. Cong. Jour., vol. 45, No. 7, July 1959, pp. 59–63.

recovery and tends to decrease efficiency of subsequent uranium-recovery operations.

Improvements in leaching noted during the year included the control of pH and leaching temperature at the Mary Kathleen mill in Australia. Control of these conditions significantly decreased quantities of silica and phosphate going into solution. Port Pirie mill in Australia revised its leaching technique to insure that all titanium would be precipitated at a desirable point in the flowsheet.

Procedure for the Urgeicera uranium operation in Portugal took advantage of natural leaching by bedding large piles of low-grade ores on prepared pads, then collecting the drainage from rain or spraying. Collected liquors were neutralized, and the resulting sludges were taken to the Urgeicera mill for further treatment. About 60 to 80 percent of the uranium could be removed from certain ores by natural leaching. Originally, South African gold-uranium mills processed the ores, first, for gold recovery, and second, the tailings for uranium recovery. By reversing the procedure and acid-leaching first for uranium recovery, it was found that gold recovery was improved.

In solvent-extraction techniques, research was directed toward improvement of efficiencies of solvents and chemicals. Work by the Bureau of Mines at Salt Lake City demonstrated that by using a combination of solvents in an organic carrier, it was possible to co-extract both uranium and vanadium and then co-strip them from the solvent with a carbonate solution. Methods for easily moving resins countercurrently with liquors, to permit continuous ion exchange, were being investigated.

Upgrading and concentrating uranium ores received attention, and some variations of these procedures were noted at the Union Carbide Nuclear Co. concentrators at Slick Rock, Colo., and Green River, Utah, at the COG Mineral Corp. mill, White Canyon, Utah, Trace Elements, Corp. mill, Maybell, Colo., and at the Climax Uranium Co. mill, Grand Junction, Colo.

Pollution control for effluents from uranium mills was being investigated. A comprehensive paper on uranium-processing technology was delivered at the National Western Mining Conference in 1959.[41] A text describing the various phases of uranium production was published during the year.[42]

---

[41] Kuhlman, C. W., Jr., Uranium Processing Technology: Presented at Nat. Western Min. Conf., Colo. Min. Assoc., Denver, Colo., Mallinckrodt Chemical Works, St. Louis, Mo., Feb. 5, 1959.

[42] Harrington, C. D., and Ruehle, A. E., Uranium Production Technology: D. Van Nostrand Co., Inc., Princeton, N.J., 1959, 579 pp.

Vanadium

By Phillip M. Busch [1] and Kathleen W. McNulty [2]

◆

SIGNIFICANT aspects of the domestic vanadium industry in 1959 included increases in the production of vanadium-bearing ore, vanadium pentoxide, and ferrovanadium. Larger exports of vanadium-bearing materials accounted for part of the increased vanadium production. Consumption of vanadium-bearing products increased 50 percent.

World production of vanadium continued to rise with increased production in the United States, Finland, and South-West Africa.

Vanadium pentoxide production was resumed at the rebuilt and enlarged mill of the Union Carbide Nuclear Co., Rifle, Colo.

TABLE 1.—Salient vanadium statistics, short tons of contained vanadium

	1950-54 (average)	1955	1956	1957	1958	1959
United States:						
Production:						
Ore and concentrate processed	3,785	5,656	5,701	7,307	6,829	8,026
Recoverable vanadium in ore and concentrate [1]	2,476	3,286	3,867	3,691	3,030	3,719
Vanadium pentoxide	2,374	3,669	3,937	3,612	2,791	4,092
Imports:						
Ore and concentrate	460	92	-----	-----	-----	3
Vanadium-bearing flue dust	(2)	-----	-----	-----	-----	-----
Exports:						
Ferrovanadium and other vanadium alloying materials containing over 6 percent vanadium (gross weight)	[3] 80	220	139	134	76	152
Vanadium pentoxide, vanadic oxide, vanadium oxide, and vanadates [4]	18	865	928	500	631	1,240
World: Production (estimate)	3,473	3,996	4,229	4,295	4,231	5,325

[1] Measured by receipts at mills.
[2] Averages less than 1 ton.
[3] Classified as ferrovanadium 1950-52.
[4] Classified as "Ore and concentrate," 1950-52, but probably included vanadium pentoxide.

LEGISLATION AND GOVERNMENT PROGRAMS

General Services Administration on March 3, 1959, announced that it was soliciting proposals for production of ferrovanadium from Government-owned vanadium oxide held in the national stockpile. Proposals were to have been received no later than April 15, 1959. Conversion of stockpiled vanadium oxide to ferrovanadium was part of a program to convert substantial quantities of materials held by the Government to higher use forms. A contract was awarded to the

---

[1] **Commodity specialist.**
[2] **Statistical clerk.**

Vanadium Corp. of America and the conversion of stockpiled vanadium pentoxide to ferrovanadium was started. When processing was completed the ferrovanadium was to contain 1,050,000 pounds of vanadium.

DOMESTIC PRODUCTION

Ore.—Production of vanadium in ore and concentrate was about 2 percent above 1958.

The "Four Corners" area of the Colorado Plateau, consisting of southwestern Colorado, northwestern New Mexico, northeastern Arizona, and southeastern Utah, continued to be the center of vanadium-ore mining in the United States. Vanadium produced from ores mined in these States was a byproduct or coproduct of uranium production.

TABLE 2.—Recoverable vanadium in ore and concentrate produced in the United States, by States, short tons of contained vanadium

State	1950–54 (average)	1955	1956	1957	1958	1959
Colorado	1,867	2,298	2,791	3,132	2,395	2,949
Utah	182	498	549	508	376	536
Arizona and other States [1]	427	490	527	51	259	234
Total	2,476	3,286	3,867	3,691	3,030	3,719

[1] Includes Idaho, 1950–54; Montana, 1957; New Mexico, 1950–54, 1956–59; South Dakota, 1954; and Wyoming, 1954, 1956–58.

TABLE 3.—Vanadium and recoverable vanadium in ore and concentrate produced in the United States, in short tons

Year	Mine production [1]	Recoverable vanadium	Year	Mine production [1]	Recoverable vanadium
1950–54 (average)	3,700	2,476	1957	7,294	3,691
1955	4,983	3,286	1958	7,266	3,030
1956	5,635	3,867	1959	7,392	3,719

[1] Measured by receipts at mills.

Oxide.—Production of vanadium pentoxide increased about 47 percent over 1958. Vanadium pentoxide from domestic ores was produced in four plants, one more than in 1958. Data in table 4 include vanadium pentoxide produced as a byproduct of foreign chromite ores, 1950–59; produced from Peruvian concentrate, 1950–55; and produced as a byproduct of domestic phosphate rock, 1950–54.

TABLE 4.—Production of vanadium pentoxide in the United States, in short tons [1]

Year	Gross weight	V_2O_5 content	Year	Gross weight	V_2O_5 content
1950–54 (average)	4,786	4,239	1957	7,224	6,449
1955	7,426	6,552	1958	5,470	4,983
1956	7,963	7,030	1959	7,906	7,305

[1] Includes a relatively small quantity recovered as a byproduct of Peruvian concentrate and foreign chrome ore.

Ferrovanadium.—Ferrovanadium was produced in the United States principally by two companies, Vanadium Corp. of America and Union Carbide Metals Company. Production was about double that in 1958.

Vanadium Metal.—Although high-purity vanadium metal was a minor item compared with other vanadium-bearing products, production increased sharply in 1959. Reported production was about 28 short tons in a product of more than 99 percent purity.

CONSUMPTION AND USES

Ore and Concentrate.—Consumption of domestic and foreign vanadium-bearing ore and concentrate at domestic plants was about 8,026 short tons (vanadium content), an increase of 18 percent over 1958.

Vanadium Products.—Approximately 79 percent of the total estimated consumption of 2,100 tons of vanadium in 1959 was in the form of ferrovanadium. This material was used in manufacturing a wide variety of vanadium-bearing products. In 1959, a new and more detailed analysis of the end uses of vanadium-bearing products was started, as shown in table 6.

TABLE 5.—Vanadium consumed and in stock in the United States in 1959, by forms, short tons of vanadium

Form	Stocks at consumers' plants, Dec. 31, 1958	Consumption	Stocks at consumers' plants, Dec. 31, 1959
Ferrovanadium	203	1,492	269
Oxide	14	152	19
Ammonium metavanadate	12	112	28
Other	47	135	35
Total	276	[1] 1,891	351

[1] Represents approximately 90 percent of total consumption.

TABLE 6.—Vanadium consumed in the United States in 1959, by uses

Use	Short tons	Use	Short tons
Steel:		Gray and malleable castings	25
High-speed	412	Nonferrous alloys	121
Hot-work tool	66	Chemicals	135
Other tool	119	Other	45
Stainless	34	Total	[2] 1,891
Other alloy [1]	826		
Carbon	108		

[1] Includes some vanadium used in high-speed or other tool steels not specified by reporting firms.
[2] Represents approximately 90 percent of total consumption.

The consumption of vanadium in 1959 increased for virtually all end uses compared with 1958. About 83 percent was used in high-speed and other alloy steels. Ferrovanadium was used in constructional steels, wear-resistant cast irons and alloys, welding electrodes, titanium-base alloys, magnet alloys, and stainless steels and as a deoxidizer for low-carbon steel. Commercial vanadium metal was used for iron-free or low-iron alloys, wear-resistant materials, high-temperature alloys, and aluminum-base alloys; high-purity vanadium metal was used for special applications and research. A vanadium-aluminum alloy containing 2.5 to 40 percent vanadium was used to control thermal expansion, electrical resistivity, and grain size of aluminum alloys and to improve high-temperature strength. To produce titanium metal alloys, a low-impurity master alloy was used that contained 80 to 85 percent vanadium alloyed with 13 to 17 percent aluminum. Aluminum, titanium, and boron, alloyed with 25 percent vanadium, was used in alloy steels to increase depth hardening and physical properties. Vanadium oxide was used in manufacturing high-speed steel, titanium-base alloys, other alloys, ceramic pigments, chemicals, catalysts, and color compounds. Ammonium metavanadate was used as a catalyst, in paint and ceramic pigments, and in industrial cleaning compounds.

Only a small proportion of vanadium was used in tool and structural steels. In high-speed steels, the vanadium content ranged from 0.50 to 2.50 percent, although higher percentages were sometimes used. Alloy tool steels, other than high-speed steels, contained 0.20 to 1.00 percent vanadium. The quantity of vanadium added to engineering steels usually ranged from 0.10 to 0.25 percent. Most steels containing over 0.50 percent vanadium were for special purposes, such as dies, twist drills, reamers, and roughing and finishing tools. Vanadium was used alone in some carbon steel; but in most engineering and structural steels it was usually combined with chromium, nickel, manganese, boron, and tungsten.

STOCKS

Stocks of various forms of vanadium held at consumers' plants December 31, 1959, increased about 27 percent over those on December 31, 1958. Table 5 gives data on stocks.

PRICES

Vanadium oxide (V_2O_5) contained in ore was quoted at 31 cents per pound from March 1951 through 1959. This quotation disregards penalties based upon the grade of ore or the presence of objectionable impurities, such as lime, which are important to the refiners because impurities vitally affect recoveries.

The quoted price on vanadium pentoxide (Technical grade) was $1.38 a pound of V_2O_5; the price of ferrovanadium ranged from $3.20 to $3.40 a pound of contained vanadium (depending upon the grade of alloy). Vanadium metal for alloying, in 100-pound lots, ranged from $3.45 to $3.65 a pound. High-purity metal (over 99 percent vanadium) was quoted at $40 a pound.

FOREIGN TRADE[3]

In 1959, vanadium ores and concentrates were imported from Argentina—209 pounds (V_2O_5 content) valued at $202—and West Germany—9,920 pounds (V_2O_5 content) valued at $9,416. In addi-

---

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

tion, 17,000 pounds (gross weight) of ferrovanadium valued at $20,369 was imported from Sweden and 15,000 pounds (gross weight) valued at $18,229 from West Germany. Imports of vanadic acid, anhydride, and salts, compounds, and mixtures of vanadium from the United Kingdom totaled 47 pounds (gross weight) valued at $283.

Vanadium exports rose substantially to the highest level on record.

TABLE 7.—Exports of vanadium from the United States, by countries, in pounds

[Bureau of the Census]

Country	Ferrovanadium and other vanadium alloying materials containing over 6 percent vanadium (gross weight)		Vanadium ore, concentrates, pentoxide, vanadic oxide, vanadium oxide, and vanadates (except chemically pure grade) (vanadium content)		Vanadium fine dust and other vanadium waste materials (vanadium content)	
	1958	1959	1958	1959	1958	1959
North America:						
Canada	125,354	301,086	8,921	12,507	----------	----------
Mexico	----------	----------	4,480	2,800	----------	----------
Total	125,354	301,086	13,401	15,307	----------	----------
South America:						
Argentina	----------	----------	----------	2,793	----------	----------
Brazil	----------	1,000	1,951	4,323	----------	----------
Venezuela	1,000	1,000	----------	----------	----------	----------
Total	1,000	2,000	1,951	7,116	----------	----------
Europe:						
Austria	----------	----------	646,673	1,563,524	----------	----------
Belgium-Luxembourg	----------	----------	24,069	1,023	----------	----------
France	----------	----------	194,233	216,986	----------	----------
Germany, West	22,064	----------	17,226	5,059	----------	----------
Italy	----------	----------	54,523	50,229	----------	----------
Netherlands	----------	----------	91,071	86,720	11,202	78,300
Sweden	2,205	----------	----------	33,379	----------	----------
Trieste	----------	----------	18,242	168,567	----------	----------
United Kingdom	1,120	----------	1,092	1,423	----------	----------
Total	25,389	----------	1,047,129	2,126,910	11,202	78,300
Asia:						
India	----------	----------	582	994	----------	----------
Japan	330	----------	198,020	330,016	----------	4,881
Total	330	----------	198,602	331,010	----------	4,881
Grand total:						
Pounds	152,073	303,086	1,261,083	2,480,343	11,202	83,181
Value	$294,933	$529,697	$2,624,960	$4,667,764	$2,100	$40,317

WORLD REVIEW

Argentina.—Production of vanadium-bearing ore was reported from the Nelly mine in the Province of San Luis.[4] The average grade of the ore was low—0.82 percent V_2O_5. The ore reserve was estimated at 22,500 tons. A low mining cost and an 85-percent recovery rate in a chemical plant will make it possible to recover economically about 2,200 pounds of V_2O_5 concentrate a month.

Poland.—Vanadium and other ferrous and nonferrous metal deposits were found near Glogow, Poland.[5]

---

[4] Mining World, Argentina: Vol. 21, No. 10, September 1959, p. 117.

[5] Metal Industry (London), Polish Copper Deposits: Vol. 94, No. 6, Feb. 6, 1959, p. 115.

TABLE 8.—World production of vanadium in ores and concentrates, in short tons[1]

[Compiled by Pearl J. Thompson and Berenice B. Mitchell]

Country	1950-54 (average)	1955	1956	1957	1958	1959
North America: United States (recoverable vanadium)	[2] 2,476	3,286	3,867	3,691	3,030	3,719
South America:						
Argentina	(3)	----------	(3)	(3)	(3)	(3)
Peru (content of concentrate)	403	78	----------	----------	----------	----------
Europe: Finland	----------	----------	43	290	430	[4] 557
Africa:						
Angola	----------	----------	11	1	20	[5] 11
Rhodesia and Nyasaland, Federation of: Northern Rhodesia (recovered vanadium)	29	----------	----------	----------	----------	----------
South-West Africa (recoverable vanadium)	565	632	308	305	435	719
Union of South Africa (Transvaal)	----------	----------	----------	8	316	319
World total (estimate)[1] [6]	3,473	3,996	4,229	4,295	4,231	5,325

[1] This table incorporates some revisions.
[2] Includes vanadium recovered as a byproduct of phosphate-rock mining, 1950–54.
[3] Negligible.
[4] Exports.
[5] Estimate.
[6] Total represents data only for countries shown in table and excludes vanadium in ores produced in Belgian Congo, Mexico, Morocco (Southern), Norway, Spain, and U.S.S.R., for which figures are not available; the table also excludes quantities of vanadium recovered as byproducts from other ores and raw materials.

TECHNOLOGY

Research and development efforts were extended to widen the uses of vanadium and its derivatives.[6] Vanadium compounds were used in manufacturing sulfuric acid, nylon, resins and plastics, paints, inks, and ceramics. Properties of vanadium that show promise of extending its uses include exceptional resistance to corrosion, strength at relatively high temperatures, and good thermal and electrical conductivity.

Research was continued on the use of vanadium catalysts for reducing the objectional smog-contributing components in automobile exhaust gases.[7] Several methods have been devised to reduce the hydrocarbon content of exhaust gases 60 to 90 percent. One method uses a vanadium pentoxide and aluminum oxide catalyst; although considerable progress has been made, serious shortcomings must be worked out.

Twenty-four vanadium workers were studied to determine the signs and symptoms of occupational vanadium exposure.[8] A detailed history and physical examination, including urinalysis, hematocrit, electrocardiogram, urine for vandium content, and serum cholesterol determinations, were given individuals under test. No evidence was found of chronic intoxication or injury attributable to vanadium exposure.

---

[6] Mining Journal (London), Metals and Minerals—New Rises for Vanadium: Vol. 252, No. 6441, Jan. 30, 1959, pp. 125–126.

[7] Chemical and Engineering News, Auto Makers Attack Smog: Vol. 37, No. 4, Jan. 26, 1959, p. 28.

[8] Batelle Technical Review, The Biological Effects of Vanadium. II. The Signs and Symptoms of Occupational Vanadium: Vol. 8, No. 8, August 1959, p. 489a.

Indicative of continued vanadium research was the wide range of subjects for which patents were issued.[9]

---

[9] Abkowitz, Stanley, Moorhead, Paul E., and Gross, James R. (assigned to Mallory-Sharon Metals Corp.), High-Strength Titanium Base Aluminum-Vanadium-Iron Alloys: U.S. Patent 2,884,323, Apr. 28, 1959.

Smith, Karl F., and Van Thyne, Ray J. (assigned to the United States of America as represented by the Chairman of the Atomic Energy Commission), Vanadium Alloys: U.S. Patent 2,886,431, May 12, 1959.

Pike, Robert D., Ray, Kenneth B., and The Stamford Trust Co. of Connecticut, executors, Process of Treating Ferrotitaniferous Materials: U.S. Patent 2,903,341, Sept. 8, 1959.

Korpi, Karl J., and Johnson, Raymond C. (assigned to The Lummus Co.), Method of Refining Metals: U.S. Patent 2,890,952, June 16, 1959.

Brantley, John C., and Morehouse, Edward L. (assigned to Union Carbide Corp.), Organo-Vanadium Halides and Process of Preparation: U.S. Patent 2,882,288, Apr. 14, 1959.

Chemical Trade Journal and Chemical Engineer (London), Vanadium Recovery by Solvent Extraction: Union Carbide Corp., British Patent 805,025, vol. 144, No. 3740, Feb. 6, 1959, pp. 332, 334.

Chemical Trade Journal and Chemical Engineer (London), Vanadium Recovery: United Steel Companies, Ltd., British Patent 816,609, vol. 145, No. 3781, Nov. 20, 1959, p. 994.

Vermiculite

By L. M. Otis [1] and Nan C. Jensen [2]

⁂

THE QUANTITY of crude vermiculite produced in the United States in 1959 increased 8 percent. Imports of crude vermiculite from the Union of South Africa gained 45 percent over 1958.

DOMESTIC PRODUCTION

Crude Vermiculite.—Three producers reported an output of 207,000 short tons of crude vermiculite in 1959. The value increased 13 percent to $3,082,000. Montana and South Carolina were the only producing States.

Exfoliated Vermiculite.—Production was 153,000 short tons and value $9.6 million, compared with 155,000 tons and $9.8 million in 1958.

The Zonolite Co., principal domestic producer of crude vermiculite, reported increased sales of crude vermiculite for 1959 and increased earnings of 11 percent. Sales of exfoliated material dropped in tonnage and value.

TABLE 1.—Salient statistics of vermiculite production, in thousand short tons

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Crude	202	204	193	184	191	207
Average value per ton	$12.31	$13.24	$13.20	$14.15	$14.28	$14.89
Exfoliated	[1] 145	158	159	161	155	153
Average value per ton	$74.55	$63.31	$60.93	$61.47	$63.13	$62.69
World: Crude	242	263	254	[2] 248	246	260

[1] 1954 only.
[2] Revised figure.

TABLE 2.—Screened and cleaned domestic crude vermiculite sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Quantity	Value	Year	Quantity	Value
1950–54 (average)	202	$2,488	1957	184	$2,603
1955	204	2,702	1958	191	2,728
1956	193	2,542	1959	207	3,082

---

[1] Commodity specialist.
[2] Supervisory statistical assistant.

TABLE 3.—Exfoliated vermiculite sold or used by producers in the United States
(Thousand short tons and thousand dollars)

Year	Operators	Plants	States	Quantity	Value
1955	[1] 27	54	33	158	$10,000
1956	[1] 27	55	33	159	9,674
1957	[1] 26	54	35	161	9,910
1958	25	51	35	155	9,785
1959	25	52	34	153	9,591

[1] Revised figure.

CONSUMPTION AND USES

The use pattern of vermiculite did not change appreciably. Most of the exfoliated product was used in building plaster, lightweight concrete with high insulating qualities, and loose-fill insulation. Miscellaneous uses included insulation for refrigerators, cold storage plants, poultry incubators, fireless cookers, ovens, and safes; seed propagation; soil conditioning; herbicide, insecticide, fungicide, and fumigant carriers; and beds for transporting hot steel ingots.

A new commercial application was the use of exfoliated vermiculite flakes, which by heat treatment take on a golden metallic luster. The flakes can be flocked or dusted on surface adhesives or mixed or ball-milled into plastics, paint, and paper formulations. They are chemically inert and are believed to withstand temperatures up to 1,000° F.[3]

PRICES

E&MJ Metal and Mineral Markets quoted nominal yearend prices for crude vermiculite as follows: Per short ton, f.o.b. mines, Montana, $9.50 to $18; South Africa, $30 to $32, c.i.f. Atlantic ports.

The average mine value of all domestic crude vermiculite sold or used in 1959 was $14.89 per ton, compared with $14.28 in 1958 and $14.15 in 1957.

The average value of all exfoliated vermiculite, f.o.b. processors' plants, was $62.69, 1 percent lower than in 1958.

FOREIGN TRADE

The Union of South Africa continued as an important source of high-quality crude vermiculite. Twenty percent of the South African exports was shipped to the United States, compared with 17 percent in 1958.

Although South Africa shipped 4,500 tons to Canada, most of the crude vermiculite exfoliated in Canada came from the United States.

---

[3] Materials in Design Engineering, Gold Chips Brighten Consumer Products: Vol. 50, No. 7, December 1959, p. 166.

WORLD REVIEW

Brazil.—Vermiculite was reported mined in 1957 from deposits in Congonhal, São Paulo, and Liberdade, Minas Gerais. The Brazilian subsidiary of the American firm A. P. Green Co. was the sales agent in São Paulo.

Canada.—Five companies exfoliated vermiculite at eleven locations in 1958: Vancouver, New Westminister, Calgary, Regina, Winnipeg, St. Thomas, Cornwall, Rexdale, Toronto, St. Laurent, and Montreal. All crude vermiculite used came from the Transvaal, Union of South Africa, or from the United States. The total exfoliated in 1958 was 8,220,000 cubic feet, 12 percent more than in 1957. Sixty-four percent was used as loose-fill insulation, 27 percent in insulating plaster, 6 percent as aggregate in lightweight concrete, and 3 percent in acoustical plaster, heat-insulating materials, and in agriculture.[4]

Morocco.—A United States-Moroccan group planned to mine vermiculite and other minerals. Port facilities for direct shipping were included in the program.[5]

TABLE 4.—World production of vermiculite, by countries,[1] in short tons [2]

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country [1]	1950–54 (average)	1955	1956	1957	1958	1959
Argentina	342	1,350	614	287	161	[3] 165
Australia	60	----------	1	----------	----------	----------
India	69	138	1,038	----------	----------	2
Kenya	180	380	497	33	96	112
Morocco	----------	----------	----------	147	----------	----------
Rhodesia and Nyasaland, Federation of:						
Southern Rhodesia	268	----------	305	460	280	50
Tanganyika	----------	----------	----------	----------	91	125
Union of South Africa	38,635	57,482	58,717	62,619	54,314	52,397
United Arab Republic (Egypt region)	[4] 175	----------	----------	33	302	[3] 300
United States (sold or used by producers)	202,215	204,039	192,626	183,985	190,563	206,579
World total [1] [2]	241,944	263,389	253,798	247,564	245,807	259,730

[1] Vermiculite is produced in Brazil and U.S.S.R., but data are not available, and no estimates of their production are included in the total.

[2] This table incorporates some revisions.

[3] Estimate.

[4] Average for 1951–54.

---

[4] Wilson, S. H., Lightweight Aggregates: Department of Mines and Tech. Surveys, Canadian Miner. Ind. 1958 (preliminary), Ottawa, Canada, Review 29, April 1959, 6 pp.

[5] Mining World, Mining World News Letter: Vol. 21, No. 13, December 1959, p. 7.

TABLE 5.—Exports of crude vermiculite from Union of South Africa, by countries of destination, in short tons [1] [2]

[Compiled by Corra A. Barry]

Country	1958	1959
North America:		
Canada	5,490	4,449
United States	8,141	11,827
South America:		
Venezuela	201	50
Europe:		
Austria	232	160
Belgium	449	169
Denmark	1,350	1,844
Finland	111	----------
France	8,245	6,340
Germany, West	2,865	4,444
Italy	6,170	6,100
Netherlands	1,375	811
Sweden	170	275
Switzerland	304	187
United Kingdom	10,563	16,272
Asia:		
Bahrain	----------	198
Asia—Continued		
Iraq	55	154
Israel	167	41
Japan	56	627
Kuwait	791	719
Turkey	----------	174
Africa:		
Algeria	----------	100
Rhodesia and Nyasaland, Federation of	375	301
Oceania:		
Australia	991	2,077
New Zealand	108	53
Other countries	535	644
Total	48,744	58,016
Total value [3]	$950,466	$1,120,747
Average value	$19.50	$19.31

[1] Compiled from Customs Returns of Union of South Africa.
[2] This table incorporates some revisions.
[3] Converted to U.S. currency at the rate of SA£ $2.7993 (1958) and U.S.$2.7983 (1959).

TECHNOLOGY

The geology of the Libby, Mont., vermiculite deposit and theory covering its origin were outlined.[6]

Different methods of manufacturing fired lightweight clay structural block, with particular emphasis on the use of exfoliated vermiculite as the aggregate, were described.[7]

Research programs sponsored by the Vermiculite Institute were: Fire-resistance tests, sound-transmission tests, determination of acoustical properties of vermiculite products, and development of new uses. Nineteen technical publications covering data and tests of vermiculite products were listed by the Vermiculite Institute.

New markets and technical advances in the use of vermiculite products were outlined and discussed at the 18th annual meeting of the Vermiculite Institute, held at Boca Raton, Fla., in April 1959.[8]

Exfoliated vermiculite was employed to build firewalls in the South African gold mines. This use was developed by the Chamber of Mines (Pty.), Ltd. When packed in fireproof bags and stacked across drifts or tunnel openings vermiculite sealed off air and fumes until a permanent wall of vermiculite block was built.[9]

A review of the present applications of vermiculite in ceramics was published.[10]

An article described research at Clemson College, sponsored by Zonolite Co., where pilot tests were conducted on fired blocks composed

---

[6] Bassett, William A., The Origin of the Vermiculite Deposit at Libby, Mont.: Am. Miner., vol. 44, Nos. 3–4, March–April 1959, pp. 282–299.

[7] Robinson, Gilbert C., Lightweight Clay Block Using Vermiculite: Min. Eng., vol. 11, No. 12, December 1959, p. 1227.

[8] Pit and Quarry, Technical Advances, New Markets Discussed at Vermiculite Meeting: Vol. 51, No. 12, June 1959, pp. 68, 91.

[9] Mine and Quarry Engineering (London), Vermiculite for Firewalling: Vol. 25, No. 6, June 1959, p. 280.

[10] Gitter, A. J., Recent Developments in the Use of Vermiculite in the Ceramics Field: Refractories Jour., vol. 34, September 1958, pp. 435–440.

of mixtures of clay and vermiculite. Four forming methods using vibrating block machines, slush casting, wet pressing, and dry pressing were mentioned.[11]

Patents.—A substitute for gypsum plaster consisted of a scratch coat of pumicite, sand, cement cellulose glycolate, an alkyl sulfate, and exfoliated vermiculite. The finish coat was described as being vermiculite, sand, cement cellulose sulfite, and a fungicide. Spray-gun application was recommended.[12]

In making a dry-pressed, chemically bonded insulating block or brick, exfoliated vermiculite was used in the minus-3, plus-100-mesh range, mixed with 5 to 25 percent sulfuric acid, 1 to 10 percent phosphoric acid, and 2 to 8 percent magnesium sulfate. After pressing, the shapes are heated to 212° F.[13]

Methods for making fire-resistant filaments and fabrics for use in battery separators and filters were patented, using exfoliated vermiculite or expanded perlite and asbestos fiber.[14]

A composition for making masonry water-repellent and also providing a decorative finish was patented. It comprised a wax emulsion or solution of stearate or silicone, potassium silicate, sodium silicate, latex, and a siliceous aggregate, such as exfoliated vermiculite.[15]

A patented abrasive consisted of a mixture of exfoliated vermiculite and a phenolic resin, hardened with a high-frequency current, producing a nonporous, uniform structure free from internal stresses.[16]

A patented insulating material for pipes, tanks, and roofs was made by coating exfoliated vermiculite with asphalt.[17]

Patented lightweight structural and insulating bricks were made from a mixture of gypsum, anhydrite, and a filler such as exfoliated vermiculite. After thorough kneading the mixture was extruded.[18]

To increase the useful life of clay refractories in blast furnaces, a space between the lining and the shell was filled with a mixture of high-sulfur coke and a suitable thermally insulating granular material, such as exfoliated vermiculite.[19]

In a patented method for direct field seeding of tomatoes or other plants commonly transplanted from beds to fields, the seeds were sown in the field and covered with a biocide- or insecticide-treated exfoliated vermiculite or other suitable medium.[20]

A composition useful as a castable refractory comprised alumina cement, one of the group $BaCO_3$, $CaCO_3$, $SrCO_3$, and a suitable refractory aggregate such as exfoliated vermiculite.[21]

---

[11] Robinson, G. C., Clay Bonded Block: Brick and Clay Record, vol. 134, No. 2, February 1959, pp. 38–40, 60–61.

[12] Schneebeli, W., British Patent 813,009, May 6, 1959.

[13] Ekedahl, J. C., and Veale, J. H. (assigned to Illinois Clay Products Co., Joliet, Ill.), Chemically Bonded Vermiculite Insulated Blocks and Method for Manufacturing Same: U.S. Patent 2,919,202, Dec. 29, 1959.

[14] Manning, F. W., Propulsion of Filaments by Secondary Solids in Fiberizing: Canadian Patent 586,981, Nov. 10, 1959.

[15] Nordstrom, J., Casting Composition Containing A Silicate, A. Latex Binder, and A Waxlike Material: Canadian Patent 587,013, Nov. 17, 1959.

[16] Scholz, A. (assigned to Naxos-Union Schliefnittel und Schliefmascheninfabrik), German Patent 1,001,818, Jan. 31, 1957.

[17] Montaux, E. A., and Prost, J., French Patent 1,125,552, Nov. 2, 1956.

[18] Eipeltauer, E., Austrian Patent 205,400, Sept. 25, 1959.

[19] Berry, T. F. (assigned to U.S. Steel Corp., a New Jersey Corp.), Method of Retarding Disintegration of Blast Furnace Lining: U.S. Patent 2,912,740, Nov. 17, 1959.

[20] Dresser, H. A. (assigned to Zonolite Co., Chicago, Ill.), Direct Field Seeding: U.S. Patent 2,909,869, Oct. 27, 1959.

[21] Ricker, R. W. (assigned to Aluminum Co. of America, Pittsburgh, Pa.), Castable Refractory: U.S. Patent 2,912,841, Nov. 10, 1959.

To produce material for conditioning soil or as a soil substitute, exfoliated vermiculite was heated to 350°–600° F. and sprayed with a mist composed of air and an aqueous solution of plant foods.[22]

A sound- and heat-insulating structural material was made by mixing exfoliated vermiculite with water glass and a clay mineral and treating the slurry with a soluble metal salt such as aluminum sulfate. It was then dewatered, dried, and machined.[23]

A patented fire-retardant roof covering consisted of an asphalt-saturated felt base with a coating comprising a layer of unexfoliated vermiculite between two layers of a mixture of asphalt and asbestos fiber.[24]

A patent described the use of exfoliated vermiculite as an insulating medium in which to bury hot ingots of certain composition to prevent thermal cracking.[25]

A fire-resistant, porous building unit that can be polished, nailed, or machined, was made from a patented mixture of alumina cement, asbestos fiber, exfoliated vermiculite, and water. The mixture was poured into molds to harden.[26]

A pipe insulation that will not crack with extreme expansion and contraction of the pipe was patented. A form is positioned around the pipe, and the intervening space is filled with exfoliated vermiculite or expanded perlite coated with asphalt or coal tar, thus forming a resilient jacket around the pipe.[27]

Exfoliated vermiculite was used in a patented petroleum, solvent-dispersed, insulating coating for spraying walls or other structural members.[28]

A medium for propagating plants from seeds or cuttings consisted of exfoliated vermiculite mixed with rock phosphate and ammonium nitrate.[29]

An asphalt coating composition was composed of 40 to 60 percent air-blown asphalt, 30 to 40 percent solvent for the asphalt, 7 to 9 percent exfoliated vermiculite, and 13 to 21 percent short-fiber asbestos. This coating is especially suitable for application over high-temperature insulation and walls exposed to weather.[30]

In an exfoliated vermiculite soil conditioner the vermiculite particles were wetted and treated with a small quantity of a water-soluble polyacrylate.[31]

A composition for coating pipes before encasing them in concrete consisted of a mixture of grease and exfoliated vermiculite or other

---

[22] Rice, R. W., Canadian Patent 584,382, Oct. 6, 1959.

[23] Glasser, O., Canadian Patent, 584,798, Oct. 13, 1959.

[24] Donegan, J. W. (assigned to Allied Chemical Corp.), Canadian Patent 585,524, Oct. 20, 1959.

[25] Morgan, E. R., and Zackay, V. F. (assigned to Ford Motor Co. of Canada, Ltd.), Canadian Patent 583,384, Sept. 15, 1959.

[26] Hunziker, E. (assigned to Tonwerk Lausen A.G.), Swiss Patent 332,076, Oct. 15, 1958.

[27] Goff, D. C. (assigned to Zonolite Co., Chicago, Ill.), Method of Insulating Pipe: U.S. Patent 2,901,775, Sept. 1, 1959.

[28] Hoffman, H. J. (assigned to Minnesota Mining & Mfg. Co., Minneapolis, Minn.), Canadian Patent 579,751, July 21, 1959.

[29] Schmitz, G. W., and Rothfelder, R. E. (assigned to Zonolite Co., Chicago, Ill.), Canadian Patent 581,197, Aug. 11, 1959.

[30] Hoiberg, A. J., and Cowger, C. E. (assigned to Monsanto Chemical Co., St. Louis, Mo.), Asphalt Coating: U.S. Patent 2,890,967, June 16, 1959.

[31] Ziegler, G. E. (assigned to Zonolite Co., Chicago, Ill.), Canadian Patent 578,960, July 7, 1959.

suitable material. Moderate expansion of the pipe was thus permitted without damage to the concrete.[32]

Crude vermiculite was beneficiated by employing an aqueous suspension of mine-run ore agitated on a jig, causing delamination. The flakes are concentrated toward the top of the jig bed and are continuously removed by a horizontal splitter as delamination progresses.[33]

A method of coating surfaces with exfoliated vermiculite or similar materials used a water-soluble, thermosetting resin, heated and sprayed through a stream of hot vermiculite which is thus projected against the surface where the resin polymerizes.[34]

An abrasive wheel composition consisted of 50 to 95 parts, by weight, of silicon carbide, 5 to 50 parts of phenol formaldehyde, and 5 to 25 parts exfoliated vermiculite.[35]

Exfoliated vermiculite was one of the carriers recommended for certain new insecticide formulations.[36]

A patent described simultaneous spraying of a binder and fibrous or granulated material, such as exfoliated vermiculite.[37]

A product useful for insulating pipes, stills, and chemical processing equipment was molded from a mixture of 45 to 94 percent exfoliated vermiculite or expanded perlite, 5 to 20 percent bentonite, up to 15 percent asbestos fiber, and 1 to 20 percent organic binder.[38]

A method of making an improved granulated ammonium phosphate fertilizer was patented by mixing phosphoric acid and exfoliated vermiculite and agitating while passing gaseous ammonia through the mix. Solid, dry, porous granules of uniform size are thus produced.[39]

---

[32] Goff, D. C. (assigned to Zonolite Co., Chicago, Ill.), Canadian Patent 577,436, June 9, 1959.

[33] Myers, J. B. (assigned to Zonolite Co., Chicago, Ill.), Method for Processing Vermiculite: U.S. Patent 2,868,735, Jan. 13, 1959.

[34] McReynolds, R. W. (one half assigned to A. R. Moulin, New Orleans, La.), Method and Apparatus for Coating a Surface With Lightweight Aggregate: U.S. Patent 2,870,039, Jan. 20, 1959.

[35] Rieke, G. A., Grinding Tool Formed to an Inorganic Grinding Agent: U.S. Patent, 2,874,034, Feb. 17, 1959.

[36] Trademan, L., Malina, M. A., and Wilks, L. P. (assigned to Velsicol Chemical Corp., a Corp. of Illinois), Insecticide Formulations: U.S. Patent 2,875,120–1, Feb. 24, 1959.

[37] Stumpf, F. M. (assigned to U.S. Mineral Wool Co., Stanhope, N.J.), Method of and Apparatus for Spraying Lightweight Fibrous and Granular Particles: U.S. Patent 2,890,079, June 9, 1959.

[38] Cook, H. A., Fleming, R. E., and Heilman, R. H. (assigned to the Philip Carey Mfg. Co., Cincinnati, Ohio), Thermal Insulating Material and Method of Making Same: U.S. Patent 2,884,380, Apr. 28, 1959.

[39] Ostergaard, S. E. (assigned to Canadian Industries, Ltd.), Canadian Patent 577,444, June 9, 1959.

Water

By R. T. MacMillan [1]

⁂

WATER supply was in the median range for most of the Nation in 1959, although in about one-fourth of the area the supply was below normal. Serious long-range problems of water supply in relation to prospective requirements were foreseen as the population continued to grow and water demand for industrial, agricultural, municipal, and recreational uses increased.

LEGISLATION AND GOVERNMENT PROGRAMS

Senate Resolution 48 of the 86th Congress, April 20, 1959, provided for the appointment of a Select Committee on National Water Resources. The committee was charged with studying the extent to which water-resource activities in the United States are related to the national interest. It was also a function of the committee to study the extent and character of water-resource activities, both governmental and nongovernmental, required to provide the quantity and quality of water needed for all the country's uses to 1980. The Committee was charged with considering the ability of the Nation's water resources to sustain continued economic growth and increasing living standards of the populace. A report to the Senate was to be due January 31, 1961, and the authority of the Committee was to end on that date.[2]

The Office of Saline Water, U.S. Department of the Interior, reported nationwide interest in the Saline Water Conversion Program. Over 200 locations were offered by various cities as sites for saline-water-conversion demonstration plants. All coastal States except Delaware and 12 inland States were represented. Based on the recommendations of a Process Selection Board representing science, industry, and Government, the following four processes were selected for demonstration-plant testing: (1) Long-tube vertical multiple-effect distillation, (2) multistage flash distillation, (3) electrodialysis (membrane) process, and (4) forced-circulation vapor-compression distillation.

Contracts for engineering and design of the first three plants were approved. W. L. Badger and Associates was awarded a contract for the first plant, which was to be built at Freeport, Tex. The Fluor Corp. was awarded the contract for the second plant, at San Diego,

---

[1] Commodity specialist.
[2] Select Committee on National Water Resources, S. Rep. 190, 86th Cong., 1st Sess., Apr. 15, 1959, 8 pp.

Calif., and the Bureau of Reclamation, Denver, Colo., was assigned responsibility for the third plant.

The first two plants were to be designed for converting 1 million gallons of sea water per day, and the last two plants were to be designed for converting 250,000 gallons of brackish water per day. Brackish water may be defined as water having less than 10,000 parts per million of dissolved solids; sea water averages more than 30,000.

A special advisory committee appointed to evaluate the progress of the Office of Saline Water made recommendations to expand and extend the scientific and economic studies of this agency, which was established in 1952. The committee urged cooperation with other public and private research agencies concerned with saline-water conversion, including agencies in foreign countries, and advocated construction of additional demonstration plants.[3]

Activities of the joint Federal-State program, started in 1955 to control water in anthracite mines, had resulted in 22 projects, of which 13 were completed and 9 were in various stages of completion or testing.

The program authorized the expenditure of not more than $8.5 million of Federal funds, to be matched by the Commonwealth of Pennsylvania, for the control and drainage of water adversely affecting the mining of anthracite. The projects were about equally divided between surface-drainage improvements to avoid mine flooding by surface water and pumping installations to dewater flooded mines. Three new surface-drainage-improvement and one pump project were begun in 1959.

DOMESTIC SUPPLY

The most important factor affecting water supply for the Nation is quantity and distribution of precipitation. A convenient measure of potential water supply is the flow or runoff of major streams. In 1959 runoff was in the median range for about two-thirds of the United States; it was excessive in Florida, in the extreme Northwest, and in a small area of the central plains. About one-fourth of the Nation had less than normal runoff. Included in this area were parts of the Southwest, Texas, and the Appalachian area from Alabama to Maine.

The flow of the Mississippi River at Vicksburg, draining about 40 percent of the United States, was 79 percent of the median in 1959, and the flow of the Colorado River was 52 percent. In contrast, the flow of the Columbia River was 26 percent above normal at The Dalles, Oreg. Record floods occurred in Indiana and near-record floods in Ohio, Pennsylvania, and several other States. However, for the Nation as a whole, runoff was less than in 1958.

Water levels in the principal power reservoirs at yearend were average in most areas and above average in Texas, Wisconsin, Idaho, and the Southeast. Reservoirs for irrigation, municipal, and industrial use were below average in most areas, with a few notable exceptions in Texas and California. Combined contents of Lakes

---

[3] U.S. Department of the Interior, Saline Water Conversion Report for 1959: January 1960, 108 pp.

Meade and Mohave were 6 percent above average but considerably below the 1958 level.

Ground-water levels in the United States were close to average in most areas and followed normal seasonal fluctuations. In the Southwest—particularly in parts of Arizona, New Mexico, and Nevada—ground-water levels were much below average and continued to fall owing to excessive pumping of ground water, mostly for irrigation. In Maryland, ground-water levels in the Baltimore industrial area rose because of decreased pumpage occasioned by the steel strike. Resumption of flow from some wells in Montana was attributed to the August earthquake at west Yellowstone.[4]

According to a report published by the Federal Geological Survey,[5] water stored in reservoirs for later release equaled 190 million acre-feet. The regulated flow from this source, which was of great importance to hydroelectric-power generation, irrigation, flood control, and navigation, was about 13 percent of the total flow of rivers in the United States. Although the trend in reservoir construction continued upward, water control by storage was said to follow the law of diminishing returns, thus limiting the amount of storage that is economically justified. Factors such as evaporation, seepage losses, and construction costs detract from the ultimate returns from developing storage facilities. The Colorado River was given as an example of a river basin in which storage development was approaching the useful limit. In many other areas of the Nation, however, substantial increases in water supply were considered attainable through development of additional storage.

A huge water-development system for California came closer to reality with the passage by the State legislature of the Feather River Project designed to transfer water from the Feather River north of Sacramento to the densely populated, highly industrialized, but sparsely watered areas of southern California. By a system of canals, aqueducts, and tunnels, estimated to cost more than $2 billion and to require 10 years to build, the project would distribute excess water from the northern part of the State to the water-short southern areas.[6]

Heavy water (D_2O), a coolant and moderator in some nuclear reactors, continued to be produced at the Savannah River, Ga., plant of the Atomic Energy Commission (AEC). A total of 222,787 pounds of heavy water was sold to six countries: Canada, West Germany, Japan, Denmark, France, and Switzerland. In addition, 51,546 pounds was leased to Denmark and India.

CONSUMPTION AND USES

Industry and agriculture, on approximately an equal basis, used about 92 percent of the estimated quantity of water withdrawn from streams, lakes, reservoirs, and aquifers in 1959; the remaining 8 percent was attributed to public use. Total withdrawal use was estimated

---

[4] Geological Survey (in collaboration with Canada Department of Northern Affairs and Natural Resources), Water Resources Review: Annual Summary, Water Year 1959: Oct. 27, 1959, 17 pp.

[5] Langbein, W. B., Water Yield and Reservoir Storage in the United States: Geol. Survey Circ. 409, 1959, 5 pp.

[6] MacDonald, J. R., Golden State Goliath: Wall Street Jour., June 25, 1959, p. 1.

to be more than 270 billion gallons per day. Water used for generating hydroelectric power was excluded from these estimates because it was available for reuse without treatment. Nonwithdrawal uses of water, considered by many to be equal in importance to withdrawal uses, include navigation, recreation, waste disposal, and conservation of wild life.[7]

Only water that is evaporated or incorporated into a product is said to be consumed. As much as 60 percent of water used in agriculture, principally for irrigation, is consumed, whereas public water consumption is about 10 percent and industrial water consumption 2 percent.

Preliminary statistics on the water used by the mineral industry in 1958 and predictions for 1980 were made available to the Senate Select Committee on National Water Resources, and published in Committee Print No. 8.[8] Total water use was divided into several categories: Production of metals, nonmetals, petroleum, bituminous coal, and anthracite and refining of petroleum and natural-gas liquids. Petroleum refining was by far the largest user, requiring over 1,200 billion gallons in 1954 (five times the water demand of nonmetals, the second largest user). Anthracite production required the least water (15 billion gallons).

Water injected into oil-bearing strata in the secondary recovery of 248 million barrels (1 barrel equals 42 gallons) of oil was estimated by Bureau of Mines engineers to be 2,500 million barrels in 1959. About the same quantity of oil was produced from pressure-maintenance projects which used 750 million barrels of water. Of the water used in secondary recovery, 40 percent was fresh and 60 percent saline. In pressure-maintenance projects the ratio of fresh to saline water was about 1 to 4.

PRICES

Prices paid for public water delivered at the tap varied widely from place to place. The average price was said to be between 35 and 40 cents per thousand gallons for quantities required by most users. In areas where new water resources or treatment facilities were being developed prices rose sharply.

Water used by industry continued to be largely self-supplied, and costs depended on the quality required and the expense of development, treatment, and distribution.

Irrigation water was usually less expensive than industrial water, although prices varied widely in different areas. In previous years the average price was less than 2 cents per thousand gallons.

Water rates were said to be too low to provide the improvements and the additional facilities imminently required.[9] A conservative estimate of the cost of making the necessary improvements to water systems throughout the Nation would raise rates at least 50 percent.

---

[7] Water Resource Activities in the United States, Select Committee on National Water Resources, U.S. Senate Committee Print No. 1, 1959, 59 pp.

[8] Water Resource Activities in the United States, Select Committee on National Water Resources, U.S. Senate Committee Print No. 8, 1959, pp. 91–101.

[9] Finch, L. S., Penny-Wise Water: Jour. Am. Water Works Assoc.: Vol. 51, No. 1, January 1959, pp. 1–7.

A campaign for greater public appreciation of the necessity for and value of an adequate supply of high-quality water was advocated.

The price of heavy water was maintained at $28 per pound by the AEC. It was available for sale or lease by the AEC in 125- and 500-pound stainless-steel containers also charged to the customer. Leasing charges were 4 percent per year of the monetary value of the water. The lease period for domestic reactors was 5 years subject to renewal; for foreign reactors, it was for the estimated life of the reactor.

WORLD REVIEW

Kuwait.—Total sea-water distillation capacity at Kuwait was 4.5 million gallons per day after completion of the last units of the flash evaporation system in 1958. However, to provide for future water needs, bids were asked for an additional 2-million-gallon-per-day distillation plant. Further development of brackish water, the only other source of water in Kuwait, awaited a suitable process for demineralization.[10]

United Kingdom.—A recent survey of water requirements in England and Wales showed a rapid increase in water use since 1938. As in the United States, industry and agriculture took most of the water and domestic use accounted for only a small part. Increasing demands of industry, depletion of underground sources, river pollution, and problems on the reuse of water were being studied by the Water Research Association.[11]

TECHNOLOGY

Although several processes for saline-water conversion were ready for plant testing, the problem of large-scale water desalination was still unsolved, and numerous studies were made under the sponsorship of the Office of Saline Water to develop new methods and improve existing ones.[12] Among these studies were demineralization by gas-hydrate formation, use of chelates for removing magnesium and calcium ions from sea water to overcome scaling problems, and demineralization using biological organisms such as algae.

Several projects were concerned with improving the strength, durability, and porosity of ion permeability membranes and the stability and wettability of plastic sheets used to cover solar stills. One experimental program resulted in a plastic film with a highly surface-active coating of a titanium compound that imparted nearly perfect wettability to the film—a highly desirable feature for plastic-covered stills.

Other fundamental research involved studies of scale formation in distillation and membrane demineralization processes and of the behavior of metals at high temperatures in sea water.

Demineralization of saline water by freezing was slow to develop, although it requires less energy than distillation. In Syracuse, N.Y., a 15,000-gallon-per-day pilot plant used a direct freezing process in which part of the saline water was evaporated under vacuum, produc-

---

[10] U. S. Consulate, Kuwait, State Department Dispatch 205, Feb. 1, 1959, p. 12.

[11] Chemical Age (London), Water Research: Vol. 81, No. 2080, May 23, 1959, pp. 853–854.

[12] Work cited in footnote 3.

ing a slurry of ice crystals in concentrated brine. The ice was separated, washed, and melted to produce potable water. Lithium bromide was used in one part of the process to absorb water vapor. The cost of water containing less than 500 parts per million of dissolved solids was estimated at $1 per thousand gallons and was expected to be reduced to $0.55. Numerous other freezing processes, both direct and indirect, were in various stages of development. Indirect processes used refrigerants not in direct contact with the water.

Three solar stills for converting sea water were constructed and tested at Daytona Beach, Fla. The first was glass-enclosed and covered an area of 2,500 square feet; the others were air-inflated plastic stills, each 500 square feet in area. Extensive data had been obtained on energy and flow balances necessary to evaluate the processes. Many improvements were made in design, construction, and operation. The cost of constructing a still was an important factor in the cost of water converted by solar evaporation of sea water.

The Bureau of Mines' Industrial Water Laboratory continued to supply consulting boiler-water service to Government-operated heating and powerplants. Testing equipment and reagents were distributed to the various plants for boiler-water control testing. Accuracy of the control tests was checked periodically by analyses of samples sent to the laboratory. Over 13,500 samples were analyzed in 1959.

Use of excessive makeup water in some plants caused increased return-line corrosion. Corrosion was controlled by avoiding unnecessary steam losses and blowdown. In several plants use of soda ash in boiler-water treatment aggravated corrosion problems. These problems quickly disappeared when caustic soda was used instead of soda ash. Cyclohexylamine, morpholine, and octadecylamine were useful in relieving certain corrosion problems.

Losses of stored water through evaporation from the surface and through seepage to ground water have an important effect on the total water supply. Experiments on molecular-film evaporation control indicated that evaporation of substantial quantities of water was prevented by floating monomolecular films of certain fatty alcohols (octadecanol and hexadecanol) on the water. A new method was advanced for dispersing the films on reservoirs by prewetting the alcohol particles, mixing them with water, and pumping the suspension through pipelines laid along the upwind shorelines.[13]

Basic research was conducted by the Bureau of Mines in cooperation with the Bureau of Reclamation on chemical additives and water-soluble compounds that reduce the water permeability of typical canal lining materials. Small quantities of sodium and calcium salts added to certain clay materials for lining canals were beneficial in reducing seepage. Studies were continued to determine the mechanics of the reaction and to ascertain the optimum materials and procedures.

Pollution control continued to be a primary problem in providing an adequate supply of water. Growth of population, industry, and agriculture not only greatly increased water demand but also resulted in

---

[13] Chemical Engineering Progress, Molecular Film Evaporation Control: Vol. 55, No. 10, October 1959, p. 96.

larger volumes of waste materials. Chemical wastes resulting from the manufacture of various chemical products, especially pesticides, and radioactive wastes from nuclear reactors were among the new problems resulting from technological advances. Radioactive wastes were expected to increase as more atomic energy facilities came into operation.[14]

A special strain of bacteria was developed to feed on oil-refinery wastes, including phenols, at a refinery in the Puget Sound area of Washington. A biological oxidation plant successfully treated wastes containing 20 parts per million of phenols, traces of sulfides, and mercaptans. Diammonium phosphate was added to the waste stream before treatment to act as nutrient for the specialized bacteria, and steam was injected to raise the temperature to 85° F. for greater biological activity. Compressed air replenished the oxygen consumed in the biological reaction.[15]

The increasing need for heavy water to moderate and cool nuclear reactors throughout the free world stimulated the design and construction of several new plants. Ordinary water contains heavy water in the ratio of 1 part to 6,500. Heavy water may be separated from ordinary water by fractional distillation, electrolysis, and dual temperature exchange. A combination of these processes was used at the Savannah River plant of the AEC.

Another heavy-water production process involving the separation of deuterium from gaseous hydrogen was tested in the United States and several foreign countries. After separation, the deuterium was reacted with oxygen to form D_2O, or heavy water.[16]

Improvement in a heavy-water production process was the subject of U.S. Patent 2,787,526 issued July 21, 1959, to Jerome Spevack after 2 years of litigation. The concentration of deuterium depended on the fact that hydrogen sulfide gas picks up deuterium by isotopic exchange with water at 120° C. in suitable contacting towers. In towers maintained at a lower temperature (30° C.) water picks up deuterium from hydrogen sulfide. By a series of exchanges between hydrogen sulfide and water the concentration of D_2O in the water is increased from 0.014 percent to between 1 and 5 percent. The improvement in the process consisted chiefly of a saving in heat energy, an important factor in the cost of the process.[17]

---

[14] Chemical and Engineering News, HEW Renews War on River Wastes: Vol. 37, No. 19, May 11, 1959, pp. 40–43.

[15] Chemical Engineering, Refinery Bugs Put Bite on Phenols: Vol. 66, No. 6, Mar. 23, 1959, p. 94.

[16] Chemical Engineering, Free World Engineers Map New Heavy Water: Vol. 66, No. 4, Feb. 23, 1959, pp. 64–66.

[17] Chemical Engineering, Secrets of Low-Cost Heavy Water: Vol. 66, No. 21, Oct. 19, 1959, pp. 170–173.

Zinc

By H. J. Schroeder[1] and Esther B. Miller[2 3]

◆

Contents

THE DOMESTIC zinc industry in 1959 was marked by increased consumption and continuation of import quotas that contributed to a reduction of producers' stocks by 15 percent, even though a moderate increase in slab-zinc production was recorded and purchases for the Government account were small.

This strengthening of zinc's position was reflected in a price advance from 11.5 cents a pound, East St. Louis, at the beginning of the year to 12.5 cents at yearend. Production of zinc from domestic mines registered a small gain despite lost output in the latter half of the year because of labor strikes.

A United Nations-sponsored conference on lead and zinc in late April and early May resulted in specific voluntary restrictions in zinc production by various countries. These reductions and a marked increase in world consumption brought supply into closer balance with demand by yearend. Another result of the meeting was creation of an International Lead-Zinc Study Group on a continuing basis.

---

[1] Commodity specialist.

[2] Statistical assistant.

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from reports of the U.S. Department of Commerce, Bureau of the Census.

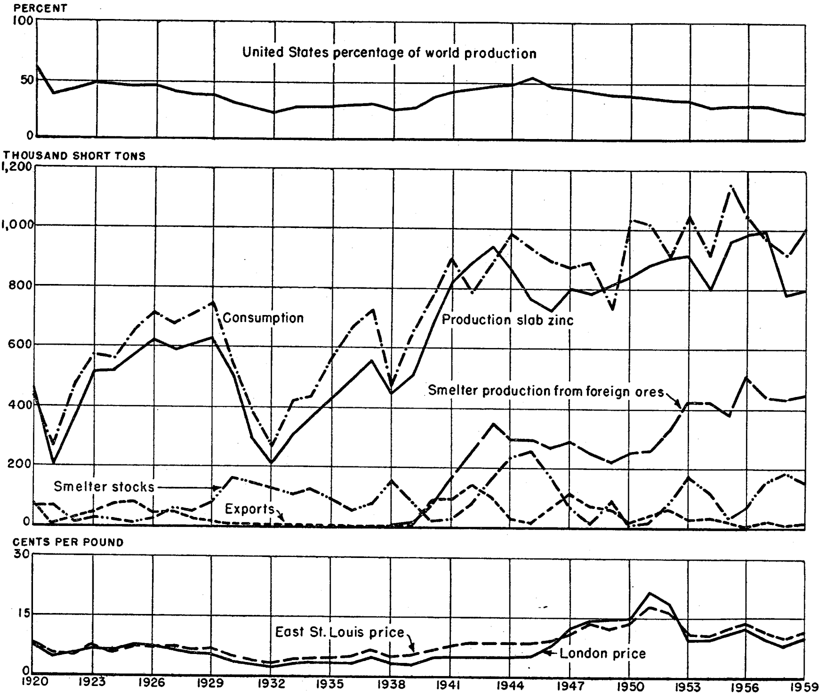

FIGURE 1.—Trends in the zinc industry in the United States, 1920–59. Consumption figures represent primary slab zinc plus zinc contained in pigments made directly from ore.

LEGISLATION AND GOVERNMENT PROGRAMS

A third United Nations conference on lead and zinc, with the aim of attaining greater stability in the industry, was held in New York in late April and early May. One result was specific voluntary commitments by various countries to restrict output to bring supply and demand into better balance. The meeting also provided for creating a continuing body designated as the International Lead-Zinc Study Group. Membership consisted of 25 nations with substantial interests in production, consumption, or trade of lead or zinc.

Import quotas on zinc metal and ore imposed by President Eisenhower, effective October 1, 1958, were in effect throughout 1959. The quotas were set at 80 percent of the U.S. average annual competitive import rate from 1953 through 1957—379,840 tons of zinc in ore and 141,120 tons of zinc in pigs, slabs, and certain other forms.

On August 22 the U.S. Senate formally ordered the Tariff Commission to conduct an investigation of the lead-zinc situation and report findings by March 31, 1960, on the adequacy of existing import restrictions. The Tariff Commission announced on September 2 that public hearings would be held in Washington January 12–15, 1960, to allow all interested parties the opportunity to express their views.

The Office of Minerals Exploration (OME), authorized in 1958

TABLE 1.—Salient zinc statistics

	1950–54 (average)	1955	1956	1957	1958	1959
United States:						
Production:						
Domestic ores, recoverable content........short tons..	598, 293	514, 671	542, 340	531, 735	412, 005	425, 303
Value........thousands..	$175, 696	$126, 609	$148, 503	$123, 235	$84, 113	$97, 787
Slab zinc:						
From domestic ores short tons..	532, 339	582, 913	470, 093	539, 692	346, 240	348, 443
From foreign ores do....	337, 283	380, 591	513, 517	446, 104	435, 006	450, 223
Total slab zinc..do....	869, 622	963, 504	983, 610	985, 796	[1] 781, 246	[1] 798, 666
From scrap (redistilled slab).....short tons..	58, 325	66, 042	72, 127	72, 481	46, 605	57, 818
Total..............do....	927, 947	1, 029, 546	1, 055, 737	1, 058, 277	[1] 827, 851	[1] 856, 484
Secondary zinc [2]...do....	246, 122	239, 298	209, 935	192, 367	184, 182	219, 027
Imports (general):						
Ores (zinc content)....do....	400, 027	478, 044	525, 350	526, 014	[3] 461, 560	499, 451
Slab zinc..............do....	150, 231	195, 696	244, 978	269, 007	195, 199	156, 963
Exports of slab zinc.......do....	30, 021	18, 069	8, 813	10, 785	[3] 2, 073	11, 629
Stocks:						
At producers' plants..do....	83, 855	39, 264	66, 875	155, 833	[3] 184, 020	156, 457
At consumers' plants [4] do....	79, 293	123, 544	104, 094	88, 342	[3] 93, 609	102, 195
Consumption:						
Slab zinc..............do....	924, 823	1, 119, 812	1, 008, 790	935, 620	868, 327	956, 197
Ores (recoverable zinc content)...........short tons..	119, 009	118, 135	113, 388	[5] 110, 311	[5] 94, 938	[5] 108, 070
Secondary (recoverable zinc content) [6]..........do....	238, 431	231, 133	200, 844	185, 662	178, 900	214, 251
Total consumption..do....	1, 282, 263	1, 469, 080	1, 323, 022	1, 231, 593	1, 142, 165	1, 278, 518
Price, Prime Western grade, East St. Louis cents a pound..	13. 93	12. 30	13. 49	11. 40	10. 31	11. 46
World:						
Mine production.....short tons..	2, 775, 000	[3] 3, 200, 000	3, 420, 000	[3] 3, 450, 000	[3] 3, 330, 000	3, 390, 000
Smelter production.........do....	2, 480, 000	[3] 2, 930, 000	[3] 3, 100, 000	[3] 3, 190, 000	[3] 2, 990, 000	3, 140, 000
Price, Prime Western, London cents a pound..	14. 83	11. 30	12. 19	10. 18	8. 24	10. 27

[1] Includes production of zinc used directly in alloying operations.
[2] Excludes redistilled slab zinc.
[3] Revised figure.
[4] Excludes remelt zinc.
[5] Includes ore used directly in galvanizing.
[6] Excludes redistilled slab and remelt zinc.

as the successor to the Defense Minerals Exploration Administration, continued to encourage exploration of strategic and critical minerals and metals. Exploration assistance for zinc was based on Government advance of 50 percent of the approved costs of qualifying projects. During 1959, OME awarded five contracts to aid in exploring for zinc or zinc and other metals for a total Government participation of $88,935. Also, five applications were rejected or withdrawn, and three were being considered at the end of the year.

Under authority of Public Law 480 (1954) and the Office of Defense Mobilization (ODM) authorization of May 1956, the Department of Agriculture, through its agent, the Commodity Credit Corporation (CCC), continued to trade perishable surplus agricultural products for zinc and other commodities of foreign origin. In 1959 CCC contracted for 29,041 tons of zinc metal (38,860 tons in 1958) to be added to the Government supplemental stockpile.

The General Services Administration (GSA) continued to be responsible for stockpile procurement and administration, procurement under foreign-aid programs as agent of the International Cooperation Administration (ICA), and administration of Defense Production Act (DPA) programs, including domestic purchase programs. Purchases of zinc produced from domestic ores were made against the maximum stockpile objective for this metal in mid-1959. These purchases are included in the 3,000 tons reported by the American Zinc Institute as being shipped by domestic producers.

Foreign zinc received at GSA warehouses under barter agreements during the year totaled 27,787 tons (40,216 tons in 1958). Such zinc was placed in the supplemental stockpile and could not be removed except by act of Congress.

TABLE 2.—DMEA contracts involving lead and zinc executed in 1959, by States

State and contractor	Property	County	Date approved	Total amount[1]
COLORADO				
Clear Creek Mining Co	Lake Central project	Clear Creek	Oct. 1	$84,500
IDAHO				
Abot Mining Co	Pilot group	Shoshane	June 23	43,550
MONTANA				
Baltimore Syndicate	Baltimore mine	Jefferson	July 27	22,930
Howard C. Banks	Hidden Hand	Powell	June 23	13,900
VIRGINIA				
Roland F. Beers, Inc	Myers	Smyth	June 16	12,990
UTAH				
Glen Larsen	Iron Blossom No. 1	Juab	June 16	43,926
Total				221,796

[1] Government participation was 50 percent in exploration projects for lead and zinc in 1959.

DOMESTIC PRODUCTION

MINE PRODUCTION

Mines in the United States produced 425,300 tons of recoverable zinc in 1959. This quantity was an increase of 3 percent over that of 1958 but was the second smallest annual zinc production since 1933. Continued reduction in output from the West Central States and increased output of States east of the Mississippi River were notable developments. Production in the first half of 1959 was 224,100 tons; the reduced output of 201,200 tons in the second half of the year was largely attributable to labor strikes.

Idaho retained its leadership among the western zinc-mining States and was the second largest producer in the Nation. The Star mine of the Bunker Hill Co. was the largest zinc mine in the State. Other principal producers were the Page mine of American Smelting & Refining Co. and the Bunker Hill mine of the Bunker Hill Co.

TABLE 3.—Mine production of recoverable zinc in the United States, by States, in short tons

State	1950–54 (average)	1955	1956	1957	1958	1959
Western States and Alaska:						
Alaska	1	--------	--------	--------	--------	--------
Arizona	41, 923	22, 684	25, 580	33, 905	28, 532	37, 325
California	6, 669	6, 836	8, 049	2, 969	51	78
Colorado	45, 530	35, 350	40, 246	47, 000	37, 132	35, 388
Idaho	74, 802	53, 314	49, 561	57, 831	49, 725	55, 699
Montana	75, 328	68, 588	70, 520	50, 520	33, 238	27, 848
Nevada	12, 251	2, 670	7, 488	5, 292	91	217
New Mexico	27, 807	15, 277	35, 010	32, 680	9, 034	4, 636
Oregon	5	--------	--------	--------	--------	--------
South Dakota	--------	--------	--------	--------	--------	--------
Texas	5	--------	--------	--------	--------	--------
Utah	32, 431	43, 556	42, 374	40, 846	44, 982	35, 223
Washington	21, 638	29, 536	25, 609	24, 000	18, 797	17, 111
Total	338, 390	277, 811	304, 437	295, 043	221, 582	213, 525
West Central States:						
Arkansas	17	--------	--------	--------	--------	49
Kansas	23, 237	27, 611	28, 665	15, 859	4, 421	1, 017
Missouri	9, 768	4, 476	4, 380	2, 951	362	92
Oklahoma	46, 338	41, 543	27, 515	14, 951	5, 267	1, 049
Total	79, 360	73, 630	60, 560	33, 761	10, 050	2, 207
States east of the Mississippi River:						
Illinois	19, 311	21, 700	24, 039	22, 185	24, 940	26, 815
Kentucky	1, 683	--------	417	837	1, 258	673
New Jersey	52, 051	11, 643	4, 667	12, 530	607	--------
New York	43, 147	53, 016	59, 111	64, 659	53, 014	43, 464
North Carolina	--------	--------	--------	2	--------	--------
Pennsylvania	--------	--------	--------	--------	10, 812	16, 718
Tennessee	36, 155	40, 216	46, 023	58, 063	59, 130	89, 932
Virginia	13, 310	18, 329	19, 196	23, 080	18, 472	20, 334
Wisconsin	14, 886	18, 326	23, 890	21, 575	12, 140	11, 635
Total	180, 543	163, 230	177, 343	202, 931	180, 373	209, 571
Grand total	598, 293	514, 671	542, 340	531, 735	412, 005	425, 303

The Iron King mine of Shattuck Denn Corp. continued to be the largest producer in Arizona. Cyprus Mines Corp. resumed operations in January at the Old Dick mine and became the second largest producer. The San Xavier mine closed late in the year.

Colorado remained the third largest zinc producer among the Western States. Major producing mines were the Eagle mine of the New Jersey Zinc Co., the Idarado Mining Co. group in San Miguel County, Emperius mine of Emperius Mining Co., and the Rico mine of Rico Mining Co.

Mine output in Utah dropped 22 percent, partly because of a strike at the International Smelting & Refining Co. slag-fuming plant during the latter part of the year. The United States and Lark mine of United States Smelting, Refining & Mining Co. continued to be the largest zinc producer in the State.

Mines in Montana produced 16 percent less than in 1958. A strike at The Anaconda Co. mines at Butte, beginning in August and continuing throughout the year, was the principal reason for the reduction.

The two principal producing mines in Washington were the Pend Oreille of Pend Oreille Mines and Metals Co. and the Grandview of American Zinc, Lead & Smelting Co. Pend Oreille, continuing operation on a curtailed basis, produced 619,800 tons of crude ore, yielding

10,800 tons of zinc and 7,800 tons of lead in concentrates. Total operating costs per ton were held to $3.116, compared with $3.037 for 1958, despite an increase of $0.212 per ton for development expenditures.[4] The Federal Bureau of Mines released a publication [5] on mine production in Pend Oreille and Stevens Counties for the years 1902–56.

Mine output in New Mexico dropped sharply. The United States Smelting, Refining, & Mining Co. Bayard-mine group remained closed throughout the year. Empire Zinc Division of The New Jersey Zinc Co. reopened its Hanover operation early in August after it had been closed since May 1958. By yearend, operations were normal.

TABLE 4.—Mine production of recoverable zinc in the United States, by months, in short tons

Month	1958	1959	Month	1958	1959
January	39, 020	35, 830	August	29, 856	31, 728
February	34, 693	36, 441	September	30, 694	30, 025
March	36, 602	37, 428	October	32, 738	31, 608
April	40, 232	38, 709	November	33, 290	36, 025
May	36, 208	38, 742	December	35, 785	39, 538
June	33, 690	36, 921			
July	29, 197	32, 308	Total	412, 005	425, 303

Mines in the West Central States of Kansas, Oklahoma, and Missouri produced only 2,200 tons of zinc, compared with 10,100 tons in 1958. All producing mines in the Tri-State district had ceased operating in 1958, and they remained closed throughout 1959. Production resulted from cleanup and mill-tailing operations. There was no recovery of zinc from southeastern Missouri lead ores.

Mine output in Tennessee again set a new record, expanding 52 percent above 1958 to 89,900 tons, and firmly establishing the State as the largest zinc producer in the country. American Zinc Co. completed initial development at its Coy mine and began stoping operations in January. The Young mine increased its annual production rate to 2,500 tons by midyear and planned to attain a 4,000-ton annual rate. New Jersey Zinc Co. brought the Jefferson City mine to planned production, enabling the mill to operate at capacity. At the Flat Gap mine, initial production began in January. By yearend the production rate had increased, and stope preparation had advanced so that mine production was expected to reach mill capacity in 1960.[6]

New York dropped from second to third largest zinc-producing State in the Nation. All production was from Balmat and Edwards mines of St. Joseph Lead Co. The company reported an increase in the workweek from 5 to 6 days in January. This continued until the entire operation was closed by a strike on July 1. Settlement was reached November 2, and work was resumed on the 6-day basis.

In the Northern Illinois and Wisconsin districts, the Eagle-Picher Co. and Tri-State Zinc, Inc., mines operated throughout the year.

---

[4] Pend Oreille Mines & Metals Co., Annual Report, 1959, pp. 2–3.

[5] Fulkerson, Frank B., and Kingston, Gary B., Mine Production of Gold, Copper, Lead, and Zinc in Pend Oreille and Stevens Counties, Washington, 1902–56: Bureau of Mines Inf. Circ. 7872, 1959, 51 pp.

[6] New Jersey Zinc Co., Annual Report, 1959, pp. 7–8.

American Zinc, Lead and Smelting Co. resumed operations late in the year at both its Vinegar Hill Division mines and Piquette mine.

Zinc output in Virginia increased 10 percent. The Tri-State Zinc Co. reopened its Timberville mine in February after it had been closed for about a year. New Jersey Zinc Co. operated its Austinville mine throughout the year and reopened the adjacent Ivanhoe mine in September after a shutdown of 13 months. At yearend the Austinville concentrating mill was operating almost at full capacity with ore from both mines.

In Pennsylvania the New Jersey Zinc Co. steadily increased the production rate at the Friedensville mine, but at a slower rate than anticipated. The mine-water problem remained difficult and expensive to control. Development of the lower mine levels continued, and by yearend the main haulage incline was connected with the 600-foot level and stoping was initiated on the 800-foot level.

In the Southern Illinois and Kentucky district, zinc produced as a byproduct of fluorspar mining increased slightly, owing to a higher zinc content of the ore.

The Sterling mine of New Jersey Zinc. Co., Sussex County, N.J., was maintained on a standby basis; the company staff conducted studies directed toward improved extractive methods when the mine is reopened.[7]

The 25 leading zinc-producing mines in the United States in 1959, listed in table 5, yielded 82 percent of the total domestic output of zinc. The four leading mines supplied 25 percent, and the first eight contributed 45 percent.

SMELTER AND REFINERY PRODUCTION

The zinc smelting and refining industry operated 16 primary reduction plants and 10 secondary plants producing slab zinc, zinc pigments, zinc dust, and zinc alloys. Some manufacturers of chemicals, pigments, diecasting alloys, rolled zinc, and brass also produced secondary zinc.

Primary Smelters and Electrolytic Plants.—The primary reduction plants processed zinc ore and concentrate, zinc fume from Waelz and slag-fuming plants, other primary zinc-bearing materials, and about half of all zinc-base scrap.

Production at primary zinc plants totaled 827,100 tons of slab zinc, of which 28,500 tons was redistilled. Besides slab zinc, primary plants also produced zinc oxide, zinc dust, and zinc-base alloys.

Primary-plant capacity for slab zinc at yearend was reported to be 1,166,800 tons. The five electrolytic plants reported 1,768 of their 4,072 electrolytic cells in use at yearend and an output of 280,800 tons (59 percent of their 479,500 tons of capacity). The seven horizontal-retort plants reported 35,364 of their 44,448 retorts in use during the year. The four remaining primary smelters were the continuous-distilling vertical-retort plants at Meadowbrook, W. Va.; Depue, Ill.; Palmerton, Pa.; and Josephtown, Pa. The first three used New Jersey Zinc Co. externally gas-fired vertical retorts, and the one at

---

[7] New Jersey Zinc Co., Annual Report, 1959, p. 7.

TABLE 5.—Twenty-five leading zinc-producing mines[1] in the United States in 1959 in order of output

Rank	Mines	District	State	Operator	Type of ore
1	Balmat	St. Lawrence County.	New York	St. Joseph Lead Co.	Lead-zinc.
2	Eagle	Red Cliff (Battle Mountain).	Colorado	The New Jersey Zinc Co.	Do.
3	Jefferson City	Eastern Tennessee	Tennessee	do	Zinc.
4	Butte mines	Summit Valley	Montana	The Anaconda Co	Do.
5	United States & Lark.	West Mountain (Bingham).	Utah	United States Smelting, Refining & Mining Co.	Lead-zinc.
6	Star	Coeur d' Alene	Idaho	The Bunker Hill Co.	Do.
7	Iron King	Big Bug	Arizona	Shattuck Denn Mining Corp.	Do.
8	Young	Eastern Tennessee	Tennessee	American Zinc Co. of Tennessee.	Zinc.
9	Friedensville	Lehigh County	Pennsylvania	The New Jersey Zinc Co.	Do.
10	Austinville	Austinville	Virginia	do	Lead-zinc.
11	Mascot No. 2	Eastern Tennessee	Tennessee	American Zinc Co. of Tennessee.	Zinc.
12	Flat Gap	do	do	The New Jersey Zinc Co.	Do.
13	Davis-Bible Group	do	do	United States Steel Corp., Tennessee Coal & Iron Div.	Do.
14	Treasury Tunnel-Black Bear Smuggler Group.	Upper San Miguel	Colorado	Idarado Mining Co.	Copper-lead-zinc.
15	Pend Oreille	Metaline	Washington	Pend Oreille Mines & Metals Co.	Lead-zinc.
16	E. P. Shullsburg	Upper Mississippi Valley.	Wisconsin	The Eagle-Picher Co.	Zinc.
17	Graham-Snyder-Spillane-Feehan.	do	Illinois	do	Lead-zinc.
18	Old Dick	Eureka	Arizona	Cyprus Mines Corp.	Copper-zinc.
19	Edwards	St. Lawrence County.	New York	St. Joseph Lead Co.	Zinc.
20	Gray	Upper Mississippi Valley.	Illinois	Tri-State Zinc, Inc.	Lead-zinc.
21	United Park City	Parker City Region.	Utah	United Park City Mines Co.	Do.
22	Burra-Boyd	Polk County	Tennessee	Tennessee Copper Co.	Copper-zinc.
23	Grandview	Metaline	Washington	American Zinc, Lead & Smelting Co.	Lead-zinc.
24	Bowers-Campbell	Rockingham County.	Virginia	Tri-State Zinc, Inc.	Zinc.
25	Mahoning Group	Kentucky-Southern Illinois.	Illinois	Ozark Mahoning Co.	Fluorspar-lead-zinc.

[1] Excludes old slag dump of the Bunker Hill Co., Kellogg, Idaho.

Josephtown used electrothermic distillation retorts. Combined horizontal and vertical-retort production of 517,900 tons was only 75 percent of the reported 1959 capacity of 687,300 tons.

The list of primary smelters published in the Zinc chapter of the 1957 Minerals Yearbook was unchanged. Athletic Mining and Smelting Co. at Fort Smith, Ark., shut down operations on December 31 reportedly because of an insufficient supply of zinc concentrate.

Slag-Fuming Plants.—Many lead smelters recover a zinc fume product containing 7.5 to 12.5 percent zinc from lead blast-furnace slags. Five such plants in the United States treated 616,400 tons of hot and cold lead slag (including some crude ore at the Tooele plant), which yielded 111,300 tons of oxide fume containing 73,300 tons of recoverable zinc. Corresponding figures for 1958 were 790,700; 148,600; and 98,000 tons, respectively.

Secondary Zinc Smelters.—Zinc-base scrap (a term that includes skimmings and drosses, die-cast alloys, old zinc, engravers' plates, new clippings, and chemical residues) was smelted chiefly at secondary smelters, although about a third usually is reduced at primary smelters, and most sal ammoniac skimmings are processed at chemical plants. Secondary smelters depend on the galvanizers and scrap dealers for their supply of scrap materials. The Apex Smelting Co., Chicago, Ill., was a new addition in 1959 to the list of 11 secondary zinc smelters given in the Zinc chapter of the 1957 Mineral Yearbook.

Primary and secondary smelting plants treating zinc-base scrap produced 57,800 tons of redistilled zinc, 4,700 tons of remelt, and 32,800 tons of zinc dust. The zinc content of these products totaled 94,100 tons.

Additional details on 127,400 tons of zinc recovered in processing copper-base scrap (table 8) may be obtained in the Secondary section of the Copper chapter of this volume.

TABLE 6.—Stocks and consumption of new and old zinc scrap in the United States in 1959, gross weight in short tons

Class of consumer and type of scrap	Stocks, beginning of year [1]	Receipts	Consumption			Stocks, end of year
			New scrap	Old scrap	Total	
Smelters and distillers:						
New clippings	279	1,798	1,659	----------	1,659	418
Old zinc	524	4,237	----------	4,103	4,103	658
Engravers' plates	518	3,530	----------	3,361	3,361	687
Skimmings and ashes	7,165	20,205	24,537	----------	24,537	2,833
Sal skimmings	801	445	588	----------	588	658
Die-cast skimmings	3,385	11,024	12,974	----------	12,974	1,435
Galvanizers' dross	6,502	55,366	56,583	----------	56,583	5,285
Die castings	5,698	34,972	----------	35,732	35,732	4,938
Rod and die scrap	2,533	3,064	----------	4,428	4,428	1,169
Flue dust	123	6,199	6,184	----------	6,184	138
Chemical residues	440	8,195	8,149	----------	8,149	486
Total	27,968	149,035	110,674	47,624	158,298	18,705
Chemical plants, foundries and other manufacturers:						
New clippings	----------	20	17	----------	17	3
Old zinc	----------	----------	----------	----------	----------	----------
Engravers' plates	----------	----------	----------	----------	----------	----------
Skimmings and ashes	1,236	5,432	4,995	----------	4,995	1,673
Sal skimmings	12,059	20,910	22,542	----------	22,542	10,427
Die-cast skimmings	----------	----------	----------	----------	----------	----------
Galvanizers' dross	14	29	----------	----------	----------	43
Die castings	----------	----------	----------	----------	----------	----------
Rod and die scrap	4	40	----------	42	42	2
Flue dust	104	514	567	----------	567	51
Chemical residues	1,016	20,330	19,578	----------	19,578	1,768
Total	14,433	47,275	47,699	42	47,741	13,967
Grand total:						
New clippings	279	1,818	1,676	----------	1,676	421
Old zinc	524	4,237	----------	4,103	4,103	658
Engravers' plates	518	3,530	----------	3,361	3,361	687
Skimmings and ashes	8,401	25,637	29,532	----------	29,532	4,506
Sal skimmings	12,860	21,355	23,130	----------	23,130	11,085
Die-cast skimmings	3,385	11,024	12,974	----------	12,974	1,435
Galvanizers' dross	6,516	55,395	56,583	----------	56,583	5,328
Die castings	5,698	34,972	----------	35,732	35,732	4,938
Rod and die scrap	2,537	3,104	----------	4,470	4,470	1,171
Flue dust	227	6,713	6,751	----------	6,751	189
Chemical residues	1,456	28,525	27,727	----------	27,727	2,254
Total	42,401	196,310	158,373	47,666	206,039	32,672

[1] Figures partly revised.

TABLE 7.—Production of secondary zinc and zinc-alloy products in the United States, gross weight in short tons

Products	1950-54 (average)	1955	1956	1957	1958	1959
Redistilled slab zinc	58,325	[1] 66,042	[1] 72,127	[1] 72,481	46,605	[1] 57,818
Zinc dust [2]	27,548	30,118	28,048	26,715	26,512	32,758
Remelt spelter	4,458	5,019	7,900	6,404	5,236	4,718
Remelt die-cast slab	8,091	12,729	12,900	10,328	12,980	13,150
Zinc-die and die-casting alloys	4,200	6,377	4,306	6,440	6,082	5,864
Galvanizing stocks	210	325	369	240	249	245
Rolled zinc	3,169	2,915	2,179	185	10	14
Secondary zinc in chemical products	35,283	28,917	30,675	33,361	32,482	40,204

[1] Includes redistilled slab made from remelt die-cast slab.
[2] Includes zinc dust produced from other than scrap.

TABLE 8.—Zinc recovered from scrap processed in the United States, by kind of scrap and form of recovery, in short tons

Kind of scrap	1958	1959	Form of recovery	1958	1959
New scrap:			As metal:		
Zinc-base	87,566	106,420	By distillation:		
Copper-base	71,312	93,909	Slab zinc [1]	46,150	57,227
Aluminum-base	1,490	2,024	Zinc dust [2]	26,010	32,119
Magnesium-base	38	53	By remelting	5,282	4,776
Total	160,406	202,406	Total	77,442	94,122
Old scrap:			In zinc-base alloys	17,683	17,611
Zinc-base	38,643	38,532	In brass and bronze	99,641	120,190
Copper-base	29,754	33,487	In aluminum-base alloys	2,941	3,948
Aluminum-base	1,436	1,734	In magnesium-base alloys	143	179
Magnesium-base	93	95	In chemical products:		
			Zinc oxide (lead-free)	16,016	19,362
Total	69,926	73,848	Zinc sulfate	(3)	(3)
			Zinc chloride	10,748	13,625
Grand total	230,332	276,254	Miscellaneous	5,718	7,217
			Total	152,890	182,132
			Grand total	230,332	276,254

[1] Includes zinc content of redistilled slab made from remelt die-cast slab.
[2] Includes zinc content of dust made from other than scrap.
[3] Included under "Miscellaneous."

SLAB ZINC

Domestic smelter output of slab zinc increased 3 percent over 1958. Included in the 856,500 tons of slab zinc produced is molten zinc used directly in alloying operations. Of the output, 798,700 tons was primary metal and 57,800 redistilled secondary zinc. Primary production was 44 percent from domestic ores and 56 percent from foreign ores; 35 percent was electrolytic and 65 percent distilled slab zinc. Primary smelters produced 49 percent of the redistilled secondary slab zinc; the remainder was obtained from secondary smelters.

Prime Western-grade zinc, which accounted for 42 percent of the total (41 percent in 1958) was the principal grade produced. Special High grade constituted 39 percent (36 percent in 1958), High grade 8 percent (11 percent), Brass Special 9 percent (10 percent), Intermediate 2 percent (2 percent), and Select a small fraction of 1 percent in both 1958 and 1959.

TABLE 9.—Distribution of 1958 zinc scrap consumption and recovery therefrom, by type of product, gross weight in short tons[1]

Scrap items	Products									Total scrap consumed	Total metal recovered	Number of plants using each item[2]
	Redistilled slab	Remelt spelter	Remelt die cast slab	Zinc die castings	Zinc dust	Zinc oxide (lead-free)	Zinc chloride	Other zinc chemicals	Brass and other alloy ingot			
New clippings	176	1,652	145						366	2,339	2,219	33
Old zinc	1,704	1,066	1,376			298			437	4,881	4,100	53
Engravers' plates	575	466	1,000			293			323	2,657	2,398	42
Skimming and ashes	10,653	3,230					4,891			18,774	2,832	20
Sal skimmings	223						16,039			16,262	7,797	12
Die-cast skimmings	4,682		4,532			28				9,242	6,572	16
Galvanizers' dross	24,524		29		24,757	3,558				52,868	44,458	26
Die-cast and die scrap	13,901	191	16,404	896	1,467	7.393			430	40.682	30,725	78
Flue dust	3,452					2,193	429			6,074	2,800	8
Chemical residues						14,588		7,969		22,557	12,067	6

[1] Prepared by A. J. McDermid, commodity specialist.

[2] 91 plants supplied 1958 information on zinc-scrap form 6-1119-M; 72,517 tons of zinc in ore and 31,207 tons of refined zinc and zinc alloys also reported on form as being used in making zinc dust, zinc oxide, and other zinc chemicals in 1958.

TABLE 10.—Primary and redistilled secondary slab zinc produced in the United States, in short tons

Year	Primary			Redistilled secondary	Total (excludes zinc recovered by remelting)
	From domestic ores	From foreign ores	Total		
1950–54 (average)	532,339	337,283	869,622	58,325	927,947
1955	582,913	[1] 380,591	963,504	66,042	1,029,546
1956	[1] 470,093	[1] 513,517	983,610	72,127	1,055,737
1957	539,692	446,104	985,796	72,481	1,058,277
1958	[1] 346,240	435,006	[2] 781,246	46,605	[2] 827,851
1959	348,443	450,223	[2] 798,666	57,818	[2] 856,484

[1] Includes a small tonnage of slab zinc further refined into high-grade metal.
[2] Includes production of zinc used directly in alloying operations.

TABLE 11.—Distilled and electrolytic zinc, primary and secondary, produced in the United States, in short tons

CLASSIFIED ACCORDING TO METHOD OF REDUCTION

Year	Electrolytic primary	Distilled	Redistilled secondary		Total
			At primary smelters	At secondary smelters	
1950–54 (average)	342,277	527,345	22,565	35,760	927,947
1955	389,891	573,613	24,747	41,295	1,029,546
1956	410,417	573,193	30,221	41,906	1,055,737
1957	409,483	576,313	35,215	37,266	1,058,277
1958	326,449	454,797	24,297	22,308	[1] 827,851
1959	280,813	517,853	28,451	29,367	[1] 856,484

CLASSIFIED ACCORDING TO GRADE

Year	Grade A		Grade B (Intermediate)	Grades C and D		Grade E (Prime Western)	Total
	Special High Grade (99.99% Zn)	High Grade (Ordinary)		Brass Special	Select		
1950–54 (average)	286,404	172,573	18,842	52,988	6,857	390,283	927,947
1955	378,215	138,597	23,792	80,209	3,904	404,829	1,029,546
1956	356,756	162,467	37,691	96,291	2,400	400,132	1,055,737
1957	354,042	152,317	32,262	84,291	1,150	434,215	1,058,277
1958	298,442	86,859	19,388	81,841	1,300	340,021	[1] 827,851
1959	331,312	71,792	17,493	75,305	1,414	359,168	[1] 856,484

[1] Includes production of zinc used directly in alloying operations.

Pennsylvania again ranked first in production of slab zinc, Texas second, and Oklahoma third. The slab-zinc output of Pennsylvania, West Virginia, Oklahoma, and Arkansas was distilled; that of Montana and Idaho was electrolytic. Part of the Illinois and Texas slab output was distilled, and part was electrolytic.

TABLE 12.—Primary slab zinc produced in the United States, by States where smelted, in short tons

Year	Arkansas	Idaho	Illinois	Montana	Oklahoma	Pennsylvania	Texas and West Virginia[1]	Total	
								Short tons	Value
1950-54 (average)	18,613	52,834	110,868	203,189	151,274	183,703	149,141	869,622	$249,291,977
1955	21,481	56,625	102,808	207,366	160,961	218,469	195,794	963,504	236,829,283
1956	27,651	57,799	101,826	214,755	166,173	198,968	216,438	983,610	270,099,306
1957	23,080	68,831	[2] 107,294	198,036	157,633	[3] 247,836	[4] 183,086	985,796	229,493,309
1958	17,952	55,454	[2] 82,844	148,921	122,138	[3] 187,243	[4] 166,694	[5] 781,246	159,686,682
1959	15,964	61,191	102,708	86,620	152,072	[3] 217,368	[4] 162,743	798,666	183,213,980

[1] Includes Missouri, 1950-53, 1955, 1956.
[2] Includes Missouri.
[3] Includes West Virginia.
[4] Texas only.
[5] Includes production of zinc used directly in alloying operations.

BYPRODUCT SULFURIC ACID

Sulfuric acid was made from sulfur dioxide gases produced in roasting zinc sulfide concentrate at some primary zinc smelters. At several plants elemental sulfur was burned to increase acidmaking capacity. In 1959 acid production at zinc-roasting plants from zinc sulfide was 803,600 short tons valued at $13.1 million, and from elemental sulfur 100,100 tons valued at $1.6 million.

ZINC DUST

Zinc dust included in data in tables 8, 9, and 13 is restricted to commercial grades that comply with close specifications as to percentage of unoxidized metal, evenness of grading, and fineness of particles, and does not include blue powder. The zinc content of the dust produced ranged from 95.0 to 99.8 percent and averaged 98.1 percent. Total shipments of zinc dust were 33,000 tons, of which 400 tons were shipped abroad. Producers' stocks of zinc dust were 2,000 tons at the end of the year.

Most of the zinc dust was made from zinc scrap, chiefly galvanizers' dross, but some was recovered from refined metal.

TABLE 13.—Zinc dust[1] produced in the United States

Year	Short tons	Value		Year	Short tons	Value	
		Total	Average per pound			Total	Average per pound
1950-54 (average)	27,548	$9,366,013	$0.170	1957	26,715	$7,859,583	$0.147
1955	30,118	9,216,108	.153	1958	26,512	[2] 7,253,683	.137
1956	28,048	9,368,032	.167	1959	32,758	9,683,265	.148

[1] All produced by distillation.
[2] Corrected figure.

CONSUMPTION AND USES

Zinc consumed as refined metal in slab or pig form totaled 956,200 tons (868,300 tons in 1958); as ore and concentrate to make pigments and salts and used directly in galvanizing, 108,100 tons (94,900); and as scrap to make alloys, zinc dust, pigments and salts, 214,300 tons (178,900). Totaled, these uses accounted for 1,278,500 tons of primary and secondary zinc, an increase of 12 percent over the 1,142,100 tons in 1958. The quantity of zinc consumed directly in making pigments and salts is reported in table 21. Zinc consumed in scrap form and the manufactured products other than remelt and redistilled are reported in tables 6, 7, and 8.

Slab-zinc consumption, as reported by 700 plants, increased 10 percent and was only 15 percent below the record 1,119,800 tons used in 1955. Zinc-base alloys consumed the most—41 percent of the 956,200 tons used by all industries. Slab zinc used by the brass industry rose 28 percent over 1958 and was 13 percent of the total. Zinc used in galvanizing steel products decreased 5 percent to 361,000 tons and represented 38 percent of total use. The remaining 8 percent went into rolled products, zinc oxide, light-metal alloys, desilverizing lead, and miscellaneous uses.

Rolling mills used 42,900 tons of slab zinc and remelted and rerolled 14,700 tons of metallic scrap produced in fabricating plants operated

TABLE 14.—Consumption of slab zinc in the United States, by industries, in short tons[1]

Industry and product	1950–54 (average)	1955	1956	1957	1958	1959
Galvanizing:[2]						
Sheet and strip	164,954	200,403	203,713	168,221	194,196	175,691
Wire and wire rope	47,347	48,171	42,937	36,468	35,638	35,602
Tubes and pipe	83,692	98,206	86,277	70,463	67,318	59,830
Fittings	13,669	10,586	10,652	9,965	8,904	10,239
Other	96,359	93,775	[3] 95,567	[3] 82,640	[3] 75,173	[3] 79,665
Total galvanizing	406,021	451,141	439,146	367,757	381,229	361,027
Brass products:						
Sheet, strip, and plate	71,074	67,550	56,207	52,873	46,967	61,234
Rod and wire	43,502	46,830	39,413	33,711	32,568	40,286
Tube	16,120	15,363	13,666	11,915	9,645	11,808
Castings and billets	6,435	7,518	6,337	5,818	4,423	4,967
Copper-base ingots	6,460	8,062	7,197	7,286	7,094	10,276
Other copper-base products	1,354	920	1,184	787	678	707
Total brass products	144,945	146,243	124,004	112,390	101,375	129,278
Zinc-base alloy:						
Die castings	274,133	417,333	349,200	363,830	309,408	383,358
Alloy dies and rod	7,859	11,754	9,322	10,149	5,400	3,745
Slush and sand castings	2,196	1,720	1,985	2,060	2,022	2,228
Total zinc-base alloy	284,188	430,807	360,507	376,039	316,830	389,331
Rolled zinc	57,196	51,589	47,359	41,269	40,616	42,949
Zinc oxide	18,598	22,433	19,160	20,428	13,331	18,248
Other uses:						
Wet batteries	1,471	1,420	1,345	1,336	846	1,244
Desilverizing lead	2,534	2,676	2,939	2,808	2,521	1,949
Light-metal alloys	3,444	3,484	5,830	4,958	3,657	3,363
Other[4]	6,426	10,019	8,500	8,635	7,922	8,808
Total other uses	13,875	17,599	18,614	17,737	14,946	15,364
Total consumption[5]	924,823	1,119,812	1,008,790	935,620	868,327	956,197

[1] Excludes some small consumers.

[2] Includes zinc used in electrogalvanizing and electroplating, but excludes sherardizing.

[3] Includes 27,760 tons used in job galvanizing in 1956, 28,286 tons in 1957, 28,502 tons in 1958, and 31,521 tons in 1959.

[4] Includes zinc used in making zinc dust, bronze powder, alloys, chemicals, castings, and miscellaneous uses not elsewhere mentioned.

[5] Includes 3,589 tons of remelt zinc in 1954, 2,997 tons in 1955, 5,230 tons in 1956, 6,805 tons in 1957, 8,073 tons in 1958, and 5,209 tons in 1959.

in connection with the rolling mills. An additional 500 tons of purchased scrap (new clippings and old zinc) also was melted and rolled.

Output of rolled zinc increased 5 percent to 40,700 tons. Stocks of rolled zinc at the mills was 3,000 tons at the end of 1959, compared with 2,200 tons on hand at the beginning of the year. Besides shipments of 21,500 tons of rolled zinc, the rolling mills consumed 33,000 tons of rolled zinc in manufacturing 19,700 tons of semifabricated and finished products.

TABLE 15.—Rolled zinc produced and quantity available for consumption in the United States

	1958			1959		
	Short tons	Value		Short tons	Value	
		Total	Average per pound		Total	Average per pound
Production:						
Sheet zinc not over 0.1 inch thick	12,388	$7,308,801	$0.295	13,015	$7,989,799	$0.307
Boiler plate and sheets over 0.1 inch thick	419	174,769	.208	432	185,730	.215
Strip and ribbon zinc [1]	24,566	9,749,501	.198	25,406	10,831,946	.213
Foil, rod, and wire	1,496	763,332	.255	1,814	967,978	.267
Total rolled zinc	38,869	17,996,403	.231	40,667	19,975,453	.246
Imports	901	285,271	.158	951	310,855	.163
Exports	3,818	2,637,346	.345	3,529	2,708,039	.384
Available for consumption	36,101			37,311		
Value of slab zinc (all grades)			.102			.114
Value added by rolling			.129			.132

[1] Figures represent net production. In addition 12,769 tons of strip and ribbon zinc in 1958 and 14,653 tons in 1959 were rerolled from scrap originating in fabricating plants operating in connection with zinc rolling mills.

Of the commercial grades of slab zinc used, Special High grade was 47 percent of the total, Prime Western 33 percent, High Grade 9 percent, Brass Special 9 percent, Intermediate 1 percent, Select and Remelt together 1 percent. All grades of slab zinc were used in making brass products, and all except Select grade was used in galvanizing. More than 98 percent of the slab zinc used in making zinc-base alloys was Special High grade.

TABLE 16.—Consumption of slab zinc in the United States in 1959, by grades and industries, in short tons

Industry	Special High grade	High grade	Intermediate	Brass Special	Select	Prime Western	Remelt	Total
Galvanizers	14,505	9,526	3,195	64,423		267,406	1,972	361,027
Brass mills [1]	29,222	66,868	837	8,611	2,087	19,225	2,428	129,278
Die casters [2]	381,833	223	79		2	6,934	260	389,331
Zinc rolling mills	15,053	8,340	8,166	11,170		220		42,949
Oxide plants	1,648					16,600		18,248
Other	4,535	1,206	454	73		8,547	549	15,364
Total	446,796	86,163	12,731	84,277	2,089	318,932	5,209	956,197

[1] Includes brass mills, brass ingot makers. and brass foundries.

[2] Includes producers of zinc-base die castings, zinc-alloy dies, and zinc-alloy rods.

CONSUMPTION OF SLAB ZINC BY GEOGRAPHIC AREAS

Among 36 States consuming slab zinc for galvanizing, Ohio, Illinois, Pennsylvania, and Indiana continued to lead, using 58 percent of the total. The iron and steel industry used zinc to galvanize steel sheets, wire, tube, pipe, cable, chain, bolts, railway-signal equipment, building and pole-line hardware, and many other items.

Connecticut, with 32 percent of the total, again ranked first in use of slab in brassmaking. Of 22 States using zinc to make zinc-base alloys, Michigan ranked first, then Illinois and Ohio.

Slab zinc used by rolling mills to make sheet, strip, ribbon, foil, plate, rod and wire totaled 42,900 tons, compared with 40,600 tons used in 1958. The major American use was for dry-cell battery cases and similar extruded cases for radio condensers and tube shields.

TABLE 17.—Consumption of slab zinc in the United States in 1959, by industries and States, in short tons

State	Galvanizers	Brass mills [1]	Die casters [2]	Other [3]	Total
Alabama	(4)	(4)	----------	(4)	27,005
Arizona	(4)	----------	----------	(4)	(4)
Arkansas	----------	----------	----------	(4)	(4)
California	19,217	(4)	16,748	(4)	38,237
Colorado	(4)	(4)	----------	(4)	(4)
Connecticut	3,190	40,636	(4)	(4)	46,066
Delaware	----------	(4)	(4)	----------	(4)
District of Columbia	----------	(4)	----------	----------	(4)
Florida	(4)	----------	----------	----------	(4)
Georgia	(4)	----------	----------	----------	(4)
Hawaii	(4)	----------	----------	----------	(4)
Idaho	----------	----------	(4)	(4)	(4)
Illinois	53,321	20,763	82,569	16,306	172,959
Indiana	36,433	(4)	22,958	(4)	78,221
Iowa	(4)	----------	----------	(4)	3,395
Kansas	----------	(4)	(4)	----------	(4)
Kentucky	(4)	(4)	(4)	----------	(4)
Louisiana	692	----------	----------	----------	692
Maine	(4)	(4)	----------	----------	(4)
Maryland	30,320	(4)	----------	(4)	30,600
Massachusetts	3,625	(4)	----------	(4)	7,059
Michigan	4,553	13,170	85,731	108	103,562
Minnesota	(4)	(4)	----------	----------	1,840
Mississippi	(4)	----------	----------	----------	(4)
Missouri	3,916	(4)	3,480	(4)	8,476
Nebraska	(4)	----------	(4)	(4)	1,723
New Hampshire	----------	(4)	----------	----------	(4)
New Jersey	7,613	6,769	(4)	(4)	27,635
New York	6,430	(4)	33,211	(4)	54,843
North Carolina	----------	----------	(4)	----------	(4)
Ohio	67,361	(4)	50,486	(4)	127,746
Oklahoma	(4)	----------	(4)	(4)	7,358
Oregon	338	(4)	(4)	(4)	1,222
Pennsylvania	52,363	7,802	20,335	(4)	111,578
Rhode Island	(4)	(4)	----------	(4)	622
South Carolina	(4)	----------	----------	----------	(4)
Tennessee	(4)	----------	(4)	(4)	1,831
Texas	10,794	(4)	(4)	(4)	41,509
Utah	(4)	----------	----------	----------	(4)
Virginia	(4)	(4)	----------	(4)	319
Washington	(4)	----------	(4)	(4)	1,397
West Virginia	(4)	(4)	----------	----------	6,846
Wisconsin	2,224	(4)	(4)	(4)	13,103
Total [5]	359,055	126,850	389,071	76,012	950,988

[1] Includes brass mills, brass ingotmakers and brass foundries.
[2] Includes producers of zinc-base diecastings, zinc-alloy dies, and zinc-alloy rods.
[3] Includes slab zinc used in rolled-zinc products and in zinc oxide.
[4] Figure withheld to avoid disclosing individual company confidential data.
[5] Includes States not individually shown; excludes remelt zinc.

Weather-stripping, roof flashing, photoengraving plates, and household electric fuses were other uses. States using slab zinc in rolled products, in descending order of use, were Illinois, Indiana, Pennsylvania, New York, Iowa, Massachusetts, and Connecticut.

Other slab zinc uses included slush castings, wet batteries, desilverizing lead, light-metal alloys, zinc dust, chemicals, bronze powders, zinc oxide, and part of the zinc used for cathodic protection.

ZINC PIGMENTS AND SALTS[8]

Production and Shipments.—Production of the principal zinc pigments and salts was enough for all requirements of the domestic market.

Outputs of lead-free and leaded zinc oxide were 22 and 3 percent, respectively, above 1958. The value of paint sales increased 9 percent, and consumption of natural and synthetic rubber together increased 20 percent. Output of zinc chloride and zinc sulfate increased 20 percent over 1958. The values of public and private construction increased 6 and 13 percent, respectively.

Pigments and salts were made from various zinc-bearing materials, including ore, slab zinc, scrap, and residues. The zinc in pigments and salts produced directly from ore exceeded 95,000 tons; that in zinc oxide and zinc chloride produced from slab zinc exceeded 18,000 tons; and zinc in pigments and salts derived from secondary material exceeded 41,300 tons.

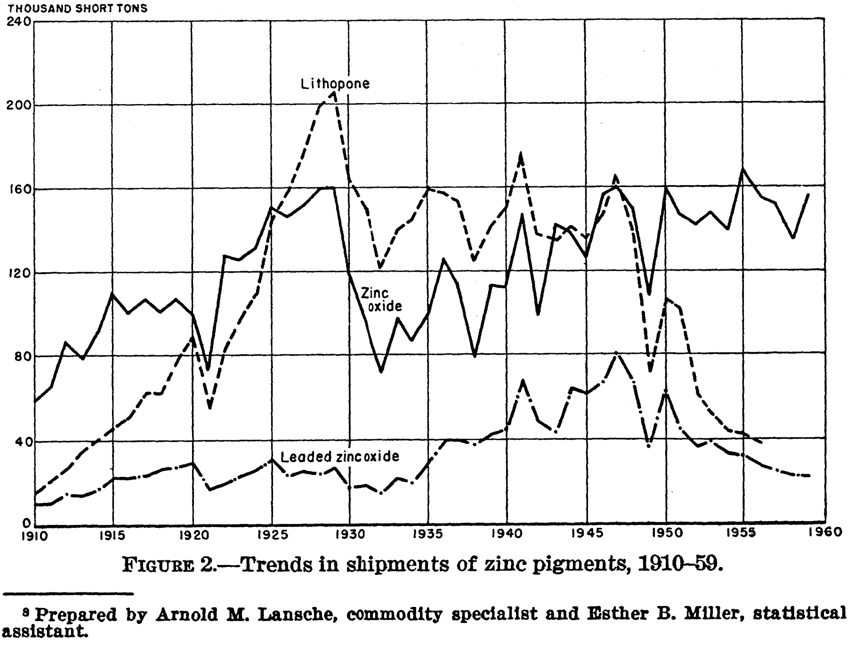

FIGURE 2.—Trends in shipments of zinc pigments, 1910–59.

---

[8] Prepared by Arnold M. Lansche, commodity specialist and Esther B. Miller, statistical assistant.

TABLE 18.—Salient statistics of the zinc pigments[1] industry of the United States

	1950–54 (average)	1955	1956	1957	1958	1959
Shipments:						
Zinc oxide____short tons__	147,933	168,541	154,955	151,267	135,991	154,234
Leaded zinc oxide__do____	43,978	32,661	27,164	24,203	23,288	22,626
Value of pigments____________	$63,357,000	$58,031,000	$55,245,000	$47,036,000	$42,797,000	$47,521,000
Value per ton received by producers:						
Zinc oxide________________	279	258	271	271	270	269
Leaded zinc oxide_________	281	259	282	249	263	267
Foreign trade:						
Value of imports__________	540,000	685,186	770,156	1,043,629	2,263,865	3,301,089
Value of exports__________	1,723,000	771,621	846,883	985,325	789,995	764,760
Export balance_________	1,183,000	86,435	76,727	−58,304	−1,473,870	−2,536,329

[1] Excludes lithopone; figure withheld to avoid disclosing individual company confidential data.

Lead-free zinc oxide was made by several processes: 65 percent from ores and residues by the American process, 24 percent from metal by the French process, and 11 percent by "Other" processes from scrap residues and scrap materials. Leaded zinc oxide was made from ores, zinc chloride from slab zinc and secondary zinc materials, and zinc sulfate from ores and scrap zinc.

Three grades of leaded zinc oxide classified according to lead content were produced. There was no production of 5 percent or less of leaded zinc oxide reported; the more-than-5-through 35-percent grade constituted the bulk of production; smaller quantities were produced in the more-than-35-through 50-percent and over-50-percent grades.

Both ordinary and high strength (titanated) lithopone were manufactured.

TABLE 19.—Production and shipments of zinc pigments and salts[1] in the United States

Pigment or salt	1958				1959			
	Production (short tons)	Shipments			Production (short tons)	Shipments		
		Short tons	Value[2]			Short tons	Value[2]	
			Total	Average			Total	Average
Zinc oxide[3]______________	132,564	135,991	$36,671,762	$270	161,606	154,234	$41,483,742	$269
Leaded zinc oxide[3]______	22,844	23,288	6,125,033	263	23,550	22,626	6,037,604	267
Zinc chloride, 50° B_____	63,593	65,761	8,754,543	133	76,196	72,864	7,335,175	101
Zinc sulfate_____________	34,513	33,737	4,927,162	146	41,353	40,670	6,322,882	155

[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.

TABLE 20.—Zinc pigments and salts[1] shipped by manufacturers in the United States, in short tons

Year	Zinc oxide	Leaded zinc oxide	Zinc chloride (50° B.)	Zinc sulfate
1950–54 (average)	147, 933	43, 978	56, 610	21, 654
1955	168, 541	32, 661	54, 161	23, 864
1956	154, 955	27, 164	53, 201	32, 200
1957	151, 267	24, 203	58, 569	33, 620
1958	135, 991	23, 288	65, 761	33, 737
1959	154, 234	22, 626	72, 864	40, 670

[1] Excludes zinc sulfide and lithopone, figures withheld to avoid disclosing individual company confidential data.

TABLE 21.—Zinc content of zinc pigments[1] and salts produced by domestic manufacturers, by sources, in short tons

Pigment or salt	1958					1959				
	Zinc in pigments and salts produced from—				Total zinc in pigments and salts	Zinc in pigments and salts produced from—				Total zinc in pigments and salts
	Ore		Slab zinc	Secondary material[2]		Ore		Slab zinc	Secondary material[2]	
	Domestic	Foreign				Domestic	Foreign			
Zinc oxide	60, 096	8, 767	13, 077	24, 049	105, 989	71, 126	16, 339	18, 000	23, 680	129, 145
Leaded zinc oxide	9, 164	4, 901	--------	--------	14, 065	4, 820	2, 798	--------	--------	7, 618
Total pigments	69, 260	13, 668	13, 077	24, 049	120, 054	75, 946	19, 137	18, 000	23, 680	136, 763
Zinc chloride	--------	--------	(3)	11, 700	11, 700	--------	--------	(3)	17, 644	17, 644
Zinc sulfate	(3)	(3)	--------	(3)	11, 869	(3)	(3)	--------	(3)	14, 254

[1] Excludes zinc sulfide and lithopone; figures withheld to avoid disclosing individual company confidential data.

[2] These figures are higher than those shown in the report on Secondary Metals—Nonferrous because they include zinc recovered from byproduct sludges, residues, etc., not classified as purchased scrap material.

[3] Figure withheld to avoid disclosing individual company confidential data.

Consumption.—Total lead-free zinc oxide shipments increased 13 percent over 1958. Shipments of zinc oxide to the rubber industry increased 17 percent, ceramics industry 15 percent, floor-coverings industry 24 percent and other industries 23 percent. Shipments to the coated fabrics and textiles industries declined 9 percent.

TABLE 22.—Distribution of zinc oxide shipments, by industries, in short tons

Industry	1950–54 (average)	1955	1956	1957	1958	1959
Rubber	75,344	86, 677	80, 459	81, 745	68, 176	79, 505
Paints	33,427	33, 932	32, 485	32, 605	33, 335	33, 708
Ceramics	9,723	10, 617	10, 160	8, 459	9, 095	10, 486
Coated fabrics and textiles[1]	6,974	11, 263	8, 447	3, 623	2, 327	2, 125
Floor coverings	2,636	2, 281	1, 436	1, 249	971	1, 207
Other	19,829	23, 771	21, 968	23, 586	22, 087	27, 203
Total	147,933	168, 541	154, 955	151, 267	135, 991	154, 234

[1] Includes the following tonnages for rayon: 1955—5,769; 1956—7,721; 1957—2,838; and 1958—1,149. Figure for 1959 withheld to avoid disclosing individual company confidential data.

Paintmaking accounted for 92 percent of the leaded zinc oxide consumption. Rubber and other uses consumed the remainder.

TABLE 23.—Distribution of leaded zinc oxide shipments, by industries, in short tons

Industry	1950-54 (average)	1955	1956	1957	1958	1959
Paints	43,451	32,178	26,825	23,904	23.021	20,748
Rubber	76	483	339	299	267	1,878
Other	451					
Total	43,978	32,661	27,164	24,203	23,288	22,626

Lithopone was used in paint, varnish and lacquer, floor covering, coated fabrics and textiles, rubber, printing inks, and chemicals.

Statistics on end-use distribution of zinc chloride were not available. The principal uses were for soldering and tinning fluxes, battery making, galvanizing, vulcanizing fiber, preserving wood, refining oil, and fungicides.

Rayon and agriculture were the chief consumers of zinc sulfate, receiving 64 and 13 percent, respectively, of the total shipments; the "Other" category (chemical, flotation reagents, glue manufacturing, medicinal, mineral, and rubber industries) received 23 percent. Zinc sulfate consumed by rayon manufacturers increased 32 percent, and that for other uses 287 percent; agricultural uses declined 54 percent, compared with 1958.

TABLE 24.—Distribution of zinc sulfate shipments by industries, in short tons

Year	Rayon		Agriculture		Other		Total	
	Gross weight	Dry basis	Gross weight	Dry basis	Gross weight	Dry basis	Gross weight	Dry basis
1950-54 (average)	9,019	7,282	6,076	5,241	6,559	4,958	21,654	17,481
1955	10,732	9,537	8,187	7,089	4,945	3,722	23,864	20,348
1956	21,083	18,825	7,051	6,291	4,066	3,190	32,200	28,306
1957	19,903	17,785	9,818	8,261	3,899	3,465	33,620	29,511
1958	19,796	17,747	11,525	9,819	2,416	2,191	33,737	29,757
1959	26,062	23,354	5,262	4,696	9,346	7,428	40,670	35,478

Prices.—American process lead-free zinc oxide was quoted at 14.5 cents a pound in carlots during 1959. The 5- to 35-percent leaded product made by this process was quoted in 15.125 cents a pound in carlots until October 12, when it was quoted at 15.375 cents, where it remained through December 31. Green-seal and white-seal French-process zinc oxides remained at 16.25 and 16.75 cents a pound in carlots, respectively, throughout the year; red seal opened the year at 15.25 cents and advanced 0.5 cent in May to 15.75, where it remained through December 31. Lithopone was at 9.125 cents a pound in less than carlots throughout 1959. Zinc chloride (50-percent solution), zinc sulfate (in less than carlots), and zinc sulfide (in carlots) were quoted at 5.15, 9.75, and 25.30 cents a pound, respectively, all year.

Foreign Trade.—Imports of zinc pigments and salts increased 46 percent in value and 45 percent in quantity over 1958. The quantity imported totaled about 19,100 tons. Zinc oxide composed 86 percent of these imports.

TABLE 25.—Value of zinc pigments and salts imported into and exported from the United States

[Bureau of the Census]

	Imports for consumption			Exports		
	1957	1958	1959	1957	1958	1959
Zinc pigments:						
Zinc oxide	$1,043,629	$2,263,865	$3,301,089	$985,325	$789,995	$764,760
Zinc sulfide	104,930	91,273	72,280	(1)	(1)	(1)
Lithopone	8,124	9,307	8,752	177,891	122,462	99,578
Total	1,156,683	2,364,445	3,382,121	1,163,216	912,457	864,338
Zinc salts:						
Zinc arsenate	----------	3,776	----------	(1)	(1)	(1)
Zinc chloride	104,498	92,046	127,405	(1)	(1)	(1)
Zinc sulfate	74,710	60,171	168,817	(1)	(1)	(1)
Total	179,208	155,993	296,222	(1)	(1)	(1)
Grand total	1,335,891	2,520,438	3,678,343	(1)	(1)	(1)

[1] Data not available.

TABLE 26.—Zinc pigments and salts imported for consumption in the United States

[Bureau of the Census]

Year	Short tons							Total value
	Zinc oxide		Lithopone	Zinc sulfide	Zinc chloride	Zinc arsenate	Zinc sulfate	
	Dry	In oil						
1950-54 (average)	2,109	8	420	32	328	(1)	174	[2] $707,400
1955	3,320	----------	30	265	500	(1)	634	903,703
1956	3,667	----------	143	510	632	17	824	[2] 1,146,092
1957	5,245	----------	57	342	601	----------	722	1,335,891
1958	11,729	----------	69	295	547	1	565	2,520,438
1959	16,510	----------	73	235	766	----------	1,563	3,678,343

[1] Less than 1 ton.
[2] Data known to be not comparable to other years.

Exports of zinc oxide and lithopone together declined 5 percent in value. Zinc oxide was down 1 percent, and lithopone 12 percent in quantity exported.

TABLE 27.—Zinc pigments exported from the United States

[Bureau of the Census]

Year	Short tons		Total value	Year	Short tons		Total value
	Zinc oxide	Lithopone			Zinc oxide	Lithopone	
1950-54 (average)	5,137	9,351	$3,230,180	1957	3,144	991	$1,163,216
1955	2,649	1,892	1,072,581	1958	2,543	613	912,457
1956	2,748	1,387	1,086,775	1959	2,516	538	864,338

STOCKS

National Stockpile.—Inventories in the National Stockpile at the end of 1959 approximately equaled or exceeded the basic and maximum objectives. During 1959, 3,000 tons of domestically produced zinc was reported by industry[9] to have been shipped to Government account. The total of such shipments reported by industry for 1945 through 1959 was 1,173,951 tons. GSA also acquired 27,787 tons of foreign zinc in 1959, under surplus agricultural-product barter contracts authorized under the Agricultural Trade Development and Assistance Act of 1954 and amendments. The 322,094 tons acquired from 1956 through 1959 under this program was placed in the supplemental stockpile.

Producers' Stocks.—Smelters' stocks of slab zinc began the year at 184,000 tons, rose to 206,000 tons by the end of March. They declined to 169,000 tons at the end of June, rose to 193,000 tons at the end of September, and then followed a downward trend to a yearend low of 156,500 tons.

TABLE 28.—Stocks of zinc at zinc-reduction plants in the United States at end of year, in short tons

	1955	1956	1957	1958	1959
At primary reduction plants	37,322	64,794	153,338	182,111	152,657
At secondary distilling plants	1,942	2,081	2,495	[1] 1,909	3,800
Total	39,264	66,875	155,833	[1] 184,020	156,457

[1] Revised figure.

Consumer Stocks.—Stocks of slab zinc at consumers' plants were 93,600 tons at the beginning of the year and declined during the next 4 months to the year's low of about 75,000 tons at the end of April. A general upward trend occurred for the remainder of the year, and stocks reached a high of 102,200 tons at yearend. An additional 7,000 tons of slab zinc was in transit to consumer plants. At the average monthly rate of consumption, total consumer stocks plus metal in transit represented about 6 weeks' supply.

TABLE 29.—Consumers' stocks of slab zinc at plants at the beginning and end of 1958, by industries, in short tons

	Galvanizers	Brass mills [1]	Zinc die casters [2]	Zinc rolling mills	Oxide plants	Other	Total
Dec. 31, 1958	[3] 48,250	[3] 12,226	[3] 26,783	5,019	178	[3] 1,153	[3] [4] 93,609
Dec. 31, 1959	56,773	13,412	25,291	4,930	393	1,396	[4] 102,195

[1] Includes brass mills, brass ingot makers, and foundries.
[2] Includes producers of zinc-base die castings, zinc-alloy dies, and zinc-alloy rods.
[3] Revised figures.
[4] Stocks on Dec. 31, 1958 and 1959, exclude 747 tons and 696 tons, respectively, of remelt spelter.

---

[9] Kimberly, J. L., A review of the Zinc Industry in the United States During 1959, Am. Zinc Inst., New York 17, N.Y., 16 pp.

PRICES

The quoted price for Prime Western zinc at East St. Louis was 11.5 cents per pound at the beginning of 1959. On February 25, the price decreased 0.5 cent to 11 cents, where it remained until September 21, when an increase of 1 cent raised the price to 12 cents. On October 20, the price was again raised 1 cent to 13 cents by several smelters and 0.5 cent to 12.5 cents by other smelters. This dual pricing continued until November 2, when the price was established at 12.5 cents, where it remained the balance of the year, averaging 11.46 cents a pound for the year.

The average monthly zinc quotation on the London Metal Exchange was 82.127 a long ton (equivalent to 10.27 cents a pound computed at the exchange rate recorded by the Federal Reserve Board). The price for January was 74.884 (9.36 cents a pound) and ranged from a low of 71.125 (8.96 cents per pound) in early May to a high of 97.375 (12.17 cents per pound) in November; the price for December at 95.190 (11.9 cents per pound) was the highest monthly average and represented a considerable gain during the year.

TABLE 30.—Price of zinc concentrate and zinc

	1955	1956	1957	1958	1959
Joplin 60-percent zinc concentrate:[1] Price per short ton____dollars__	77.50	83.89	76.94	60.55	60.36
Average price common zinc at—					
St. Louis (spot)[1]____cents per pound__	12.30	13.49	11.40	10.31	11.46
New York [1]____do____	12.80	13.99	11.90	10.81	11.96
London [2]____do____	11.30	12.19	10.18	8.24	10.27
Price indexes (1947–49 average—100):[3]					
Zinc (New York)____	101	111	94	86	94
Lead (New York)____	94	100	91	76	76
Copper (New York)____	177	199	144	125	148
Straits tin (New York)____	103	110	105	103	111
Nonferrous metals____	143	156	137	128	136
All commodities____	111	114	118	119	120

[1] Metal Statistics, 1960.

[2] E&MJ Metal and Mineral Markets English quotations converted into American money on basis of average rates of exchange recorded by Federal Reserve Board.

[3] Based upon price indexes of U.S. Department of Labor.

Prices of new and old scrap zinc varied with market quotations for slab zinc. Sales of clean new zinc clippings, trimmings, and engravers' or lithographers' plates averaged 5 cents a pound in January, where they remained through August. In September, October, November and December the average price increased 0.21, 0.67, 0.62, and and 0.19 cents, respectively, to a 6.69 cents per pound average for December; the price ranged from 4.75 to 7 cents a pound and averaged 5.36 cents. Old zinc scrap ranged in price from 3.25 to 4.75 cents a pound, averaging 3.67 cents.

TABLE 31.—Average monthly quoted prices of 60-percent zinc concentrate at Joplin, and of common zinc (prompt delivery or spot), St. Louis and London[1]

Month	1958			1959		
	60-percent zinc concentrates in the Joplin region (dollars per ton)	Metallic zinc (cents per pound)		60-percent zinc concentrates in the Joplin region (dollars per ton)	Metallic zinc (cents per pound)	
		St. Louis	London[2] [3]		St. Louis	London[2] [3]
January	56.00	10.00	7.88	68.00	11.50	9.36
February	56.00	10.00	8.05	67.50	11.42	9.21
March	56.00	10.00	8.00	64.00	11.00	9.47
April	56.00	10.00	7.86	64.00	11.00	9.16
May	56.00	10.00	7.79	64.00	11.00	9.75
June	56.00	10.00	8.02	64.00	11.00	9.88
July	56.00	10.00	7.95	64.00	11.00	10.15
August	56.00	10.00	7.98	64.00	11.00	10.66
September	56.00	10.00	8.13	66.56	11.38	10.76
October	62.50	10.87	8.81	72.30	12.26	11.42
November	66.80	11.40	9.41	76.00	12.50	11.87
December	68.00	11.50	9.29	76.00	12.50	11.90
Average for year	60.55	10.31	8.24	60.36	11.46	10.27

[1] Joplin: Metal Statistics, 1960, p. 592. St. Louis: Metal Statistics, 1960, p. 559. London: E&MJ Metal and Mineral Markets.

[2] Conversion of English quotations into American money based on average rates of exchange recorded by Federal Reserve Board.

[3] Average of daily mean of bid and asked quotations at morning session of London Metal Exchange.

TABLE 32.—Average price received by producers of zinc, by grades, in cents a pound

Grade	1955	1956	1957	1958	1959
Grade A:					
Special High Grade	12.79	14.26	12.13	10.45	11.78
High Grade	12.59	13.98	11.70	10.13	11.42
Grade B: Intermediate	12.30	14.06	11.69	10.81	11.85
Grades C and D:					
Brass Special	12.21	13.71	11.31	10.38	11.39
Select	11.13	13.41	10.56	10.48	10.93
Grade E: Prime Western	11.74	13.13	11.24	9.98	11.18
All grades	12.29	13.73	11.64	10.22	11.47
Prime Western; spot quotation at St. Louis[1]	12.30	13.49	11.40	10.31	11.46

[1] Metal Statistics, 1960, p. 559.

FOREIGN TRADE

Imports.—Import quotas imposed October 1, 1958, by Presidential Proclamation 3257, dated September 22, 1958, were in effect throughout 1959. The quotas limited annual competitive imports of unmanufactured zinc (not including zinc in fume) to 379,840 tons in ores and concentrates and 141,120 tons as metal. The quotas established were 80 percent of the average dutiable imports into the United States during 1953–57. Specific quotas were assigned to major importing countries and an "all other" quota was established to cover the needs of the remaining small importers.

Imports for consumption (imports for immediate consumption plus withdrawals for consumption from bonded warehouses) given in table 35 give a close approximation of dutiable imports of unmanufactured zinc entering the United States and reflect the effect of the quotas.

Comparison of competitive imports in 1959 with similar figures for 1957 (the last full year before establishing quotas) shows decreases of 36 percent for zinc ores and concentrates and 39 percent for zinc metal. Zinc fume was excluded from quota restrictions and these imports increased from 36,000 tons in 1958 to an estimated 63,000 tons in 1959.[10]

General imports (imports for immediate consumption plus entries into bonded warehouses) presented in table 33 show all physical entries of unmanufactured zinc into the United States. In 1959 general imports increased 8 percent to 499,500 tons for ores and concentrates and decreased 20 percent to 157,000 tons for zinc metal.

Exports.—Exports of slab zinc increased from about 2,000 tons in 1958 to 11,600 tons in 1959. Significant increases in imports were reported for the United Kingdom, Sweden, Belgium-Luxembourg, India, Chile, Mexico, and Oceania.

TABLE 33.—Zinc imported into the United States, in ores, blocks, pigs, or slabs, by countries, in short tons [1]

[Bureau of the Census]

Country	1950-54 (average)	1955	1956	1957	1958	1959
Ores (zinc content):						
North America:						
Canada	129,267	173,157	177,087	158,220	[2] 155,506	151,681
Cuba	36	3,704	1,155	1,209	223	188
Guatemala	5,303	8,353	11,433	9,313	6,483	8
Honduras	401	1,433	2,288	2,589	1,435	1,427
Mexico	168,903	186,461	193,007	192,519	158,609	182,051
Other North America	11	----------	4	(3)	(3)	1
Total	303,921	373,108	384,974	363,850	[2] 322,256	335,356
South America:						
Argentina	1,231	----------	2	165	9	101
Bolivia	12,046	1,833	7,294	7,633	7,328	2,531
Chile	1,241	4,858	346	1,400	977	479
Peru	53,600	83,915	98,541	119,004	[2] 102,990	86,654
Other South America	279	142	212	8	121	63
Total	68,397	90,748	106,395	128,210	[2] 111,425	89,828
Europe:						
Germany, West	----------	----------	----------	----------	----------	5,756
Italy	1,748	----------	----------	----------	----------	14,766
Spain	9,479	----------	----------	----------	----------	16,571
Other Europe	4,597	3,043	1,923	1,398	80	3,613
Total	15,824	3,043	1,923	1,398	80	40,706
Asia:						
Philippines	868	465	828	777	92	40
Other Asia	481	----------	66	79	240	1
Total	1,349	465	894	856	332	41
Africa:						
Union of South Africa	5,781	5,050	13,400	21,048	21,700	7,957
Other Africa	601	----------	----------	1,896	1,032	803
Total	6,382	5,050	13,400	22,944	22,732	8,760
Oceania: Australia	4,154	5,630	17,764	8,756	[2] [4] 4,735	24,760
Grand total	400,027	478,044	525,350	526,014	[2] 461,560	499,451

See footnotes at end of table.

---

[10] U.S. Tariff Commission Report to the Congress on Investigation No. 332–16 (suppl.), March 1960, table 18.

TABLE 33.—Zinc imported into the United States, in ores, blocks, pigs, or slabs, by countries, in short tons—Continued

[Bureau of the Census]

Country	1950–54 (average)	1955	1956	1957	1958	1959
Blocks, pigs, or slabs:						
North America:						
Canada	95,371	113,402	116,875	103,964	93,475	88,414
Mexico	17,869	19,480	17,153	23,536	23,256	9,338
Total	113,240	132,882	134,028	127,500	116,731	97,752
South America: Peru	3,599	9,767	6,590	22,947	9,736	12,337
Europe:						
Austria	----------	----------	2,296	1,020	110	220
Belgium-Luxembourg	8,034	17,748	32,353	34,163	21,707	7,666
Germany [5]	5,254	6,642	15,285	8 772	2,673	55
Italy	7,200	6,190	13,486	10,010	6,166	7,459
Netherlands	2,407	1,079	5,965	2,504	2,520	----------
Norway	3,194	504	----------	----------	2,769	168
United Kingdom	1,379	79	611	1,791	672	841
Yugoslavia	1,035	----------	500	10,909	5,781	3,643
Other Europe	160	----------	110	----------	----------	----------
Total	28,663	32,242	70,606	69,169	42,398	20,052
Asia:						
Japan	44	----------	4,883	2,887	2,039	----------
Other Asia	(3)	----------	----------	----------	----------	----------
Total	44	----------	4,883	2,887	2,039	----------
Africa:						
Belgian Congo	2,956	15,228	17,782	33,007	20,991	12,790
Rhodesia and Nyasaland, Federation of	[6] 213	280	3,808	3,974	1,064	4,667
Other Africa	110	1,264	----------	----------	----------	----------
Total	3,279	16,772	21,590	36,981	22,055	17,457
Oceania: Australia	1,406	4,033	7,281	9,523	2,240	9,365
Grand total: Blocks, pigs, or slabs	150,231	195,696	244,978	269,007	195,199	156,963

---

[1] Data include zinc imported for immediate consumption plus material entering country under bond.
[2] Revised figure.
[3] Less than 1 ton.
[4] Includes 52 tons imported from French Pacific Islands.
[5] West Germany, 1952–59.
[6] Northern Rhodesia.

TABLE 34.—Zinc imported for consumption in the United States, by classes,[1] in thousand dollars

[Bureau of the Census]

Year	Ore (zinc content)		Blocks, pigs, slabs		Sheets		Old and worn out	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1950-54 (average)	381,704	[2] $51,437	148,844	$38,017	172	$73	1,202	$213
1955	384,648	36,811	195,059	46,452	431	[2] 148	176	28
1956	462,379	49,231	244,726	65,034	454	172	185	36
1957	679,416	88,516	268,824	[2] 64,129	732	245	227	32
1958	[3] 537,699	[3] 51,121	185,693	[3] 35,511	901	285	235	31
1959	436,009	38,568	164,462	33,996	951	311	183	26

Year	Dross and skimmings		Zinc dust		Total value [4]
	Short tons	Value	Short tons	Value	
1950-54 (average)	2,789	$221	361	$71	[2] $90,032
1955	108	3	72	18	[2] 83,460
1956	417	61	72	18	[2] 114,552
1957	363	57	112	[2] 28	[2] 153,007
1958	737	77	96	14	[3] 87,039
1959	955	116	44	6	73,023

[1] Excludes imports for manufacture in bond and export, which are classified as "imports for consumption" by Bureau of the Census.

[2] Data known to be not comparable with other years.

[3] Revised figure.

[4] In addition manufactures of zinc were imported as follows: [2] 1950-54 (average)—$50,619; [2] 1955—$190,076; [2] 1956—$287,361; [2] 1957—$264,348; 1958—$389,803; 1959—$811,916.

TABLE 35.—Zinc imported for consumption in the United States, in ores, blocks, pigs, or slabs, by countries, in short tons [1]

[Bureau of the Census]

Country	1950-54 (average)	1955	1956	1957	1958	1959
Ores (Zinc content):						
North America:						
Canada	132,502	152,307	145,610	217,441	169,474	137,220
Cuba	148	428	1,103	1,247	52	135
Guatemala	5,021	8,137	13,209	10,337	6,093	10
Honduras	258	78	458	3,562	[2] 1,428	1,292
Mexico	154,129	155,647	187,305	261,265	208,202	147,580
Other North America	13	----------	----------	2	111	1
Total	292,071	316,597	347,685	493,854	[2] 385,360	286,238
South America:						
Argentina	882	----------	----------	105	9	(3)
Bolivia	10,147	170	5,523	8,644	6,838	2,137
Chile	1,130	4,686	390	3,035	1,072	212
Peru	48,417	57,454	91,691	147,073	110,165	80,564
Other South America	281	83	11	70	121	4
Total	60,857	62,393	97,615	158,927	118,205	82,917
Europe:						
Germany, West	(3)	----------	----------	8	----------	7,290
Italy	2,539	----------	----------	----------	----------	10,514
Spain	9,972	----------	----------	----------	----------	15,970
Other Europe	4,477	3,043	861	215	11	2,344
Total	16,988	3,043	861	223	11	36,118

See footnotes at end of table.

TABLE 35.—Zinc imported for consumption in the United States, in ores, blocks, pigs, or slabs, by countries, in short tons—Continued

[Bureau of the Census]

Country	1950–54 (average)	1955	1956	1957	1958	1959
Ores (Zinc content)—Continued						
Asia:						
Philippines	868	465	816	942	92	29
Other Asia	446	----------	----------	9	211	----------
Total	1,314	465	816	951	303	29
Africa:						
Union of South Africa	6,605	7	407	19,751	[2] 27,190	4,963
Other Africa	589	----------	----------	(3)	524	1,375
Total	7,194	7	407	19,751	[2] 27,714	6,338
Oceania: Australia	3,280	2,143	14,995	5,710	[4] 6,106	24,369
Grand total: Ores	381,704	384,648	462,379	679,416	[2] 537,699	436,009
Blocks, pigs, or slabs:						
North America:						
Canada	95,380	113,402	116,875	103,964	93,327	88,414
Mexico	16,528	18,730	16,929	23,690	22,804	9,718
Total	111,908	132,132	133,804	127,654	116,131	98,132
South America: Peru	3,595	9,767	6,590	22,947	9,736	12,337
Europe:						
Austria	----------	----------	2,296	1,020	55	305
Belgium-Luxembourg	8,034	17,748	32,353	34,163	17,969	11,648
Germany [5]	5,254	6,642	15,257	8,772	2,035	662
Italy	7,149	6,303	13,486	10,010	5,816	7,173
Netherlands	2,407	1,079	5,965	2,504	730	1,705
Norway	3,194	504	----------	----------	2,601	329
United Kingdom	1,379	79	611	1,791	112	1,363
Yugoslavia	1,035	----------	500	10,572	5,009	3,384
Other Europe	160	----------	110	----------	----------	----------
Total	28,612	32,355	70,578	68,832	34,327	26,569
Asia:						
Japan	44	----------	4,883	2,887	1,708	355
Other Asia	(3)	----------	----------	----------	----------	----------
Total	44	----------	4,883	2,887	1,708	355
Africa:						
Belgian Congo	2,956	15,228	17,782	33,007	20,991	12,790
Rhodesia and Nyasaland, Federation of	[6] 213	280	3,808	3,974	560	4,840
Other Africa	110	1,264	----------	----------	----------	298
Total	3,279	16,772	21,590	36,981	21,551	17,928
Oceania: Australia	1,406	4,033	7,281	9,523	2,240	9,141
Grand total: Blocks, pigs, or slabs	148,844	195,059	244,726	268,824	185,693	164,462

---

[1] Excludes imports for manufacture in bond and export, classified as "imports for consumption" by Bureau of the Census.
[2] Revised figure.
[3] Less than 1 ton.
[4] Includes 52 tons imported from French Pacific Islands.
[5] West Germany, 1952–59.
[6] Northern Rhodesia.

TABLE 36.—Slab and sheet zinc exported from the United States, by destinations, in short tons

[Bureau of the Census]

Destination	Slabs, pigs, and blocks				Sheets, plates, strips, or other forms, n.e.s.			
	1956	1957	1958	1959	1956	1957	1958 [1]	1959 [1]
North America:								
Canada	8	13	6	13	2,596	2,581	1,864	1,790
Cuba	86	31	31	114	105	123	132	76
Mexico	839	513	[2] 845	1,255	716	315	425	316
Other North America	21	58	46	55	90	40	57	71
Total	954	615	[2] 928	1,437	3,507	3,059	2,478	2,253
South America:								
Argentina	--------	6	--------	43	--------	--------	--------	--------
Brazil	49	17	--------	135	61	69	87	26
Chile	96	40	36	523	7	37	--------	14
Colombia	--------	55	14	37	344	408	195	134
Venezuela	1	--------	8	--------	97	72	86	105
Other South America	7	3	--------	--------	37	21	61	11
Total	153	121	58	738	546	607	429	290
Europe:								
Belgium-Luxembourg	1,428	1,064	--------	1,624	--------	5	47	19
Denmark	--------	--------	--------	--------	34	64	105	111
Germany, West	279	336	--------	56	46	34	73	174
Italy	--------	--------	--------	--------	14	7	1	4
Netherlands	44	476	--------	280	9	22	122	60
Sweden	--------	--------	--------	2,475	8	36	149	123
Switzerland	448	--------	--------	--------	34	26	87	133
United Kingdom	5,040	6,504	672	4,065	30	11	106	162
Other Europe	25	(3)	--------	--------	2	4	29	81
Total	7,264	8,380	672	8,500	177	209	719	867
Asia:								
India	2	672	--------	635	68	53	36	3
Japan	1	4	1	25	6	5	11	1
Korea, Republic of	433	912	--------	--------	--------	--------	--------	--------
Philippines	--------	8	5	--------	85	53	73	35
Other Asia	6	73	405	14	34	19	21	4
Total	442	1,669	411	674	193	130	141	43
Africa:								
Union of South Africa	--------	--------	--------	--------	21	51	42	50
Other Africa	--------	--------	4	--------	--------	--------	3	4
Total	--------	--------	4	--------	21	51	45	54
Oceania	--------	--------	--------	280	--------	--------	6	22
Grand total	8,813	10,785	[2] 2,073	11,629	4,444	4,056	3,818	3,529

[1] Due to changes in classification by Bureau of the Census data known to be not strictly comparable to earlier years.
[2] Revised figure.
[3] Less than 1 ton.

TABLE 37.—Zinc ore and manufactures of zinc exported from the United States, in thousand dollars

[Bureau of the Census]

Year	Zinc ore, concentrates (zinc content)		Slabs, pigs, or blocks		Sheets, plates, strips, or other forms, n.e.s.		Zinc scrap and dross (zinc content)		Zinc dust	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1950-54 (average) [1]	2,111	$543	30,021	$10,817	4,859	$2,893	5,897	$804	(2)	(2)
1955 [1]	---	---	18,069	4,175	3,657	2,193	21,612	2,250	445	$162
1956 [1]	854	162	8,813	2,465	4,444	3,031	14,921	1,540	372	136
1957 [1]	7	(3)	10,785	2,553	4,056	2,950	5,469	822	595	195
1958 [1]	---	---	[4] 2,073	[4] 704	[5] 3,818	[5] 2,637	5,344	364	519	170
1959 [1]	1	(3)	11,629	2,673	[5] 3,529	[5] 2,708	11,332	1,053	521	182

[1] Effective Jan. 1, 1952, zinc and zinc-alloy semifabricated forms, n.e.c., were exported as follows: 1952—$191,746 (quantity not available); 1953—286 tons ($151,496); 1954—543 tons ($257,316); 1955—651 tons ($295,685); 1956—582 tons ($301,230); 1957—485 tons ($246,527); [5] 1958—1,168 tons ($542,069); 1959—1,071 tons ($612,388).

[2] Not included in 1950-54 averages; 1950—506 tons ($186,557); 1951—723 tons ($400,656); 1952 included with "scrap"; 1953—502 tons ($181,055); 1954—509 tons ($150,756).

[3] Less than $1,000.

[4] Revised figure.

[5] Due to changes in classification by the Bureau of the Census, data not strictly comparable to earlier years.

Tariff.—The duty on slab zinc remained at 0.7 cent a pound, that on zinc contained in ore and concentrate at 0.6 cent a pound, and that on zinc scrap at 0.75 cent a pound throughout 1959. The duties on zinc articles under the Tariff Act of 1930 were unchanged, remaining as shown on page 1290, Volume I, 1953 Minerals Yearbook.

WORLD REVIEW

NORTH AMERICA

Canada.—Consolidated Mining & Smelting Co. continued to lead Canadian zinc production. According to the annual company report, the Sullivan silver-lead-zinc mine at Kimberly, British Columbia, produced 2,440,000 tons of crude ore. Rock excavation was nearly completed on the 500-foot extension to the main shaft to open two new levels for production. The Bluebell lead-zinc mine at Riondel, British Columbia, produced 251,400 tons of ore. Shaft sinking to lower levels was in progress, but some difficulty was encountered from water. The H. B. zinc-lead mine near Salmo, British Columbia, produced 463,500 tons of ore. An exploration program consisting of a 900-foot adit and 1,200 feet of drifting in the main ore zone was conducted at the Duncan lead-zinc property in the Lardeau area of British Columbia. Production of slab zinc at the company electrolytic plant at Trail, British Columbia, was 194,499 tons, 76 percent of total Canadian output. Approximately 78 percent was produced from concentrates of company-owned mines, 11 percent from retreatment of stockpiles of zinc-plant residues and lead-blast furnace slag, and 11 percent from purchased ores and concentrates.

TABLE 38.—World mine production of zinc (content of ore),[1] by countries,[2] in short tons[3]

[Compiled by Augusta W. Jann and Berenice B. Mitchell]

Country [2]	1950-54 (average)	1955	1956	1957	1958	1959
North America:						
Canada [4]	360,879	433,357	422,633	413,741	425,099	396,175
Cuba	---	1,134	1,638	752	[5] 110	---
Greenland [5]	---	---	6,050	9,350	6,700	8,350
Guatemala	5,540	10,400	12,000	10,300	5,278	---
Honduras [6]	400	1,433	2,288	2,589	1,435	1,427
Mexico	238,336	296,961	274,351	267,891	247,033	290,938
United States [4]	598,293	514,671	542,340	531,735	412,005	425,303
Total	1,203,448	1,257,956	1,261,300	1,236,358	1,097,660	1,122,193
South America:						
Argentina	17,319	23,260	26,350	32,420	40,100	44,100
Bolivia (exports)	28,664	23,509	18,818	21,678	15,677	3,740
Chile	1,909	3,200	2,969	2,747	1,340	[5] 1,100
Peru	135,137	183,074	193,037	170,258	149,094	[5] 150,000
Total	183,029	233,043	241,174	227,103	206,211	198,940
Europe:						
Austria	4,486	5,787	5,868	6,334	6,463	6,522
Bulgaria [5]	22,900	35,200	39,400	50,000	55,000	61,300
Finland	4,365	23,300	43,000	47,400	51,800	59,600
France	14,100	12,100	13,870	13,640	13,800	15,500
Germany:						
East [5]	5,300	7,700	7,700	7,700	7,700	7,700
West	91,347	101,558	101,898	104,015	94,137	90,477
Greece [7]	6,941	13,500	22,300	26,900	20,200	15,100
Ireland	1,453	2,769	1,798	1,792	463	1,013
Italy	115,649	132,057	137,531	144,623	150,796	145,246
Norway	6,011	7,411	7,007	7,735	10,015	10,692
Poland [5]	137,500	139,000	138,000	132,000	136,000	138,000
Spain	87,150	101,800	96,100	89,096	90,764	96,603
Sweden	47,925	64,810	72,797	74,528	77,807	86,548
U.S.S.R. [5] [8]	207,000	260,000	310,000	330,000	360,000	420,000
United Kingdom	1,811	3,167	1,563	1,085	283	---
Yugoslavia	53,455	65,834	63,426	64,032	66,160	66,900
Total [2] [5]	815,000	985,000	1,071,000	1,110,000	1,150,000	1,230,000
Asia:						
Burma	2,623	9,100	8,100	10,200	12,100	12,100
China [5]	11,000	31,000	39,000	44,000	50,000	72,000
India	1,929	2,900	4,200	4,500	4,300	6,000
Iran [9]	7,700	6,300	5,200	5,000	9,900	[5] 5,000
Japan	90,399	119,787	135,585	149,921	157,601	154,628
Korea:						
North [5]	[10] 16,500	39,000	55,000	55,000	66,000	66,000
Republic of	115	---	440	311	369	---
Philippines	[11] 689	---	1,050	330	---	6
Thailand	1,276	3,200	2,400	1,820	600	840
Turkey [5]	2,403	770	1,090	2,120	2,090	1,300
Total [2] [5]	134,600	213,000	253,000	273,000	303,000	318,000
Africa:						
Algeria	16,791	35,982	35,703	32,743	36,724	39,968
Belgian Congo	104,179	74,700	129,551	117,682	125,646	77,130
Egypt	704	757	692	---	---	---
Morocco: Southern zone	28,416	47,686	46,549	53,864	54,953	69,378
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	[8] 26,897	38,070	38,134	40,353	38,034	46,497
South-West Africa [4]	17,082	18,612	23,728	25,349	15,910	12,395
Tunisia	4,155	6,311	5,200	3,867	4,566	3,656
Total	198,224	222,118	279,557	273,858	275,833	249,024
Oceania: Australia	240,978	287,352	311,452	326,573	294,462	276,296
World total (estimate)[2]	2,775,000	3,200,000	3,420,000	3,450,000	3,330,000	3,390,000

[1] Data derived in part from Yearbook of American Bureau of Metal Statistics, United Nations Statistical Yearbook, and Statistical Summary of Mineral Industry (Overseas Geol. Surveys, London).

[2] In addition to countries listed, Czechoslovakia and Rumania also produce zinc, but production data are not available; estimates for these countries are included in totals.

[3] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in detail.

[4] Recoverable.

[5] Estimate.

[6] U.S. imports.

[7] Includes zinc content of mixed ores, except 1959 figure, which represents Zn content of mixed ores only.

[8] Smelter production.

[9] Year ended March 21 of year after that stated.

[10] 1 year only, as 1954 was first year of commercial production.

[11] Average for 1951-54.

TABLE 39.—World smelter production of zinc by countries,[1] in short tons [2] [3]

[Compiled by Augusta W. Jann and Berenice B. Mitchell]

Country	1950-54 (average)	1955	1956	1957	1958	1959
North America:						
Canada	229,894	256,542	255,564	247,316	252,093	255,342
Mexico [4]	59,645	61,878	62,136	62,353	63,329	61,362
United States	869,622	963,504	983,610	985,796	781,246	798,666
Total	1,159,161	1,281,924	1,301,310	1,295,465	1,096,668	1,115,370
South America:						
Argentina	11,191	14,881	16,200	16,150	17,400	[5] 17,600
Peru	6,971	18,801	10,419	32,483	32,034	29,595
Total	18,162	33,682	26,619	48,633	49,434	47,195
Europe:						
Austria	----------	1,493	7,932	10,291	11,698	12,608
Belgium [6]	214,187	233,625	254,289	259,755	236,730	247,250
Bulgaria	----------	1,497	6,435	8,282	9,000	9,900
France	92,152	123,624	124,106	143,905	165,190	162,260
Germany, West	160,180	197,026	204,964	202,548	146,816	152,046
Italy	58,575	75,201	79,817	82,107	78,656	83,499
Netherlands	26,345	31,347	31,980	33,085	29,285	35,445
Norway	45,523	50,176	53,762	53,299	50,180	53,215
Poland	137,500	172,200	169,000	175,013	179,252	185,263
Spain	24,331	26,291	25,381	24,138	27,239	26,369
U.S.S.R.[5]	207,000	260,000	310,000	330,000	360,000	420,000
United Kingdom	81,246	91,108	91,247	86,111	83,537	81,722
Yugoslavia	15,034	15,176	21,890	32,473	34,445	35,220
Total [1,5]	1,069,000	1,284,000	1,386,000	1,447,000	1,418,000	1,510,000
Asia:						
China (refined) [5]	11,000	29,000	38,000	41,000	45,000	66,000
Japan	78,576	124,075	150,169	152,152	155,401	175,642
Total [5]	89,600	153,000	188,000	193,000	200,000	242,000
Africa:						
Belgian Congo	[7] 21,936	37,443	46,390	54,227	58,905	60,418
Rhodesia and Nyasaland, Fed. of: Northern Rhodesia	26,897	31,248	32,396	33,040	33,880	33,483
Total	48,833	68,691	78,786	87,267	92,785	93,901
Oceania: Australia	99,188	113,220	117,592	123,589	128,547	130,436
World Total (estimate)	2,480,000	2,930,000	3,100,000	3,190,000	2,990,000	3,140,000

[1] In addition to countries listed Czechoslovakia and Rumania also produce zinc, but production data are not available; estimates are included in total.

[2] Data derived in part from Yearbook of American Bureau of Metal Statistics, United Nations Monthly Bulletin and Statistical Yearbook, and Statistical Summary of Mineral Industry (Overseas Geol. Surveys, London).

[3] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in detail.

[4] In addition other zinc-bearing materials totaling 30,288 tons in 1953; 18,545 in 1954; 37,442 in 1955; 39,554 in 1956; 30,504 in 1957; 19,572 in 1958; and 314 in 1959.

[5] Estimate.

[6] Includes production from reclaimed scrap.

[7] Average for 1953-54.

The annual report of the Pend Oreille Mines & Metals Co. showed that the Reeves McDonald Mines, Ltd., produced 421,600 tons of ore at its Remac, British Columbia mine, yielding 32,376 tons of concentrates containing 14,267 tons of zinc and 4,408 tons of lead plus values in silver and cadmium. Shaft sinking was completed to an elevation of 1,045 feet above sea level. Other development work was accomplished to assure future production.

Sheep Creek Mines, Ltd., Windermere, British Columbia, reported production for the year ending May 31, 1959, to be 190,800 tons of ore grading 2.36 percent lead and 5.45 percent zinc.[11]

Hudson Bay Mining & Smelting Co. operated its mines on the Manitoba-Saskatchewan boundary and returned to the position of Canada's second largest producer of zinc. The mill treated 1,671,000 tons of ore, an increase of 1,500 tons over 1958. Mill feed was 86.7 percent from the Flin Flon mine, 7.4 percent from the Birch Lake mine, and 5.9 percent from the Schist Lake mine. The company did development work at its Coronation mine, 13½ miles southwest of Flin Flon, at the Stall Lake mine, 4 miles southeast of Snow Lake, and at Chisel Lake, 5 miles southwest of Snow Lake. Slab zinc production at the company electrolytic zinc plant at Flin Flon (Manitoba) was 62,582 tons—25 percent of the total Canadian output.[12]

The Manitouwadge (Ontario) mine of Willroy Mines, Ltd., was the third largest zinc producer in Canada. Preliminary estimates for the year indicated mill feed to be 375,000 tons, yielding concentrates containing 32,500 tons of zinc, 2,750 tons of copper, and considerable quantities of lead, silver, and gold.[13]

Geco Mines, Ltd., at Manitouwadge, milled 1,290,000 tons of ore with a calculated grade of 2.10 percent copper, 2.38 percent zinc, and 1.30 ounces per ton of silver. The ore yielded 42,178 tons of zinc concentrates assaying 54.7 percent zinc. Exploration and development continued, and major improvements were made to the mine ventilation system.

Sherbrooke Metallurgical Co., a subsidiary of Mathieson & Hegeler Zinc Co., was erecting a zinc roasting and sulfuric acid plant at Port Maitland, Ontario. The two roasters (with a capacity of 150,000 tons of concentrate) were expected to be operating in the summer of 1960. A long-term contract was made for sale of the sulfuric acid and the roasted zinc concentrate was to be shipped to the parent company's two plants in the United States, as well as to other zinc smelters in the United States and Europe.[14]

In Quebec, Quemont Mining Corp., Ltd., milled 850,100 tons of ore containing 2.64 percent zinc plus values in copper, gold and silver. Production was 32,071 tons of zinc concentrate containing 51.8 percent zinc. During the year, the shaft was deepened to 4,150 feet, providing four additional levels at 150-foot intervals. Other Quebec producers of zinc concentrate included Waite Amulet Mines, Ltd., which treated 311,000 tons of ore containing 3.73 percent zinc and 4.36 percent copper, and produced 16,630 tons of zinc concentrate assaying 51.3 percent zinc; and Normetal Mining Corp., Ltd., which milled 376,400 tons of a copper-zinc-gold-silver ore, producing 18,162 tons of zinc concentrate assaying 52 percent zinc.

The Mattagami area of northwestern Quebec continued to be the center of intense exploration by numerous mining companies, and over a dozen drills were active along the main belt of mineralization. General structural and stratigraphic controls of ore deposition were established as a guide to further exploration and development.[15]

---

[11] Mining Magazine (London), vol. 101, No. 4, October 1959, p. 188.
[12] Hudson Bay Mining & Smelting Co., Annual Report, 1959, 19 pp.
[13] Northern Miner, vol. 45, No. 43, Jan. 14, 1960, p. 1.
[14] Precambrian Mining in Canada, vol. 32, No. 11, November 1959, p. 22.
[15] Northern Miner, vol. 65, No. 48, Feb. 18, 1960, p. 1.

In New Brunswick, Heath Steele Mines, Ltd. (subsidiary of American Metal Climax, Inc.) remained on a standby basis.[16]

In Newfoundland, Buchans Mining Co., Ltd., operated its lead-zinc-copper property near Red Indian Lake throughout the year. Production, as of June 1, was curtailed to 90 percent of the 1958 rate, conforming with the announcement made by the company at the United Nations-sponsored meeting on lead and zinc. The new concrete-lined McLean shaft was deepened 1,321 feet to reach 3,444 feet. Diamond drilling extended the R-4 ore body 740 feet to a depth of 3,265 feet. Shaft sinking was to be suspended at 3,521 feet, pending additional work to determine the extent of the ore body.[17]

In the Yukon Territory, United Keno Hill Mines, Ltd., operated its Mayo district silver-lead-zinc mine. Production for the year consisted of 16,074 tons of lead concentrate and 13,767 tons of zinc concentrate containing 8,859 tons of zinc plus values of silver, lead, and cadmium. Ore reserves at yearend were estimated to be 550,000 tons assaying 38.21 ounces of silver per ton, with 6.60 percent lead and 4.89 percent zinc.[18]

Greenland.—The lead-zinc mine at Mestersvig probably would be depleted in about 3 years, because the reserve in the mine and surrounding area was not increased despite vigorous prospecting.[19]

Mexico.—The Mexican Government previously had decided to proceed with construction of a Government-owned zinc refining plant to be organized under the corporate name of Zincamex S.A. to process zinc concentrates of producers not handled by private smelters. The process to be used had not been decided upon nor had the plant location been selected.

American Smelting & Refining Co. continued operating its extensive zinc-producing units in Mexico but at a somewhat reduced rate.

American Metal Climax, Inc., through its Mexican subsidiary, Cia. Minera de Penoles, S.A. mined 242,000 tons of ore. This was a 30-percent reduction from 1958, partly reflecting the announcement of the company at the United Nations meeting of its intent to reduce production voluntarily. The 3½-mile haulage tunnel at the Avalos mine, begun in 1957, was nearly complete at the end of 1959 and was expected to be in operation by April 1960.

San Francisco Mines of Mexico, Ltd., at the San Francisco and Clarines mines, Chihuahua, during the year ended September 30, 1959, milled 823,000 tons of crude ore yielding 55,000 tons of 65.58 percent lead concentrate, 94,000 tons of 57.50 percent zinc concentrate, and 8,300 tons of 27.67 percent copper concentrate.

Fresnillo Co. continued to operate its lead-zinc mines at Fresnillo in Zacatecas and at Naica in Chihuahua. In the year ending June 30, 1959, the company milled 581,600 tons of ore at the Fresnillo mill and 353,900 tons of ore at the Naica mill, yielding respectively 36,247 and 30,977 tons of 51.8 and 52.4 percent zinc concentrate.

El Potosi Mining Co. (subsidiary of Howe Sound Co.) operated its

---

[16] American Metal Climax, Inc., Annual Report 1959, p. 22.
[17] American Smelting & Refining Co., 61st Annual Report, 1959, p. 13.
[18] Mining Magazine (London), vol. 102, No. 2, February 1960, p. 107.
[19] Mining World Annual Review, Apr. 25, 1960, p. 139.

El Potosi mine in the Santa Eulalia district, Chihuahua. Development disclosed several ore bodies of average grade and tonnage.

Minas de Iquala, S.A., subsidiary of The Eagle-Picher Co., operated its zinc-lead-copper mine and mill near Parral, Chihuahua.

SOUTH AMERICA

Argentina.—Compania Minera Aguilar, S.A., a subsidiary of St. Joseph Lead Co., operated its lead-zinc-silver mine in the Province of Jujuy. The mill treated a record tonnage of crude ore, producing 67,500 tons of zinc concentrate, compared with 61,000 tons in 1958. The zinc concentrate was roasted at the Sulfacid, S.A., plant at Borghi. The sinter was reduced to slab zinc at an electrothermic zinc smelter owned by Cía. Metalúrgica Austral-Argentine, S.A. Production of slab zinc by Austral smelter was adversely affected by power shortages and dropped from 9,800 tons in 1958 to 8,400 tons in 1959.[20]

Production at National Lead Co. operations for 1959 was reported to be 15,100 tons of concentrate containing 9,000 tons of zinc.

Bolivia.—The Pulacayo and Animas mines continued to be the leading Bolivian zinc producers. Total reported exports of zinc declined from 15,700 tons in 1958 to 3,700 tons in 1959.

Peru.—Production of slab zinc at La Oroya smelter of Cerro de Pasco Corp. was 29,595 tons, smelted entirely from concentrate produced at company-owned mines.[21] Compañía de Minas Buensventura, S.A., experienced its most profitable year since its formation 6 years before. Minas de Venturosa, S.A., had a loss for the year. Its mine and contrating mill were shut down early in 1959, and the future of the company was uncertain. The Santander mine of Cía. Minerales Santander, Inc., initially placed in production in December 1958, produced 21,865 tons of zinc concentrate. Among other significant zinc producers in Peru were Volcan Mines Co., Cía. Minera Atacocha, Cía. des Mines de Huaron, and Northern Peru Mining Co.

EUROPE

Austria.—The lead-zinc mines of Austria produced 250,000 tons of crude zinc ore. Concentrates from this ore, plus imported concentrates, were treated at the Bleiberger Bergwerks Union electrolytic plant at Gailitz, yielding Austria's production of 12,600 tons of slab zinc.

Bulgaria.—A large increase in flotation-plant capacity was planned to provide for rapid expansion in the newly developed deposits in the Rhodope mountains near the Greek border. The plant was to be completed in two stages—the first to provide a daily capacity of 1,200 tons, and the second an additional 2,000 tons. The average metal content of the ore was expected to be over 2.36 percent zinc and 2.90 percent lead.[22]

Finland.—The principal zinc producer was the Vihanti mine, which produced zinc concentrate containing 60,500 tons of zinc as well as

---

[20] St. Joseph Lead Co., Annual Report, 1959, p. 11.
[21] Cerro de Pasco Corp., Annual Report, 1959, p. 10.
[22] Mining Journal (London), vol. 254, No. 6503, Apr. 8, 1960, p. 407.

values in copper and lead from 453,000 tons of ore. A new copper-lead-zinc mine at Pyhasalmi in central Finland began shipping ore in late November. Completion of the mine was scheduled for 1962, when mining was expected to be at an annual rate of 335,000 tons containing 18,000 tons of zinc. The ore reserve was calculated to be adequate for 25 years at this rate.

Italy.—The Salafossa mine, near Belluno, reported increased production. Approximately 1.5 million tons of about 1-percent lead and 5- to 6-percent zinc ore had been developed. Mining was to be by room-and-pillar method, using systematic roof bolting.[23]

Portugal.—An old established Spanish company, Companhia Real Asturiana de Minas, installed a factory for zinc rolling in the north of Portugal at Matosinhos. This was the first plant of its kind in Portugal.[24]

Spain.—Plans were announced for two electrolytic zinc plants to be built in Spain. Sociedad Austruiana del Zinc, a new firm, which was 40-percent owned by Real Compania Austuriana, was to build a plant at Aviles to produce 20,000 tons a year. Minera Celdran, S. A., mining and exporting zinc ores from Cartagena province, planned production in 1959 from a new 12,000-ton-a-year plant.[25]

Sweden.—Boliden Mining Co. announced that it had a 63-million-ton reserve of lead-zinc-copper sulfide ore. In the Skelleften district, the Boliden, Langsele, Renstrom, Kristiveberg, Ravliden, Adak-Lindskold, Brannmyran, Rudtjebacken Ostra Hogkulla, and Langdal mines contained 26.4 million tons. The Loisvall, Lovstrand, and Vassbo mines contained 31 million tons, and the central Swedish group of Garpenberg, Kalvbacken, Svardsjo, Saxberget, and Ljusnarsberg mines, contained about 5.6 million tons.[26]

U.S.S.R.—Russia's output of zinc, estimated at 130,000 tons in 1950, was reported to have doubled by 1955 and to have reached 300,000 to 350,000 tons by 1958. In addition, about 100,000 tons a year had been imported. As fast as production increased, it was reported that consumption probably would increase at a faster rate and Russia might well become a bigger importer of zinc.[27]

United Kingdom.—The British Government announced that all slab zinc remaining in its stockpile was to be sold during the next 4 years, considering prevailing conditions and any relevant reports of the International Lead and Zinc Study Group. The stockpile contained 53,000 tons consisting of about 35,000 tons of Regular High grade, 12,750 tons of Special High grade, and 5,250 tons of Good Ordinary Brand (Prime Western) zinc.[28]

Production of lead and zinc declined. Operation at Greenside mine, at Glenridding near Lake Ullswater in the Lake district, ceased toward the end of the year, as the ore reserves had been exhausted.[29]

Yugoslavia.—A lead-zinc ore body of about 2 million tons, containing 5 percent lead and 4 percent zinc, was developed at Zute Prline,

---

[23] Mining World Annual Review, Apr. 25, 1960, p. 121.

[24] Foreign Trade (Ottawa), vol. 113, No. 2, Jan. 16, 1960, p. 21.

[25] Engineering and Mining Journal, vol. 160, No. 4, April 1959, p. 138.

[26] Mining World, vol. 21, No. 8, July 1959, pp. 83–84.

[27] Address at American Zinc Institute, Annual Meeting Apr. 23, 1959, by R. Lewis Stubbs, Director, Zinc Development Association (London).

[28] Mining Record, vol. 71, No. 10, Mar. 10, 1960, p. 3.

[29] Mining World Annual Review, Apr. 25, 1960, p. 125.

Kopaonik mountain. An ore body at Blagvdat containing 8 percent lead and 7 percent zinc was proved.

The Zletovo mines in Macedonia were steadily increasing lead and zinc concentrate production. Further east, at Sase on the Ruen mountain, over 1 million tons of 5-percent lead and 5-percent zinc ore had been found.

The smelter at Celje, Slovenia, produced 18,122 tons of zinc (17,656 tons in 1958) and the electrolytic zinc plant at Sabac, Serbia, 13,829 tons (13,592 tons in 1958). The Celje smelter was installing a fluosolid plant and a second sulfuric acid plant. The Sabac plants were being enlarged by 50 percent.

At Mojkovac, Montenegro, a large zinc deposit had been ascertained. The building of a zinc electrolytic plant in Montenegro wos being discussed.[30]

ASIA

Burma.—The Burma Corp., Ltd., continued to operate the Bawdwin lead-zinc-silver mine in the Shan States of northern Burma. Production was 21,300 tons of zinc concentrate. Exports were 10,500 tons to Belgium, 10,800 tons to United Kingdom, and 500 tons to the United States.

India.—Output of lead-zinc ores, all from the Zawar mines, increased 38 percent to 178,500 tons. Milling recovered 11,000 tons of zinc concentrate, which was shipped to Japan for smelting. The Government approved in principle the proposal of the Metal Corp. of India to build a zinc smelter with an initial annual capacity of 16,500 tons of zinc. The project was based on ore from the Zawar mines and visualized an increased output to 1,650 tons per day.

Iran.—All lead-zinc concentrate produced in Iran was sold to the U.S.S.R. In the latter half of May, trade negotiations were held in Tehran, resulting in purchase contracts for 1959. Prices finally agreed upon were about 12 to 15 percent below those fixed for 1958, which, according to Iranian mine owners, would make profitable operations very difficult.

Japan.—The production of 178,000 tons of primary zinc, consisting of 158,000 tons from domestic ore, 16,000 tons from imported ore, and 4,000 tons from other sources, represents an increase of 13 percent and a record high. Monthly capacity of zinc refineries as of March 1959 was 15,300 tons, an increase of 8 percent over a year earlier. The increase was attributed mainly to expansion of electrolytic facilities.[31] There was a noticeable increase in output from the country's 48 major zinc mines. The Kanniolsa mine of Mitsui Mining & Smelting Co., Ltd., with a daily milling capacity of 4,000 tons of crude ore, supplied more than 30 percent of the total output.

In northern Honshu the Dowa Mining Co. discovered an ore body 1 mile south of the old Koska mine. Ore was in a wide vein 550 feet below the surface. Two types of ore, one siliceous and the other with a barite gangue, had been developed. Ore with barite was a mixed copper-lead-zinc sulfide with gold and silver. The siliceous ore contained copper.

---

[30] Work cited in footnote 29.

[31] Ministry of International Trade and Industry, Japanese Mining Industry, 1960, pp. 47–48.

A reserve of more than 4 million tons had been indicated, and exploration continued. The company started a 2-year development plan entailing shaft sinking and lateral development, construction of a 22,000-ton-per-month mill, and enlargement of the smelter.[32]

AFRICA

Algeria.—Société Algérienne du Zinc [33] reported its mine across the border from Bou Beker, Morocco, produced 112,000 tons of ore containing 25.47 percent zinc and 3.68 percent lead during the year ending September 30, 1959. The decrease in tonnage from 169,000 for the previous year was attributed to strikes and difficulties associated with foreign exchange, because the Moroccan and French francs were devalued on different dates. Ore was treated in Morocco at the mill of Société Nord-Africaine du Plomb. The company's ore reserve was enough for 3 years of full-scale production. Diamond drilling completed during 1959 indicated zones of mineralization, to be explored further in 1960.

Belgian Congo.—The Prince Leopold copper-zinc mine of the Union Minière du Haut Katanga at Kipushi, near Elisabethville, was the only zinc producer in the Congo. According to the company's annual report 1,021,000 tons of ore milled at the concentrator produced 130,000 tons of zinc concentrate, containing 60.32 percent zinc. A subsidiary of the company roasted 146,000 tons of concentrate, producing sulfuric acid for ore treatment and 122,000 tons of sintered concentrate. During the year 95,500 tons of roasted concentrate was sold to Metalkat (Société Métallurgique du Katanga) for electrolytic processing, and 78,600 tons of raw and sintered concentrate was shipped to Belgium. A study was being made of ways to recover the zinc contained in the slag of the spoil heap at the Lubumbashi copper plant.

Morocco.—Production of zinc concentrate in Morocco increased from 96,000 tone in 1958 to 113,000 tons containing about 65,000 tons of zinc in 1959.

Rhodesia and Nyasaland, Federation of.—At Broken Hill, the Rhodesia Broken Hill Development Co., Ltd.[34] mined 207,100 short tons of crude ore (164,300 in 1958). The leach plant treated 108,800 tons of material containing 37.9 percent zinc. The heavy-medium separation plant treated 149,300 tons of feed to recover 117,400 tons of sink product that was part of the 175,300 tons of feed to the sulfide flotation plant producing 50,700 tons of zinc concentrate assaying 57.2 percent zinc. Leach solution and calcined concentrate were processed in the company electrolytic plant to yield 33,400 tons of slab zinc. During the year, more zinc concentrate was produced than could be roasted. The surplus was stockpiled, pending completion of the new Imperial vertical furnace-type smelter.

South-West Africa.—The Tsumeb Corp., Ltd., mined and milled 625,000 tons of ore averaging 23.7 percent combined copper, lead, and zinc during the year ending June 30, 1959. The company sold zinc

---

[32] Mining World Annual Review, Apr. 25, 1960, p. 129.
[33] Newmont Mining Corp., Annual Report, 1959, p. 14.
[34] The Rhodesia Broken Hill Development Co., Ltd., 50th Annual Report, 1959, 19 pp.

concentrate containing 21,609 tons of zinc during the year. Tsumeb's assured ore reserve above the 30th level as of June 30, 1959, was 8,165,000 tons with an average zinc content of 4.45 percent. Recent diamond drilling below the 30th level had added at least 2 million tons of ore with a zinc content of 1.9 percent.[35]

Tunisia.—Production of zinc concentrate, all from the El Akhouat mine-mill unit, totaled about 6,600 short tons, containing 3,700 tons of zinc.

United Arab Republic (Egypt Region).—In accordance with a Soviet-Egyptian agreement, press reports indicated receipt of equipment for mining, extraction, and additional exploration of a lead-zinc deposit at Um Gheig near the Red Sea coast. Also under consideration was construction of a zinc plant in Suez with an annual productive capacity of 5,000 tons.

OCEANIA

Australia.—The Broken Hill district of New South Wales was again the leading Australian zinc-producing area. Mining companies operating were New Broken Hill Consolidated, Ltd.; Zinc Corp., Ltd.; Broken Hill South, Ltd.; and North Broken Hill, Ltd. Estimated output in the Broken Hill district was 2,130,000 short tons of crude ore yielding zinc concentrate containing about 158,000 tons of zinc in addition to lead concentrate and silver.

During the fiscal year ending June 30, 1959, Mount Isa Mines, Ltd., milled 1,030,000 short tons of silver-lead-zinc ores from its properties in the Cloncurry district of Queensland. The ore yielded 30,554 tons of zinc concentrate, containing 16,154 tons of zinc and 63,879 tons of lead bullion (containing 5,023,218 ounces of silver).[36] Exploration and development resulted in substantially increased reserves. Late in the year, the Commonwealth Government of Australia announced that it would lend the State of Queensland funds for rehabilitating the Townsville-Mount Isa Railway. The railway improvements would make possible further expansion of the Mount Isa operation.

Lake George Mines, Pty., Ltd., during the fiscal year ended June 30, 1959, milled 236,000 tons of ore to produce 36,800 tons of zinc concentrate, containing 20,800 tons of zinc as well as values in lead, copper, pyrites, and gold from ores mined in the Captain's Flat district of New South Wales.[37] Development below the 2,030-foot level was reduced awaiting results of the drilling program initiated from that level.

For the fiscal year ended June 30, 1959, the mines of the Electrolytic Zinc Co. of Australasia, Ltd. (in the Read-Rosebery district) milled 222,000 short tons of ore yielding 84,000 tons of lead, zinc, and copper concentrates. The zinc concentrates from this district and the Broken Hill district were treated at the company Risdon electrolytic plant to produce 128,000 tons of slab zinc.[38] Construction work on plant extensions and improvements was continued during the year.

---

[35] American Metal Climax, Inc., 1959 Annual Report, p. 29.
[36] American Smelting & Refining Co., Annual Report, 1959, p. 16.
[37] Lake George Mining Corp., Ltd., Annual Report, 1959, 16 pp.
[38] E Z Industries, Ltd., Annual Report, 1959, p. 7.

TECHNOLOGY

The American Zinc Institute and Lead Industries Association reported that their cooperative research program was successful in those portions devoted to the plating of zinc diecastings and zinc lithographic plates and that progress was achieved in other research projects.

Several papers reported research by the Federal Bureau of Mines[39] and Geological Survey.[40]

Zinc was extracted[41] from zinc sulfide concentrate by an oxidation process in a sulfuric acid solution. In the process, the agitated acid mixture contained in an autoclave at 110° C. was reacted with oxygen under 20 p.s.i. pressure. About 99 percent of the zinc in the zinc sulfide was converted to zinc sulfate with finely divided free sulfur as a byproduct.

A series of zinc alloys[42] (U.S. Patent 2,472,402) containing titanium and copper was said to be superior to other zinc alloys in strip and sheet form in low creep rate, low coefficient of linear expansion, and resistance to grain growth during annealing.

Patents issued included a solderable zinc-tin alloy;[43] a cyanide-type plating bath for depositing a zinc-tin alloy;[44] a process for making a buff-red zinc oxide;[45] a method of gasplating objects with zinc metal;[46] zinc-base alloys characterized by a high wear resistance provided by inclusion of iron-titanium-aluminum particles or iron-zirconium-aluminum particles;[47] a process for producing pigment-grade zinc ferrite;[48] and the use of zinc to remove certain fission product metals from a solution of uranium in liquid bismuth.[49]

---

[39] Grosh, W. A., and Evans, T. A., Jr., Zinc-Ore Mining and Milling Methods, Piquette Mining and Milling Co., Tennyson, Wisc.: Bureau of Mines Inf. Circ. 7877, 1959, 16 pp.

Chester, J. W., Application of Electrical-Resistivity Surveys to Explorations for Zinc-Lead Deposits, Racine-Spurgeon Area, Newton County, Mo.: Bureau of Mines Rept. of Investigations 5503, 1959, 57 pp.

Hild, John H., and Rose, C. K., Exploration of Lead-Zinc Deposits in the Ross Basin-Lake Como Area, San Juan County, Colo.: Bureau of Mines Rept. of Investigations 5518, 1959, 54 pp.

[40] Harrison, J. E., Wells, J. D., Geology and Ore Deposits of the Chicago Creek Area, Clear Creek County, Colo.: Geol. Survey, Prof. Paper 329, 1959, 92 pp.

Heyl, A. V., Jr., Agnew, A. F., Lyons, E. J., Behre, C. H., Jr., and Flint, A. E., The Geology of the Upper Mississippi Valley Zinc-Lead District: Geol. Survey, Prof. Paper 309, 1959 (1950), 310 pp.

[41] Forward, F. A., Veltman, H., Direct Leaching Zinc-Sulfide Concentrates by Sherritt Gordon: Jour. of Metals, Vol. 11, No. 12, December 1959, pp. 836–840.

[42] American Metal Market, New Jersey Zinc Reports Extensive Tests on New Ti-Cu Rolled Alloys: Vol. 66, No. 166, Aug. 25, 1959, p. 7.

[43] Saubestre, Edward B. (assigned to Sylvania Electric Products Inc.) Solderable Zinc Alloy Coating: U.S. Patent 2,884,350, Apr. 28, 1959.

[44] Saubestre, Edward B., and Arnant, Arnold D. (assigned to Sylvania Electric Products Inc.) Electroplating of Zinc-Tin Alloys: U.S. Patent 2,989,724. Aug. 4, 1959.

[45] Conn, John B., and Humphrey, William Karl (assigned to Merck & Co., Inc., Rahway, N.J.) Process for Preparing Zinc Oxide: U.S. Patent 2,898,191, Aug. 4, 1959.

[46] Drummond, Folsom E. (assigned to The Commonwealth Engineering Co., Dayton, Ohio) Zinc Gas Plating: U.S. Patent 2,898,227, Aug. 4, 1959.

[47] Holzwarth, James C., and Thomson, Robert F. (assigned to General Motors Corp., Detroit, Mich.) Highly Wear-Resistant Zinc Base Alloy: U.S. Patent 2,899,304, Aug. 11, 1959; Highly Wear-Resistant Zinc Base Alloy and Method of Making Same; U.S. Patent 2,912,324, Nov. 10, 1959.

[48] Downs, Charles Donald, and Martin, John (assigned to Columbian Carbon Co., New York, N.Y.) Method for Producing Zinc Ferrite Pigment: U.S. Patent 2,904,395, Sept. 15, 1959.

[49] Dwyer, Orrington E., Howe, Herbert E., and Avrutik, Edward R. (assigned to U.S.A. as represented by the Chairman of the Atomic Energy Commission). Removal of Certain Fission Product Metals From Liquid Bismuth Compositions: U.S. Patent 2,914,399, Nov. 24, 1959.

A silver-zinc primary battery[50] was developed for guided missiles. The battery had a power output of 31 watt-hours a pound. The 72-pound battery could be prepared to meet specification voltages within 3 seconds. In the dry condition, it was claimed to have a 5-year shelf life and when activated, a useful life of 8 hours.

---

[50] Journal of the Electrochemical Society, Silver-Zinc Missile Battery: Vol. 106, No. 11, November 1959, p. 295c.

Zirconium and Hafnium

By F. W. Wessel[1]

❖

PRODUCTION of zirconium increased moderately in 1959, and the Atomic Energy Commission (AEC) contracted for additional supplies of hafnium. Production, imports, and demand for zircon reached new peaks.

LEGISLATION AND GOVERNMENT PROGRAMS

On October 12 the General Services Administration asked for bids on 1,300 short tons of baddeleyite and 7,000 tons of zircon from the national stockpile, but no satisfactory offers were received.

The same month AEC contracted with Carborundum Metals Co. for the production of 25,300 pounds of hafnium sponge by the end of fiscal year 1960.

Wah Chang Corp. held the AEC contract for conversion of hafnium residues to hafnium sponge. The agreement called for producing 0.7 pound of sponge per pound of oxide.

TABLE 1.—Salient statistics of zirconium and hafnium in the United States

	1955	1956	1957	1958	1959
Zircon:					
Production……short tons	28,110	44,174	[1] 56,802	30,443	(2)
Year-end price	(2)	(2)	$55.00	$41.00	$47.25
Imports……short tons	29,091	31,140	41,692	19,225	54,878
Year-end price	$43.30	$58.90	$45.10	$42.00	$44.60
Zirconium sponge:					
Production……short tons	187	238	(2)	1,265	1,404
Price, year-end per pound	$10.00	(2)	$7.50	$6.25	$6.25
Hafnium: Production……short tons	(2)	(2)	(2)	[3] 31	[4] 17

[1] Florida only.
[2] Data not available.
[3] Includes metal content of oxide.
[4] Sponge only.

DOMESTIC PRODUCTION

Mine Production.—Output of zircon, entirely from Florida, showed a substantial increase over 1958. Humphreys Gold Corp. derived its entire production from the Skinner tract in South Jacksonville, Fla., trucking a black-sand concentrate to the permanent mill on the property of Rutile Mining Co., of Florida. E. I. du Pont de Nemours & Co. and Florida Minerals Co. produced zircon throughout the year at Trail Ridge and Vero Beach, respectively.

---

[1] Commodity specialist.

Glidden Co. took over from American Metal Climax, Inc., a large black-sand body in Ocean County, N.J. A plant will probably be completed late in 1961, and zircon presumably will be one of the products.

A black-sand body on Ship Island, near Biloxi, Miss., which was examined by Bureau of Mines engineers, may be of future importance.

Metal Production.—Production of zirconium sponge was 2,809,000 pounds, of which almost all was hafnium-free. Most of this production was supplied by Carborundum Metals Co., Parkersburg, W. Va.; Columbia-National Corp., Pensacola, Fla.; and Mallory-Sharon Metals Corp., Ashtabula, Ohio.

Columbia-National Corp. became a wholly owned subsidiary of Columbia-Southern Chemical Corp. during the year; its plant at Pace Junction, Fla., was shut down on December 1 pending the outcome of extensive testing of its product.

Production of zirconium ingot was 1,659,000 pounds, the principal melters being Allegheny Ludlum Steel Corp., at various plants; Carborundum Metals Co., Akron, N.Y.; Harvey Aluminum, Inc., Torrance, Calif.; Mallory-Sharon Metals Corp., Niles, Ohio; and Westinghouse Electric Corp., Pittsburgh, Pa.

Union Carbide Metals Co. continued to make zirconium ferroalloys at Alloy, W. Va., and Ashtabula, Ohio, and Vanadium Corp. of America, the zirconium-bearing Grainal 79 at Cambridge, Ohio.

The Zirconium Association, with headquarters in Cleveland, was formed by 16 companies that produce, melt, or fabricate the metal. The following companies are members:

Calumet & Hecla, Inc., Wolverine Tube Division, Detroit, Mich.
Carborundum Metals Co., Akron, N.Y.
Carpenter Steel Co., Union, N.J.
Columbia-National Corp., Pensacola, Fla.
Copperweld Steel Co., Superior Steel Division, Carnegie, Pa.
Damascus Tube Co., Greenville, Pa.
Firth Sterling, Inc., Pittsburgh, Pa.
Harvey Aluminum Inc., Torrance, Calif.
Jessop Steel Co., Washington, Pa.
Mallory-Sharon Metals Corp., Niles, Ohio.
National Lead Co., Titanium Alloy Manufacturing Division, New York, N.Y.
Oregon Metallurgical Corp., Albany, Oreg.
Superior Tube Co., Norristown, Pa.
Tube Reducing Corp.,Wallington, N.J.
Universal-Cyclops Steel Corp., Bridgeville, Pa.
Wah Chang Corp., New York, N.Y.

The Association's goals are to promote cooperation between the industry and governmental agencies and to expand the uses of zirconium.

Data on hafnium production in 1959 were as follows: Oxide produced, 89,500 pounds; metal equivalent, 62,600 pounds; sponge produced, 35,000 pounds; sponge shipped, 23,000 pounds; and crystal bar shipped, 15,700 pounds. Much hafnium is in the form of inventory in process.

Production of Refractories and Oxide.—The Norton Co., Huntsville, Ala., and Titanium Alloy Metals Division of National Lead Co., Niagara Falls, N.Y., were the principal producers of zirconium oxide.

Zirconium Corp. of America began expanding its oxide production facilities at Solon, Ohio.

Production of various zirconia-bearing refractories totaled 16,500 short tons. The major producers were Corhart Refractories Co., which, in addition to its facilities at Louisville, Ky., took over production of refractories from Corning Glass Works at Corning, N.Y.; Chas. Taylor Sons Co., Cincinnati, Ohio; and Harbison-Carborundum Co., Falconer, N.Y., which started operations this year as a joint enterprise of Harbison-Walker Refractories Co. and Carborundum Co.

CONSUMPTION AND USES

Apparent consumption of zircon in the United States in 1959 was about 81,500 tons. This quantity was distributed approximately as follows:

	Percent
Ceramic and foundry zircon	57.5
Refractories	15.5
Chemicals, abrasives, and ceramic compounds	11.0
Metal and alloys	8.5
Oxide	7.5
	100.0

Consumption of zirconium ingot was 1,492,000 pounds; Jessop Steel Co., Mallory-Sharon Metals Corp., and Westinghouse Electric Corp. were the principal fabricators.

The construction of nuclear-powered naval vessels continued in 1959 and required substantial quantities of zirconium and hafnium for the power units. By the end of the year 9 nuclear-powered submarines were operable, 24 more were under construction, and another 4 were authorized; these included 9 submersibles capable of firing the Polaris missile. Construction of a nuclear-powered cruiser, a carrier, and a destroyer continued during the year.

STOCKS

Dealers' stocks of zircon concentrate increased to 7,920 tons, and consumers' stockpiles increased to 42,363 tons by yearend.

PRICES AND SPECIFICATIONS

At the beginning of the year domestic zircon concentrate sold for $41 (Jacksonville) and $42 (Starke) per short ton. On February 12 the price at Starke was reduced to $41 and on April 16 was increased to $47.25, where it remained until yearend. On April 16, quotations at Jacksonville were suspended. Imported zircon sold at $46–48 per long ton, c.i.f. Atlantic coast ports, until April 16; the price then rose to $50, where it remained until the end of the year.

Australian zircon, selling at £14–£15 at the beginning of 1959 on the London exchange, closed the year at £16 per long ton.

The following prices remained constant throughout the year:

	Price per pound
Zirconium sponge, hafnium free	$6.25
Zirconium powder, flash	4.00
Zirconium mill shapes	$11.00–30.00
Ferroalloys:	
12/15 zirconium ferrosilicon	0.0925
SMZ alloy	.2000
Grainal 79	.5000

FOREIGN TRADE [2]

Imports.—Imports of zircon nearly trebled over 1958. Part of the increase was due to importation of high-hafnium ore from Nigeria, which commanded a price of approximately $150 per ton.

About 70 percent of all zircon imports entered the port of Philadelphia; New York, Houston, Portland (Oreg.), and Long Beach-Los Angeles ports accounted for another 25 percent.

Export.—Exports of zircon in 1959 totaled 1,511 tons; 945 tons went to Canada, 281 tons to Mexico, and 285 tons to other countries. Total value of these shipments was $262,772, or $174 per ton. Zircon reexported to Canada amounted to 83 tons.

Exports of 40 tons of crude metal, alloy, and scrap of widely different unit values were distributed as follows: To Mexico, 3,400 pounds valued at 50 cents per pound; to Canada and Italy, 32,900 pounds valued at $3 per pound; to the United Kingdom, France, and West Germany, 43,400 pounds valued at $6 to $8 per pound. Total value of these exports was $384,000.

Semifabricated forms valued at $277,000 were exported principally to Canada, Sweden, and France; shipments totaled 10,100 pounds.

TABLE 2.—Zircon imported for consumption in the United States, by countries, in short tons

[Bureau of the Census]

Country	1950–54 (average)	1955	1956	1957	1958	1959
Australia [1]	20,768	27,542	30,351	41,659	19,175	53,650
Brazil [2]	1,474	1,549	331	------	------	------
Canada [3]	28	------	303	14	------	24
Nigeria	------	------	------	------	50	868
Union of South Africa	------	------	------	------	------	280
United Kingdom [3]	------	------	155	19	------	56
Total: Short tons	22,270	29,091	31,140	41,692	19,225	54,878
Value	[4] $556,886	$813,448	$791,612	$1,142,472	$467,391	$1,517,485

[1] Imports from Australia through 1954 were partly in the form of mixed concentrate containing small quantities of rutile and ilmenite.
[2] Concentrate from Brazil includes some baddeleyite.
[3] Believed to be country of shipment rather than country of origin.
[4] 1954 data known to be not comparable with other years.

---

[2] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

WORLD REVIEW

SOUTH AMERICA

Chile.—A black-sand deposit in southern Chile, said to contain 200 million yards of material, was under development.

EUROPE

Denmark.—The A/S Dansk Tung-Sand Industri has been formed to operate a black-sand deposit in northern Jutland. A plant with annual capacity of 15,000 tons of heavy minerals is under construction. Products will be magnetite, titanium minerals, zircon, and garnet.

Germany, East.—The VEB Electrochemical Combine was scheduled to start producing zirconium, and possibly zirconia, in January 1960 in a plant built at Bitterfeld.

Germany, West.—Degussa A. G. reportedly began producing hafnium-free zirconium at its plant at Frankfurt am Main.

Rumania.—A large mining and metallurgical combine examined alluvial deposits containing zircon in the mountainous area of central Rumania and may be contemplating operation.

U.S.S.R.—It was reported that all atomic reactors in the U.S.S.R. use zirconium-clad fuel rods, and that zirconium also is used for other purposes in the reactors.

TABLE 3.—World production of zirconium ores and concentrates, by countries, in short tons[1]

[Compiled by Augusta W. Jann and Berenice B. Mitchell]

Country	1950-54 (average)	1955	1956	1957	1958	1959
Australia	[2] 36,105	54,514	81,153	99,188	66,382	[2] 110,000
Brazil [4]	3,828	3,312	2,829	1,799	2,939	(5)
Egypt	123	126	402	45	[3] 45	(5)
India	----------	3	3	10	10	[3] 10
Madagascar	[6] 2	----------	----------	1	58	(5)
Malaya, Federation of (exports)	----------	91	51	47	28	[3] 100
Nigeria (U.S. imports)	----------	----------	----------	----------	50	868
Senegal	467	----------	1,268	3,197	6,057	9,557
Union of South Africa	----------	----------	----------	----------	1,129	5,924
United States	[7] 18,839	28,110	44,174	[8] 56,802	[9] 30,443	(10)

[1] This table incorporates some revisions.
[2] Estimated zircon content of zircon-bearing concentrates.
[3] Estimate.
[4] Chiefly baddeleyite.
[5] Data not available.
[6] Average for 1952-54.
[7] Average for 1951-54; previous years not available for publication.
[8] Includes Florida only.
[9] Excludes Idaho.
[10] Figure withheld to avoid disclosing individual company confidential data.

Black-sand deposits rich in both zircon and titanium minerals have been found on the Dnieper River, and a processing plant similar to that at Trail Ridge, Fla., is planned.

United Kingdom.—Associated Electrical Industries, Ltd., reported development of a new zirconium-based alloy which has been designed into a gas-cooled, graphite-moderated reactor currently under construction.

Goodlass, Wall & Lead Industries, Ltd., established a zircon division to market products over a wide area and provide consumers with technical service.

Morgan Refractories, Ltd., offers laboratory ware of "fully stabilized zirconia."

ASIA

Ceylon.—A black-sand mining project at Pulmoddai reportedly went into production in February.

China.—Small-scale work is being done on zirconium and hafnium for atomic uses. The nation's first reactor was completed in June.

Japan.—During the first half of the year 105,000 pounds of zirconium was produced.

AFRICA

Egypt.—The Ramlah organization produced zircon and other black-sand minerals, exporting them principally to West Germany and the Netherlands. Capacity was to be expanded to 60,000 metric tons.

French West Africa.—Private companies and government organizations prospected extensively in Senegal, Mauritania, Dahomey, and the Ivory Coast. This work may have resulted from the removal of the export tax on titanium and zirconium minerals and the reduction of royalties from 5 to 2 percent for the first 8,000, 40,000, and 2,000 tons of annual production of zircon, ilmenite, and rutile, respectively.

Gambia.—Gambia Minerals, Ltd., early in 1959 offered for sale its plant for separation of ilmenite, rutile, and zircon.

Nigeria.—Important quantities of high-hafnium zircon were exported to the United States for the first time in 1959; the shipper was Tin & Associated Minerals, Ltd., a subsidiary of Kennecott Copper Corp. The company reports a sizable reserve of zircon containing 3 to 5 percent hafnium oxide (HfO_2).

Union of South Africa.—Exports to the United States reached a significant total in 1959.

OCEANIA

Australia.—Western Titanium N. L. at the beginning of the year was producing zircon at the rate of 5,500 tons annually. The plant of Westralian Oil, Ltd., was reported to have started in March. Production of zircon along the east coast continued during the year; demand for zircon and ilmenite was large, but demand for rutile was limited. Some pressure toward company mergers was apparent.

TECHNOLOGY

Wah Chang Corp. installed a third electron-beam furnace, four rolling mills, and miscellaneous forging, extruding, swaging, and drawing equipment. In December, Wah Chang Corp., and Oregon Metallurgical Corp. each contracted with Westinghouse Electric Corp. to melt 600,000 pounds of sponge into ingot.

Mallory-Sharon Metals Corp. announced receipt of a contract from General Electric Co. to supply zirconium cladding for the first German power reactor. Its subsidiary, Johnston & Funk Metallurgical Corp., has moved its plant and offices from Wooster, Ohio, to Huntsville, Ala.

Harvey Aluminum, Inc., extruded zirconium tubing in lengths exceeding 50 feet.

Alloys of copper and zirconium were developed for high-temperature electrical service and for resistance welding by American Metal Climax, Inc., and P. R. Mallory & Co., Inc., respectively.

The Norton Co. announced the availability of a fused stabilized zirconia capable of service at 2,450° C.

Research on space vehicle reentry problems, as well as problems involving jet aircraft, is performed with the aid of wind tunnels. The airblast is preheated to relatively high temperatures in pebble stoves, the pebbles for which are made of zirconia. Nine such stoves are known to be in operation, and the zirconia required to line and fill them is about 2 percent of the annual production.

The solvent-extraction process developed by the Bureau of Mines in the pioneer zirconium production plant at Albany, Oreg., was described.[3]

An alloy of 49, 48, and 3 percent of zirconium, columbium, and titanium, respectively, has been developed at Ohio State University; it is reported to maintain high strength at temperatures up to 2,000° F.[4]

A furnace has been designed in which a heating element of pure zirconia is heated by waves of radio frequency.[5] It is said to be capable of attaining 5,000° F., with efficiency increasing at higher temperatures; it is intended for use in brazing, soldering, and melting.

Vitro Engineering Corp. will reprocess up to 150 tons of fuel elements annually for the AEC, recovering zirconium and other metals.[6] The spent fuel elements will originate at Hanford, Wash.

Research during the year, based on published papers and patents, again emphasized corrosion; much of the work done was to determine performance of zirconium and its alloys in the environments peculiar to nuclear reactors. New and improved analytical methods were developed, and a number of papers and patents dealt with methods of preparing or purifying zirconium metal. Oxide systems, cermets, and refractories containing zirconium and hafnium oxides, carbides, and borides were also studied extensively. Melting, casting, and fabrication of zirconium and the zircaloys continued to attract research interest.

From a further comparison of the cost of zirconium and stainless steel for nuclear-power reactor service it was concluded that some advantage was to be expected by cladding with zircaloy.[7]

Results of a study of the preparation and uses of hard alloys containing hafnium carbide were published, indicating possibilities for their use in machine tools.[8]

---

[3] Stickney, W. A., Zirconium-Hafnium Separation: Bureau of Mines Rept. of Investigations 5499, 1959, 22 pp.

[4] Chemistry, vol. 32, No. 6, February 1959, p. 44.

[5] Steel, vol. 145, No. 15, Oct. 12, 1959, p. 111.

[6] Chemical Engineering Progress, vol. 55, No. 10, October 1959, p. 105.

[7] Beecher, N., and Benedict, M., Which for Minimum Fuel Cost—Zircaloy or Stainless Clad?: Nucleonics, vol. 17, No. 7, July 1959, pp. 64–68.

[8] Kieffer, R., Benesovsky, F., and Messmer, K., Hafnium-karbidhaltige Hartmetalle: Metall, vol. 13, No. 10, October 1959, pp. 919–922.

Minor Metals

Charles T. Baroch,[1] Donald E. Eilertsen,[2] Frank L. Fisher,[2] James Paone,[2]
H. Austin Tucker,[2] and F. W. Wessel [2] [3]

⁂

Contents

CESIUM AND RUBIDIUM [4]

RESEARCH strengthened the position of cesium as the preferred material (commonly but erroneously called "fuel") for ionic propulsion engines. Its use as an element of the plasma thermocouple for generating electricity also seemed more likely.

Domestic Production.—No domestic ore of cesium and rubidium was produced. San Antonio Chemicals, Inc., San Antonio, Tex., and Maywood Chemical Works, Maywood, N.J., continued to produce cesium and rubidium compounds including carbonate, chromate, hydroxide, nitrate, sulfate, and all four halides. Rocky Mountain Research, Inc., Denver, Colo., began producing various cesium and rubidium salts. American Potash & Chemical Corp., Los Angeles, Calif., offered cesium and rubidium for sale.

Consumption and Uses.—The use of Alkarb, a potassium-rubidium-cesium carbonate produced by San Antonio Chemicals, Inc., in the glass and ceramic industry continued to account for most of the cesium and rubidium consumed.

Cesium metal became the most important potential "fuel" for space-vehicle propulsion. The metal is vaporized in a boiler and passed through a heated tungsten grid. The cesium atoms thus become ionized and are passed through electrical or magnetic fields, accelerating the ions to a very high velocity. They are then expelled through an orifice to provide thrust for the vehicle.

Cesium also is the active constituent in solar batteries.[5] Power companies throughout the United States supported research seeking

---

[1] Chief, Branch of Rare and Precious Metals.

[2] Commodity specialist.

[3] Unless otherwise noted figures on imports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

[4] Prepared by F. W. Wessel.

[5] Means, Paul, The Search for Space Vehicle Power: Missiles and Rockets, vol. 5, No. 31, July 27, 1959, pp. 22–45.

direct conversion of heat to electricity. One phase of this research, conducted by the General Atomic Division of General Dynamics Corp., was based on use of a cesium cell, and overall plant efficiencies of 25 to 30 percent were predicted.[6]

Cesium halide crystals were used in infrared spectometry, a rapidly expanding field. Numerous photomultiplier tubes were available; in all a form of cesium was used as dynode and/or cathode material.

The radioisotope, cesium 137, a product of nuclear fission in reactors, is a beta emitter of moderate intensity and is being used in the treatment of cancer, supplementing cobalt 60. It has a half life of about 30 years. Other potential applications for cesium 137 include teletherapy, industrial radiography, sterilization of surgical and medical supplies, promotion of chemical reactions, and construction of density gages.

Prices.—The price of Alkarb was increased to $132.50 per ton in bulk carloads, f.o.b., San Antonio, Tex. The price of 25-percent cesium ore (pollucite) was estimated at $0.75 per pound of contained metal.

Cesium metal was offered by American Potash & Chemical Corp., and Penn Rare Metals at prices ranging from $1.10 to $3.35. Rubidium was quoted at $1.07 to $3.45, depending on purity and size of lot. Purity ranges from 99.0 to 99.8 percent.

In 10-kilo lots, cesium salts were quoted at 16 to 27 cents per gram and rubidium salts at 16 to 31 cents.

World Review.—Montgary Explorations, Ltd., continued development of its mine at Bernic Lake, Manitoba, Canada. A contract has been arranged with W. R. Grace & Co., New York, N.Y., and Metallgesellschaft, Frankfurt am Main, West Germany, for marketing lithium and cesium minerals.

Technology.—The geology of the pegmatite deposit at Bernic Lake was described.[7]

The Rocketdyne Division of North American Aviation, Inc., described the ion rocket engine and discussed propellent materials. Research in ion propulsion by General Electric Co. led to the design of a cesium-ion rocket.[8]

A plant is to be designed for the United Kingdom Atomic Energy Authority to recover radioactive cesium from wastes produced in processing irradiated fuel. A method of recovery, developed by General Electric Co., was proposed.[9]

GALLIUM[10]

Domestic Production.—Gallium metal was produced by Aluminum Co. of America at East St. Louis, Ill., The Anaconda Co. at Great Falls, Mont., and The Eagle-Picher Co. at Joplin, Mo. The last-named firm also produced gallium oxide. More gallium metal was produced and shipped than in 1958.

---

[6] Hernqvist, K. G., Thermionic Converters: Nucleonics, vol. 17, No. 7, July 1959, pp. 49–55.

[7] Hutchinson, R. W., Geology of the Montgary Pegmatite: Paper presented at annual meeting, AIME, Feb. 15–19, 1959.

[8] Edwards, R. N., and Kuskevics, G., Cesium-Ion Rocket Research Studies: Paper presented at Aviation Conf., ASME, Mar. 9–12, 1959.

[9] Van Tuyl, H. H., and Moore, R. L., Recovery of Fission Product Cesium From Acidic Wastes: Ind. Eng. Chem., vol. 51, No. 6, June 1959, pp. 741–744.

[10] Prepared by Donald E. Eilertsen.

Uses.—Small quantities of gallium were used as a sealant for glass joints and valves in vacuum equipment, as a backing material for optical mirrors, in thermometers, and in low-melting alloys, and research workers were searching for new important electronic applications of the metal. Gallium compounds reported to be of interest included gallium arsenide, for use in solar cells and high-temperature rectifiers, transistors, and semiconductor devices for computers, missiles, and communication equipment; gallium phosphide, for diodes in high-temperature missile and satellite instrumentation; and gallium antimonide, for rectifiers and transistors.

Prices.—Gallium was quoted, in E&MJ Metal and Mineral Markets, at $3.25 a gram in small quantities and $3 a gram in 1,000-gram quantities.

World Review.—Hungary's first plant, producing gallium as a byproduct of processing bauxite, was put into operation.[11]

Technology.—The electrical characteristics of gallium phosphide electronic devices were described.[12] A new method for growing crystals of the arsenide, phosphide, or antimonide of gallium was reported.[13]

GERMANIUM [14]

Germanium production and consumption increased significantly. The 125 million germanium electronic devices manufactured in the United States or imported was more than twice the number used in 1958.

Domestic Production.—Production of germanium equaled consumption and was estimated at 45,000 pounds. This quantity includes germanium produced from domestic raw materials and that obtained by processing germanium-bearing base-metal concentrate from South-West Africa. The recovery of germanium scrap from manufacturer's waste and transistor and other rejected semiconductor devices became an important segment of the industry and is not included as new supply or production. Many major manufacturers using germanium began processing their own plant scrap, and the three primary germanium producers purchased scrap outright or processed it on a toll basis. This shift to large-scale scrap recovery is attributed to improved processing technology and occurred when the quantity of germanium per transistor was much less and the number of rejects per acceptable transistor had been greatly reduced.

The domestic producers of germanium from raw materials were Eagle-Picher Company, Miami, Okla.; American Zinc Company, Fairmont, Ill.; and Sylvania Electric Products, Inc., Towanda, Pa. Plans for a new germanium facility at Carteret, N.J., were announced by American Metal Climax, Inc. In addition to producing germanium dioxide from raw material imported from South-West Africa, the plant will process germanium scrap.

---

[11] Chemistry and Industry (London), Chemical Trade Developments in Hungary: No. 18, May 2, 1959, p. 561.

[12] Mandelkorn, J. (U.S. Army Signal Res. and Dev. Lab., Fort Monmouth, N.J.), Electrical Characteristics of Some Gallium Phosphide Devices: Proc. Inst. Radio Eng., vol. 47, No. 11, November 1959.

[13] Chemical and Engineering News, Army Research Highlighted; Vol. 37, No. 28, July 13, 1959, pp. 46–47.

[14] Prepared by Frank L. Fisher.

Consumption and Uses.—The number of germanium transistors, diodes, and rectifiers manufactured or imported was estimated at 125 million units, a sharp increase over 1958 despite greater competition from high-purity silicon and other semiconductor materials. Germanium rectifiers were used mainly in the chemical and metallurgical industries where their high efficiency can be most effectively utilized.

Nonelectronic uses of germanium were small; the most important was as a fluorescent powder in lamps where the red luminescence of germanium oxide corrects the blue tint of the mercury-vapor light. The use of germanium "germanes" in organic chemistry, as a catalyst, and in optical glasses was under laboratory investigation. Six domestic and foreign germanium producers formed a Germanium Development Committee to combine their search for more diversified applications for germanium, its alloys, and compounds.

Prices.—Germanium prices, quoted in E&MJ Metal and Mineral Markets, decreased several times in the first half of 1959 but remained unchanged for the remainder of the year at the following prices, f.o.b. shipping point, announced June 16:

Grade	*Cents per gram*
First reduction—1,000-gram lots	34.5–35
Intrinsic quality—1,000-gram lots	[1] 35–37
First reduction—10,000-gram lots	33
Intrinsic quality—10,000-gram lots	[1] 35

[1] Delivered price.

This dioxide was quoted at 18.5 cents a gram and single-crystal intrinsic quality germanium at 60.5 cents a gram in 10,000-gram lots and 68.5 cents a gram in 1,000-gram lots during 1959.

World Review.—*Belgium.*—Socíeté générale metallurgique de Hoboken increased its capacity for producing Electronic-grade germanium dioxide to 135,000 pounds, the second major increase in capacity in 4 years.

Canada.—Germanium was reported southeast of Powell River, British Columbia, and active prospecting was begun.[15]

Italy.—The Societa Mineraria Metallurgica Pertuscola began producing germanium concentrate at its zinc plant in Crotone, Catanzaro. The germanium was being refined in Belgium.

Japan.—Japan became the world's largest consumer of germanium, as the rapidly expanding Japanese electronic industry gained a large share of the world germanium transistor market. U.S. transistor imports from Japan were valued at $60 million and accounted for an estimated 40 percent of the U.S. transistor market. Japanese domestic production was estimated at 15,000 pounds, less than one-fourth the quantity consumed.

South-West Africa.—The Tsumeb Corporation Ltd., completed construction of electromagnetic and pyrochemical facilities for recovering and processing germanium concentrate at Tsumeb.

Technology.—The two major developments in germanium technology were the sucessful growth of thin, uniform, flat ribbons of germanium in dendritic single crystals by Westinghouse Electric Corp. and the

---

[15] Buckland, F. C., Germanium in British Columbia: Western Miner and Oil Review, vol. 32, No. 9, September 1959, pp. 30–34.

marketing by General Electric Co. of germanium tunnel diodes in quantity for design into electronic circuitry.

The search continued for sources of germanium in commercial quantities, independent of base-metal operations. Studies emphasized the evaluation and recovery of germanium from coal.[16]

Refinements in processing technology resulted in the production of germanium sufficiently pure to meet the exacting specifications of the electronic industry. A description of the basic processing technology was published.[17]

The successful, continuous growth of germanium single-crystal ribbons by Westinghouse greatly simplifies the production of small germanium disks used in transistors and other electronic instruments. The process was developed under an Air Force contract and permitted important innovations in molecular electronics.[18]

INDIUM[19]

Domestic Production.—The American Smelting & Refining Co., Perth Amboy, N.J., produced indium metal, chloride, and sulfate; and The Anaconda Co., Great Falls, Mont., produced indium metal. Production of indium was about the same as in 1958 and shipments were greater.

Uses.—Principal uses for indium were in electronics, bearing alloys, and low-melting alloys. Interest increased in developing applications for indium compounds: Indium phosphide for transistors, indium antimonide for infrared photodetectors and galvanomagnetic devices, and indium arsenide phosphide for thereomelectric applications.

Prices.—Indium, 99.9 percent pure, was quoted, in E&MJ Metal and Mineral Markets, at $2.25 a troy ounce in small quantities and $1.25 to $2.25 a troy ounce in quantities over 5,000 ounces. Prices for 99.999–percent indium ranged from $3.20 to $6 a troy ounce, depending upon the quantity.

Technology.—Indium was one of several metals used in Bureau of Mines research seeking improved magnesium-base alloys.

A comprehensive treaties on indium, containing more than a thousand references, was published for the period 1863–1958,[20] and production of indium in Canada was described.[21]

RADIUM[22]

Domestic commercial activities in the radium industry continued at about the 1958 level, although imports for consumption decreased 14 percent.

---

[16] Schleicher, J. A., Germanium in Kansas Coals: State Geol. Survey of Kansas Bull. 134, Reports of Studies, pt. 4, 1959, pp. 161–179.

[17] Wilson, J. M., Large Scale Preparation of Ultra-Pure Germanium: Research—Applied in Industry, vol. 12, No. 2, February 1959, pp. 47–53.

[18] Materials in Design Engineering, Germanium Crystals Grown Ready for Immediate Use: Vol. 50, No. 4, October 1959, pp. 133–134.

[19] Prepared by Donald E. Eilertsen.

[20] Ludwick, Maria Thompson, Indium: Indium Corp. of America, Utica, N.Y., 1959, 770 pp.

[21] Hunt, B. G., White, C. E. T., and King, R. A., Commercial Production of Indium: The Canadian Min. and Met. Bull., vol. 52, No. 566, June 1959, pp. 359–365.

[22] Prepared by James Paone.

Domestic Production.—There was no domestic production of radium. Domestic requirements were met by imports.

Principal domestic distributor of radium, its derivatives, and related compounds was the Radium Chemical Co., Inc., New York, N.Y. Other firms in the radium industry were Canadian Radium & Uranium Corp., New York, N.Y.; United States Radium Corp., Morristown, N.J.; and A. Bruce Edwards, Philadelphia, Pa. Radium Chemical Co., Inc., was sales representative for Union Minière du Haut Katanga, the world's leading radium producer, and A. Bruce Edward was sales representative for Atomic Energy of Canada, Ltd.

Consumption and Uses.—Radium and radium salts continued to be sold and leased principally for use in industrial radiography, radium-beryllium neutron sources, and medical curietherapy units to treat cancer. Radium was also used in self-activated luminescent paint and static-elimination equipment.

Prices.—Throughout 1959 the price of radium was quoted by E&MJ Metal and Mineral Markets at $16 to $21.50 per milligram of radium content, depending on quantity.

Foreign Trade.—Radium salts were imported chiefly from Belgium where they were purified from ores and slimes produced by Union Minière de Haut Katanga in the Belgian Congo. Radium was also imported from Canada and the United Kingdom.

TABLE 1.—Radium salts and radioactive substitutes imported for consumption in the United States

[Bureau of the Census]

Year	Radium salts		Radioactive substitutes, value[1] (thousands)
	Milligrams	Total value (thousands)	
1950-54 (average)	97,484	$1,533	$83
1955	65,545	975	189
1956	43,221	633	[2] 514
1957	76,206	1,061	844
1958	38,419	538	908
1959	32,967	518	1,145

[1] Includes artificial radioactive isotopes that are not substitutes for radium.

[2] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable with other years.

RHENIUM[23]

Domestic Production.—Chase Brass & Copper Co., Waterbury, Conn., and the Department of Chemistry, University of Tennessee, Knoxville, Tenn., were the only domestic producers of rhenium.

Uses.—Rhenium was used in thermocouples for filaments in mass spectrographs. Experimental quantities of rhenium were used in filaments and tube components for electronic equipment, electrical contacts, and other research studies.

Prices.—The University of Tennessee quoted rhenium at $2.10 a gram in small quantities and $1.20 a gram for 1,000-gram quantities.

Technology.—The Bureau of Mines continued its search for new sources of rhenium, and research on improved methods for rhenium

---

[23] Prepared by Donald E. Ellertsen.

recovery, and improved and simpler analytical procedure for quantitative analysis of rhenium.

A comprehensive report on rhenium was published,[24] and the geochemistry of rhenium was discussed.[25]

SCANDIUM [26]

Scandium is little known because it has been extremely scarce and has no distinctive uses. New sources and an intensified program to find its potential applications brought scandium nearer to commercialization.

Domestic Production.—Union Carbide Metals Co., Niagara Falls, N.Y., produced 1 pound of scandium—probably the largest quantity that ever existed in one place—under a contract with the U.S. Air Force, Wright Air Development Center. The material was in two disks about 3 inches in diameter and ¾-inch thick. It was 99 percent pure and was to be used to study the physical, chemical, and mechanical properties of the metal.

St. Eloi Corp., Cincinnati, Ohio, announced in October that they could supply experimental quantities of 99-percent-pure scandium. Vitro Chemical Co., Chattanooga, Tenn., began producing scandium oxide and derived salts as a byproduct of uranium milling. Others reporting an interest in the production of scandium or its compounds include City Chemical Corp., New York, N.Y.; Fairmont Chemical Co., Inc., Newark, N.J.; King Products, Arlington, N.J.; and Research Chemicals Division, Nuclear Corp, of America, Burbank, Calif.

Uses.—There was no commercial market for scandium. Application to missiles or aircraft was suggested because scandium has a density of 3.0 grams per cubic centimeter, comparable to aluminum, and a melting point of about 1,550° C. compared with 659° C. for aluminum.

Prices.—Sales are based on individual contracts, frequently on a custom basis, and prices vary widely depending mainly on quantity and purity. Scandium metal was quoted at $30 to $70 per gram and scandium oxide at $15 to $30 per gram.

Norwegian thortveitite concentrate containing about 5 percent Sc_2O_3 was offered occasionally at about 32 cents per gram.

Foreign Trade.—Thortveitite concentrate from Norway and Madagascar were the only sources of scandium mineral until 1959. The richer Norwegian sources appear to have become exhausted, and only low-grade material was offered. Madagascar thortveitite could be sold only to the Atomic Energy Commission of France.

Technology.—Scandium accumulates in the organic liquid as it is recycled in the solvent extraction process used in some uranium plants, but the amount of scandium in the uranium ore is so small that it cannot be estimated by present analytical procedures. Some scandium was recovered from the Vitro Uranium Co. mill at Salt Lake City,

---

[24] Materials Advisory Board, National Academy of Sciences, National Research Council, Report of the Raw Material Group Panel on Rhenium: Rept. of the Committee on Refractory Metals, MAB–154–M(1), vol. 2, Panel Repts., ch. 9, Oct. 15, 1959, pp. 257–288.

[25] Fleischer, Michael, The Geochemistry of Rhenium, With Special Reference to Its Occurrence in Molybdenite: Econ. Geol., vol. 54, No. 8, December 1959, pp. 1406–1413.

[26] Prepared by Charles T. Baroch.

Utah. The organic liquid was treated to recover a complex precipitate containing about 5 percent scandium. This precipitate was sent to Vitro Chemical Co. for further treatment.

Methods of recovering scandium from the Vitro and other 11 uranium mills that use solvent extraction or ion exchange were studied by the Bureau of Mines. Scandium recoverable from each plant may be a pound or more per day.

The process used by St. Eloi Corp. to produce scandium from thortveitite was described.[27] Pure scandia is recovered by ion exchange and fluorinated, and the scandium fluoride is reduced at 1,400° C. under argon with calcium in a tantalum crucible. Then, pure scandium is recovered by vacuum distillation at 1,600° to 1,750° C.

Research on scandium metal was begun by Union Carbide Metals Co. under contract to the Air Force. It was found that scandium can be arc-melted in argon without loss by volatilization and fabricated with difficulty, but it can be cold-reduced about 50 percent before annealing in a vacuum or inert atmosphere at 600° to 700° C. Scandium is highly reactive in air and combines with nitrogen and oxygen at 800° C.

SELENIUM[28]

World production and consumption of selenium increased, despite a copper strike in the United States which sharply curtailed output. The firm demand throughout the year stemmed primarily from selenium's growth as a semiconductor material.

Selenium remained in Group I of the national stockpile list of Critical and Strategic Materials. Applicants for exploration assistance were eligible for government financial assistance under the Office of Minerals Exploration (OME) program. Selenium was also designated by the President as eligible for acquisition under the 1959 Barter Program.

Domestic Production.—Primary production of selenium increased 10 percent to 799,000 pounds, most of which was obtained as a byproduct of electrolytic copper refining. A strike in the copper industry during the last 5 months of the year sharply curtailed selenium production. About 7 percent of the available supply was recovered from secondary sources.

Companies reporting selenium production were: Allied Chemical Corp., American Metal Climax, Inc., American Smelting & Refining Co., International Smelting & Refining Co., Kawecki Chemical Co., and Kennecott Copper Corp.

Consumption and Uses.—Shipments to consumers and apparent selenium consumption approached an alltime high. Selenium for manufacturing dry-plate rectifiers and other electronic devices accounted for more than half the quantity consumed. The use of high-purity selenium as a semiconductor material increased in the electrical and electronic industries. The quantity of selenium used in stainless

---

[27] Chemical and Engineering News, Scandium Nears Commercialization: Vol. 37, No. 43, Oct. 26, 1959, pp. 88, 90.

[28] Prepared by Frank L. Fisher.

steels, to improve ductility and machinability, continued to increase, as the quantity used in the pigment, glass, ceramic, and pharmaceutical industries.

TABLE 2.—Salient selenium statistics, thousand pounds contained selenium

	1950–54 (average)	1955	1956	1957	1958	1959
Production [1]	666	[2] 699	[2] 928	1,077	727	799
Shipments	774	882	1,035	625	737	1,011
Imports	209	192	235	148	184	224
Apparent consumption	983	1,074	1,270	773	920	1,234
Producers' stocks	96	76	191	651	551	339
Price, commercial grade, per pound	$2.00	$5.00–$9.00	$9.00–$15.00	$7.50–$12.00	$7.00–$7.50	$7.00

[1] Includes small quantities of secondary selenium in 1954–59.
[2] Revised figure.

Stocks.—Producers' stocks dropped sharply for the second consecutive year. The abnormally high accumulation of stocks at producers' plants, which reached a peak in 1957, was reduced to approximately a 4-month supply.

Prices.—The prices quoted for selenium were lowered on February 19, 1958, to $7 a pound for Commercial and $9.50 a pound for High-Purity grade. These prices were unchanged throughout 1959. Ultra-High-Purity selenium in pellets, with a minimum of 99.999+ percent Se, was quoted at $20 a pound. The price of ferroselenium was unchanged at $2 a pound.

Foreign Trade.—Imports of selenium and selenium salts for consumption totaled 223,699 pounds, an increase of 22 percent over 1958. Imports from Canada were 168,294 pounds. Belgium-Luxembourg supplied 40,740 pounds, Japan 2,094, Sweden 835, and the United Kingdom 11,736. In addition, 50,230 pounds of selenium contained in selenium-bearing concentrates was imported from the Federation of Rhodesia and Nyasaland and is not included in the import total.

World Review.—*Canada.*—The preliminary estimate of Canadian selenium production was 564,400 pounds worth Can$3,850,000. Of this quantity, 333,000 pounds originated in Quebec, 105,163 in Saskatchewan, 100,000 in Ontario, and 26,252 in Manitoba.

Belgium.—Production of selenium was 124,600 pounds. The selenium was a byproduct of Belgian Congo and Rhodesian copper refining.

Finland.—Selenium production in Finland was 13,000 pounds. The output was a byproduct of the copper operations of Outokumpu Oy at Pori.

Japan.—Japanese selenium producers reported a production of 180,000 pounds. The selenium was a byproduct operation of several copper refineries, a gold refinery, and two ammonia sulfate plants.

Mexico.—Mexico produced 8,900 pounds of selenium; most of the output was selenium in lead flue dusts.

Peru.—Peru produced 8,000 pounds of selenium, obtained as a byproduct of the Cerro de Pasco copper refinery at Oroya.

Rhodesia and Nyasaland, Federation of.—Production of selenium in copper slimes totaled 32,600 pounds.

TABLE 3.—World production of selenium, by countries, 1938–59, in pounds

[Compiled by Augusta W. Jann]

Year	North America			South America	Europe			Asia	Africa	Oceania	World total
	Canada	Mexico	United States		Belgium [1]	Finland	Sweden	Japan	Northern Rhodesia	Australia	
1938	358,929	---	225,700	---	---	---	---	39,396	4,078	---	628,103
1939	150,771	---	227,100	[1,2] 1,290	---	---	---	46,541	1,277	---	426,979
1940	179,860	137	328,700	[1,2] 254	---	---	---	43,514	---	---	552,465
1941	406,930	[3] 431,807	620,500	---	---	---	[1] 151,017	52,059	---	---	1,662,313
1942	495,369	[3] 248,375	506,400	---	---	---	[1] 130,088	42,604	---	---	1,422,836
1943	374,013	---	635,600	---	---	---	[1] 126,082	36,464	---	---	1,172,159
1944	298,592	---	485,400	---	---	---	[1] 100,839	48,913	---	---	933,744
1945	379,187	---	458,500	---	---	---	[1] 750	15,408	---	---	853,845
1946	521,867	---	291,100	---	---	---	[1] 122,246	1,651	[3] 108,889	1,566	1,047,319
1947	501,090	---	512,600	---	---	---	[1] 89,098	4,815	11,826	1,603	1,121,032
1948	390,894	---	561,200	---	---	2,075	[1] 50,521	10,055	21,132	1,656	1,037,533
1949	318,225	---	468,500	---	---	2,793	[1] 21,305	20,163	20,958	1,362	853,306
1950	261,973	1,457	511,300	---	---	1,517	[1] 83,776	32,196	27,056	2,394	921,669
1951	382,603	---	494,900	---	24,251	3,146	115,113	43,997	9,772	1,924	1,075,706
1952	242,030	---	678,400	[1,2] 187	37,479	5,758	107,570	58,693	31,758	2,000	1,172,875
1953	262,346	2,798	924,000	---	61,729	7,224	115,884	65,571	29,410	3,791	1,472,753
1954	323,529	14,703	713,200	[4] 4,057	65,036	5,567	166,235	92,344	14,352	3,442	1,402,465
1955	427,109	132,758	699,300	[5] 7,756	61,068	7,595	139,841	127,053	17,160	2,455	1,622,095
1956	330,389	201,864	928,400	[5] 6,149	81,571	8,390	168,532	162,916	32,055	2,581	1,922,847
1957	321,392	175,475	1,077,000	[4] 6,865	24,471	9,219	143,300	154,335	25,137	3,002	1,940,196
1958	306,990	108,025	727,400	[4] 8,419	48,942	13,051	[1] 116,844	175,920	24,805	[6] 3,000	1,533,396
1959	564,415	8,891	799,100	[4] 8,155	124,560	13,196	132,276	179,952	32,587	[6] 3,000	1,866,132

[1] Exports.
[2] Bolivia.
[3] Recovered from electrolytic copper slimes accumulated during the war years.
[4] Peru.
[5] Argentina and Peru.
[6] Estimate.

Technology.—Research centered on the production and plating of high-purity selenium coatings for new and diverse applications. Research on a new purification process was described.[29] Electrodeposition and plating of ultrathin coatings were described.[30]

An extensive survey on selenium in Canadian sulfides was published.[31]

The Federal Geological Survey issued a report on the selenium content of volcanic rocks,[32] and a report was published on the determination of selenium in Mexican gold-silver ores.[33]

Widespread basic research was conducted on binary and ternary selenides for use in thermoelectrics, but no results have been published. Indications are that the heavy-metal selenides have similar thermoelectric properties and characteristics to the tellurides.

SILICON [34] [35]

Substantial growth and significant new technical discoveries and uses characterized the high-purity silicon industry.

Domestic Production.—More producers entered the high-purity silicon field and domestic production continued the upward trend of the preceding 3 years. Consumption was about one-half greater than in 1958. New commercial producing firms were Trancoa Chemical Corp. (subsidiary of Transistron Electronic Corp.), Kemet Co. (division of Union Carbide Corp.), and Allegheny Electronic Chemicals Co. (subsidiary of Baugh Chemicals Co. and Baugh & Sons, Baltimore, Md.). Companies building plants were Monsanto Chemical Co., near St. Charles, Mo., and Dow Corning Corp., near Midland, Mich. Both companies have licensed the Siemens-Westinghouse process for making high-purity silicon.

Consumption and Uses.—The electronics industry consumed 65,000 pounds of high-purity silicon valued at about $16 million. From this quantity, the electronic industry made 53.5 million high-purity silicon diodes and rectifiers, valued at $101.2 million, and about 5 million transistors, valued at $72 million.[36] Sales of silicon diodes and rectifiers in 1958 totaled only 26.2 million units, valued at $67.8 million. About 40 percent more silicon transistors were used than in 1958.

The silicon solar cell became increasingly useful as a power source for various appliances, particularly in space vehicles. Solar cells supplied the power to operate transistorized radio sets, Forest Service radio links, light sensors, flashers, clocks, and an experimental electric automobile.

---

[29] Nielsen, S., and Heritage, R. J.,A Method for the Purification of Selenium. Jour. Electrochem. Soc., vol. 106, No. 1, January 1959, pp. 39–43.

[30] Graham, A. K., Pinkerton, H. B., and Boyd, H. J., Electrodeposition of Amorphous Selenium : Jour. Electrochem. Soc., vol. 106, No. 8, August 1959, pp. 651–654.

[31] Hawley J. E., and Nichol, I., Selenium in Some Canadian Sulfides : Econ. Geol., vol. 54, No. 4, June–July 1959, pp. 608–628.

[32] Davidson, D. F., and Powers, H. A., Selenium Content of Some Volcanic Rocks from Western United States and Hawaiian Islands : Geol. Survey. Bull. 1084–C, Contributions to Geochemistry, 1959, pp. 69–81.

[33] Eiss, M. I., and Giesecke, P., How To Determine Selenium in Ores and Cyanide Solutions : Eng. Min. Jour., vol. 160, No. 12, December 1959, pp. 102–103.

[34] Data on lower grades of silicon, such as those used for alloying aluminum and copper alloys and in producing silicones, are included in the Ferroalloys chapter.

[35] Prepared by H. Austin Tucker.

[36] Electronic Industries Association, Marketing Data Department monthly publications : Factory Sales of Semiconductor Diodes and Rectifiers and Factory Sales of Transistors, January–December 1959.

Prices.—The prices of the various polycrystalline grades of high-purity silicon remained at the same level. However, the prices of single crystals dropped as much as $150 a pound. The new prices ranged from $700 to $850 a pound.

Foreign Trade.—Effective March 1, the Bureau of Foreign Commerce, U.S. Department of Commerce, added all silicon transistors to the Positive List of Commodities under schedule B, No. 70848, requiring validated licenses for shipment to all destinations except Canada.

Technology.—Producers of high-purity silicon made increasingly more single crystals, and the electronic industry fabricated more efficient devices at an accelerated rate. Industrial consumers appeared to prefer high-power silicon rectifiers, and space-vehicle launchings brought solar-cell energy converters into prominence.

Silicon producers made increasingly larger quantities of single crystals to sell to electronic fabricators who could not economically make their own. Producers grew, sliced, doped, and diced crystals, preparing them for the consumer to fabricate into electronic components.

One producer of silicon reported a new crystal-growing technique using a vapor-phase process.[37] This firm has grown a film of single-crystal silicon on a single-crystal slice. The process permits close control of "doping" elements introduced to control resistivity. Also, the thickness of the vaporized films can be controlled to one ten-thousandth of an inch. The films range in thickness from 0.0001 to 0.020 inch. By such means, the producer can supply the electronic industry with easy-to-make single crystals. Further, by piling films of appropriate characteristics, one on top of the other, molecular electronic or molectronic devices can be made.

Electronic-device manufacturers developed components of equipment in the molectronic category. One such device is 100 times smaller than the transistorized, printed-circuit unit that it replaced.[38] The new device performs simultaneously 16 electronic functions in a solid block of silicon measuring 0.250 by 0.125 by 0.31 inch.

General Electric Co. developed the tunnel diode invented in 1958 by the Japanese scientist, Leo Esaki.[39] This diode operates on a different principle than other semiconductor devices. Energy is transmitted at the speed of light through the diode by the quantum-mechanical tunneling of electrons. Silicon tunnel diodes perform more consistently over a wider range of temperatures than those made of other materials. The new silicon diode operates effectively at 650° F., or 250° F. higher than conventional diodes. Tunnel diodes require much less material than conventional ones and can be made of silicon, gallium arsenide, germanium, or several other materials.

Electronic-device designers shifted their emphasis from alloyed-junction to diffused-junction silicon diode transistor.[40] The diffusion process permits production of large-area junctions with greater reproducible accuracy.

---

[37] Lydon, J. Crystal Research at Merck Aids Miniaturization Study, Electronic News, vol. 5, Whole No. 193, Mar. 22, 1960, p. 76.

[38] Missiles and Rockets, vol. 6, No. 13, Mar. 28, 1960, p. 42.

[39] Hebb, M. H., Tieman, J. J., and Fancher, H. B., Introducing the New Tunnel Diode: Signal, vol. 14, No. 2, October 1959, pp. 10, 12, 14, 26.

[40] Carlson, Franklin A., Emphasis Shifts Toward Diffused Diode Transistor: Ind. Laboratories, vol. 10, No. 8, August 1959, pp. 82–84.

A trend was reported toward using silicon rectifiers almost exclusively for new power-conversion installations in the electrochemical field.[41] High-powered silicon rectifiers were said to have higher operating voltage ratings, current density, and maximum junction temperature than those made of competitive materials.

Space vehicles launched in 1959 used thousands of silicon solar cells to convert sunlight to electrical energy. The paddle-wheel satellite, Explorer VI, contained 8,000 solar cells in its paddles to recharge the 40-watt-capacity chemical battery. Another satellite, Tiros, carried 9,600 solar cells.

The electronic industry continued to produce more powerful semiconductor devices. A high-power silicon transistor was marketed that can control 5 kw. of power when used as a switch. Collector-to-emitter voltage ratings range from 30 to 200 volts, and the current carrying capacity is 30 amperes.

The producers of high-purity silicon and the fabricators of electronic devices made notable progress in marketing and technology. The producers showed an aggressive attitude in marketing their material by making and preparing single crystals for the device makers who were unable to produce their own. In turn, the fabricators succeeded in making their products more attractive by developing solid-state silicon components that perform multiple functions simultaneously. These so-called molectronic devices are miniatures of the units they replaced; thus, they are ideal for the space age. One device maker exploited a new electronic principle in developing the tunnel diode.

TELLURIUM [42]

The tellurium industry gained sharply in all departments, as widespread interest developed in the use of tellurium as a component in thermoelectric applications.

Domestic Production.—Production of tellurium increased, despite a copper strike during the last half of the year which sharply curtailed output. The domestic supply was produced as a byproduct of electrolytic copper refining and the refining of lead. Producers were: American Metal Climax, Inc.; American Smelting and Refining Co.; International Smelting and Refining Co.; Phelps Dodge Refining Corp.; and United States Smelting, Refining, and Mining Co.

TABLE 4.—Salient tellurium statistics, thousand pounds of contained tellurium

	1950–54 (average)	1955	1956	1957	1958	1959
Production	167	180	233	255	170	196
Shipments	115	[2] 209	[2] 255	[2] 214	[2] 182	316
Stocks, end of year	104	77	126	167	134	63
Imports	(1)	(1)	(1)	2	6	16
Price per pound	$1.75	$1.75	$1.50–$1.75	$1.50–$1.75	$1.65–$1.75	$1.65–$3.00

[1] Data not available.
[2] Revised figure.

---

[41] Shields, G. E., Stratford, R. P., and Zielinski, H. H., Silicon Power Rectifiers Take Over: Chem. Eng., vol. 66, No. 3, Feb. 9, 1959, pp. 119–122.

[42] Prepared by Frank L. Fisher.

Consumption and Uses.—Shipments of tellurium to consumers increased sharply. A prolonged copper strike in the United States and increased demand stimulated inventory purchases as a barrier to rising prices. The quantity of tellurium used in thermoelectric research and development was believed to be less than 10 percent of consumption. Production of thermoelectric devices increased. The SNAP-3 (Systems for Nuclear Auxiliary Power) thermoelectric generator, announced early in the year by AEC, contained 54 lead telluride thermoelements. Demand for tellurium by the metallurgical, rubber, chemical, and ceramic industries continued to be strong.

Stocks.—Tellurium-bearing slimes and residues stored by producers decreased 9 percent after a slight increase the preceding year. Producers' stocks of tellurium dropped 53 percent, continuing a trend which began in 1958.

Prices.—The price of Commercial-grade tellurium in 100-pound lots increased from $1.65 a pound to $2 on May 1, to $2.50 on July 15, and to $3 at yearend. High-purity tellurium of semiconductor quality, 99.999+ percent Te, in fragmented pieces, was quoted at $25 a pound.

Foreign Trade.—Imports of tellurium compounds amounted to 15,900 pounds valued at $27,391. Peru supplied 14,428 pounds; the remainder came from Canada, Switzerland, and West Germany. Exports were not reported.

World Review.—*Canada.*—Preliminary estimates of tellurium production were 96,900 pounds valued at Can$208,400. The tellurium was recovered as a byproduct by International Nickel Co., Copper

TABLE 5.—World production of tellurium, by countries, 1930–59, in pounds

[Compiled by Augusta W. Jann]

Year	Canada	Japan	Peru	United States	World total
1930	---	---	---	[1] 4,720	[1] 4,720
1931	---	---	---	(2)	(2)
1932	---	---	---	[1] 1,570	[1] 1,570
1933	---	---	---	[1] 11,980	[1] 11,980
1934	5,130	---	---	27,210	32,340
1935	16,425	---	---	37,100	53,525
1936	35,591	---	---	57,960	93,551
1937	41,490	---	---	51,410	92,900
1938	48,237	---	---	11,080	59,317
1939	2,940	---	---	25,230	28,170
1940	3,491	---	---	85,620	89,111
1941	11,453	---	---	224,600	236,053
1942	11,084	---	---	225,000	236,084
1943	8,600	---	---	54,290	62,890
1944	10,661	---	755	61,870	73,286
1945	484	---	1,020	33,460	34,964
1946	15,848	---	---	11,600	27,448
1947	9,194	---	---	60,419	69,613
1948	11,425	---	---	56,900	68,325
1949	11,692	---	---	120,700	132,392
1950	10,075	---	---	107,400	117,475
1951	8,913	---	---	187,100	196,013
1952	6,035	---	---	189,100	195,135
1953	4,694	331	---	70,400	75,425
1954	8,171	992	---	97,100	106,263
1955	9,014	992	2,341	179,900	192,247
1956	7,867	331	88	232,600	240,886
1957	31,524	220	---	254,900	286,644
1958	38,250	110	14,868	170,500	223,728
1959	96,954	1,332	62,600	196,000	356,886

[1] Sold by producers.
[2] Data not available.

Cliff, Ontario, and Canadian Copper Refiners, Ltd., Montreal East, Quebec.

Peru.—Tellurium production increased to 62,600 pounds, compared with 14,900 pounds in 1958. All tellurium was obtained from the Cerro de Pasco copper refinery at Oroya.

Technology.—The technology of tellurium continued to feature basic research and was primarily concerned with developing methods for more accurate detection and analysis of tellurium, locating and determining tellurium losses in base-metal processing, and studying the thermoelectric properties of a lengthy series of heavy-metal binary and ternary tellurides. Typical work in this last-mentioned area was reviewed.[43]

Widespread publicity was given to tellurium's electronic applications as more than 850 industrial organizations and research groups were conducting research on and developing thermoelectric devices. Tellurium continued to be the predominant component of thermoelements, particularly for thermoelectric cooling and temperature sensing. The status of the industry was examined.[44]

THALLIUM [45]

Domestic Production.—The American Smelting and Refining Co., at Denver, Colo., was the only domestic producer of thallium. Shipments of thallium metal and compounds increased slightly.

Uses.—The largest use of thallium was as thallium sulfate, an odorless, tasteless, and very poisonous sulfate used to exterminate rodents and ants. Thallium-activated sodium iodide crystals, mounted in photomultiplier tubes, were used to detect gamma radiation.

Price.—Prices of thallium metal were $10 a pound for 2 to 9 pounds; $9 a pound for 10 to 24 pounds; and $7.50 a pound for larger quantities. High-purity thallium, 99.999 percent pure, in ⅜-inch diameter rods was $3 for 25 grams. Prices of thallium sulfate, in multiples of 25 pounds and in pails, were $7 a pound for the first 100 pounds and $5 a pound for larger quantities.

YTTRIUM [46]

Yttrium is always associated with the rare-earth elements and is so similar to them chemically that a practical method of isolating it has been developed only within the last decade or so. Now that pure yttrium compounds and metal are available and their properties are becoming better known, yttrium undoubtedly will be produced commercially.

Domestic Production.—Yttrium was recovered from monazite as a byproduct of thorium and the rare-earth metals and as a coproduct of the heavy rare-earth metals recovered from concentrates of gadolinite, yttrofluorite, euxenite, and similar minerals. Monazite concentrate was produced in Florida and Idaho and imported from the

---

[43] Wright, D. A., Bismuth Telluride and Related Compounds: Research—Applied in Industry, vol. 12, No. 819, August-September 1959, pp. 300–306.

[44] Missiles and Rockets, Prospects for Thermoelectricity: Vol. 5, No. 26, June 22, 1959, pp. 29–31.

[45] Prepared by Donald E. Eilertsen.

[46] Prepared by Charles T. Baroch.

Union of South Africa. Euxenite concentrate was produced by Porter Bros. Corp., Lowman and Boise, Idaho. Ores of gadolinite and yttrofluorite were produced in Colorado.

The principal firms reporting processing of rare-earth mineral concentrates and recovery of yttrium compounds were Lindsay Chemical Division of American Potash and Chemical Corp., West Chicago, Ill.; Lunex Co., Pleasant Valley, Iowa; Michigan Chemical Corp., St. Louis, Mich.; Research Chemicals Division, Nuclear Corp. of America, Burbank, Calif.; St. Eloi Corp., Cincinnati, Ohio; and Vitro Chemical Co., Chattanooga, Tenn.

Mallinckrodt Chemical Works, St. Louis, Mo., processed euxenite concentrate from Idaho to recover columbium, tantalum, and uranium for Porter Bros. Corp.; the residues containing thorium, yttrium, and rare-earth elements were delivered to the General Services Administration stockpile.

Commercial producers of the metal included Crane Co., Chicago, Ill.; Lunex Co.; Lindsay Chemical Division, Michigan Chemical Co.; and Research Chemicals, Inc. Laboratories producing yttrium metal for experimental use included the Ames Laboratory of the Atomic Energy Commission (AEC), Ames, Iowa; the Bureau of Mines laboratories at Albany, Oreg., and Reno, Nev.; and the Oak Ridge National Laboratory, (AEC), Oak Ridge, Tenn.

Uses.—Yttrium was used in electronics, nucleonics, metallurgy, ceramics, and the chemical industry.

Polycrystalline yttrium-iron-garnet components, having the composition of $Y_3Fe_5O_{12}$ and called YIG by the electronics trade, were used extensively in microwave devices, particularly frequency doublers, mixers, limiters, and certain types of amplifiers and modulators. When a YIG is placed in a magnetic field, the amount and direction of transparency to microwaves can be varied. Other rare-earth metals have been used for the same purpose, but the YIG component is more easily reproduced to exact specifications.

Yttrium has the relatively low thermal-neutron cross section of 1.3 barns, which makes it a desirable material for use in nuclear reactors. Other desirable properties are the relatively high melting point of the metal (1,552° C.) and its strength and low density (4.47 grams per cubic centimeter). Its light weight would make it applicable to airplane nuclear reactors.

Yttrium shows much promise as an alloying component. It forms eutectic mixtures with aluminum, iron, and copper; dissolves slightly in chromium, titanium, and zirconium; and is practically immiscible with columbium, tantalum, vanadium and molybdenum. Up to 1 percent yttrium added to stainless steel is believed to improve workability and weldability and increases oxidation resistance from 2,000° F. to 2,500° F. Yttrium was also found to be more effective than aluminum in improving the oxidation resistance of iron-chromium base alloys.

Bureau of Mines research at Albany, Oreg., and work by the General Electric Co. indicated that yttrium metal, long considered to be too brittle for structural use, becomes ductile and pliable in high-purity form. Much of the brittleness is caused by oxygen in the metal. Yttrium containing only about 0.02 percent oxygen was cold-rolled to foil, whereas small ingots were reduced as much as 95 percent in thickness without annealing.

The relatively high melting point of yttrium oxide, 2,410° C., is attractive to ceramists, and experimental quantities were used in high-speed aircraft and missiles.

Prices.—Prices of yttrium ores depended on the yttrium content, amenability to concentration or treatment, type of mineral, and quantity involved. Ores in large lots with 2 percent or more Y_2O_3 were valued from $0.50 to $1 per pound of contained Y_2O_3.[47]

Lindsay Chemical Division prices of yttrium metal and oxide were published[48] as follows: Yttrium metal 99.9 percent pure, 81 cents per gram in 10- to 99-gram lots and 54 cents per gram in 100- to 450-gram lots; yttrium oxide, 99.9 percent pure in similar quantities was 35 and 25 cents per gram, respectively; a 99.99-percent-pure yttria was offered at an increment of 5 cents per pound, and larger quantities were $70 and $80 per pound for 99.9- and 99.99-percent purity, respectively.

Technology.—Research Chemicals, Inc., Burbank, Calif., reported on yttrium studies conducted under contract with the U.S. Air Force.[49] Improved methods for producing pure metals, a complete metallographic procedure, and chemical and spectrographic analytical procedures were described, also data on many yttrium and rare-earth metal alloys with titanium and beryllium were listed.

Yttrium and the rare-earth metals are recovered by dissolution of the concentrates, usually as the chloride. The elements are separated by absorbing them on a column filled with an ion-exchange resin and eluting a complexing solution slowly through a long series of the ion-exchange columns. The process was developed at the Ames Laboratory of the AEC at Ames, Iowa. The separation plant of the Lindsay Chemical Division utilizes over 100 ion-exchange columns, the larger units being 18 to 60 inches in diameter and 10 to 20 feet high. The history and technical features of the plant of Michigan Chemical Corp. were described.[50]

Information on the properties, fabrication, and potential uses of yttrium and its alloys was presented in five reports at the annual meeting of the American Society for Metals in Chicago.[51]

The production of YIG single crystals was described at the annual meeting of the Ceramic Society,[52] and their properties were described in many other papers.[53]

---

[47] Whitman, Judson H., The Occurrence, Mining, and Marketing of the Yttrium Rare Earths: Presented at the San Francisco meeting of the AIME, Feb. 15–19, 1958.

[48] E&MJ Metal and Mineral Markets, vol. 30, No. 52, Dec. 24, 1959, p. 4 and vol. 30, No. 53, 1954, p. 4.

[49] Love, Bernard, Selection and Evaluation of Rare or Unusual Metals. Part II, The Metallurgy of Yttrium and the Rare-Earth Metals: Wright Air Development Center, WADC Technical Report 57–666, Part II; available from Office of Technical Services, Washington 25, D.C., March 1959, 167 pp.

[50] Chemical and Engineering News, AEC Cries for Yttrium: Vol. 37, No. 27, July 6, 1959, pp. 42–44.

[51] Chemical and Engineering News, GE Pushes Yttrium: Vol. 37, No. 46, Nov. 16, 1959, pp. 42 and 44.

[52] Rudness, R. G., and Kebler, R. W., Growth of Single Crystals of Incongruently Melting Yttrium Iron Garnet by Flame Fusion Process: Jour. Am. Ceram. Soc., vol. 43, No. 1, January 1960, pp. 117–120.

[53] Ramsey, T. H., Jr., Summary of Some Properties of Yttrium Iron Garnet: Jour. Am. Ceram. Soc., vol. 42, No. 12, December 1959, pp. 645–646.

Calhoun, B. A., Magnetic Annealing of Yttrium Iron Garnet: Jour. Appl. Phys., vol. 30, No. 4 (sup.), 1959, pp. 293–294S.

Anderson, Elmer E., Some Electrical and Magnetic Properties of Garnets: Jour. Appl. Phys., vol. 30, No. 4 (supp.), 1959, pp. 299–300S.

Three papers in the Soviet scientific press indicated a lively interest in yttrium in the U.S.S.R. One paper stated that yttrium showed high promise as an alloying component and that 0.1 to 0.2 percent yttrium reduced the grain size and improved the strength of many alloys.[54] Another study disclosed that aluminum alloys were considerably strengthened by alloying with yttrium.[55] A method of producing yttrium by reduction of yttrium fluoride with calcium and further purification by remelting in a vacuum was described.[56]

---

[54] Savitskiy, Ye. M., and Terekhova, V. F. [Yttrium and its Alloys]: Tsvetnyye Metally, vol. 32, No. 1, January 1959, pp. 48–53.

[55] Savitskiy, Ye. M., Terekhova, V. F., and Tsikalov, V. A., [Constitutional Diagram of Alloys of Aluminum with Yttrium]: Zhurnal Neorganicheskoy Khimii, vol. 4, No. 6, June 1959, pp. 1461–1462.

[56] Izhvanov, L. A., and Vershinin, N. P. [The Production of Yttrium Metal]: Tsvetnyye Metally, vol. 32, No. 1, January 1959, pp. 44–47.

Minor Nonmetals

By Albert E. Schreck[1] and James M. Foley[2]

⁂

THIS CHAPTER concerns such minor nonmetals as greensand, meerschaum, mineral wool, staurolite, and wollastonite.

GREENSAND

Output of greensand (glauconite) was slightly higher than in 1958. Open pits of The Kaylorite Corp. (Calvert County, Md.), National Soil Conservation, Inc. (Burlington County, N.J.), and Inversand Co. (Gloucester County, N.J.) accounted for the entire production.

Soil conditioning used about 72 percent of the greensand sold. The remainder was used as a water-softening agent.

Prices for greensand, f.o.b. mine, ranged from $13 to $70 per short ton.

MEERSCHAUM

Domestic requirements for meerschaum, for use in manufacturing smokers' articles such as pipe bowls and cigar and cigarette holders, were met by imports in 1959. These imports were some 10,000 pounds less than in 1958. Turkey again was the principal supplier.

For more than a century Turkey has been the world's major source of meerschaum. Production during the past 35 years has ranged from a high of 92,950 pounds in 1956 to a low of 2,200 pounds in 1957. Although meerschaum production in Kenya and Tanganyika in 1957 exceeded that of Turkey, 1958 witnessed Turkey's return to the number one position. In 1958 Turkey produced 80,850 pounds (735 boxes of 110 pounds each), Kenya 68,880 pounds, and Tanganyika 11,021 pounds. Production in 1959 was Turkey 47,069 pounds, Kenya 42,560 pounds, and Tanganyika 31,046 pounds.

Electron diffraction diagrams and X-ray powder data for samples of sepiolite (meerschaum) from Utah, Spain, Kenya, and Turkey were published.[3]

---

[1] Commodity specialist.

[2] Supervisory statistical assistant.

[3] Brindley, G. W., X-ray and Electron Diffraction Data for Sepiolite: Am. Miner., vol. 44, Nos. 5 and 6, May–June 1959, pp. 495–500.

TABLE 1.—Meerschaum imported for consumption in the United States[1]

[Bureau of the Census]

Year	Pounds	Value	Year	Pounds	Value
1950-54 (average)	10,405	$16,647	1957	10,538	$20,046
1955	5,102	15,285	1958	17,392	15,432
1956	13,140	[2] 21,770	1959	7,323	16,333

[1] 1950-54: Turkey, 10,318 pounds, $16,477; Union of South Africa, 80 pounds, $138; Italy, 4 pounds, $24; Austria, 3 pounds, $8; 1955-56: All from Turkey; 1957: Turkey, 10,426 pounds, $19,649; Union of South Africa, 112 pounds, $397; 1958: All from Turkey; 1959: Turkey, 6,304 pounds, $15,862; France, 1,019 pounds, $471.

[2] Data known to be not comparable with other years.

TABLE 2.—Meerschaum production and shipments in Turkey,[1] in boxes[2]

[Compiled by Helen L. Hunt]

Year	Production	Shipments	Year	Production	Shipments
1925	----------	----------	1942	331	369
1926	323	323	1943	174	170
1927	312	312	1944	164	238
1928	41	41	1945	817	509
1929	441	441	1946	625	354
1930	380	380	1947	208	200
1931	935	935	1948	387	248
1932	107	107	1949	236	245
1933	241	241	1950	265	306
1934	235	235	1951	330	201
1935	694	694	1952	576	452
1936	622	622	1953	537	499
1937	592	592	1954	776	903
1938	883	883	1955	1,054	853
1939	317	317	1956	845	468
1940	255	412	1957	20	10
1941	305	238	1958	735	583

[1] Mandenlerimizin Faaliyetleri, Ankara, Turkey, 1953-54, pp. 122-133, and 1956-57, pp. 3, 45.

[2] Boxes of approximately 40 kg. each (88 pounds) through 1955; thereafter, 50 kg. each (110 pounds).

MINERAL WOOL

Shipments of mineral wool produced from rock, slag, and glass in the United States in 1958 were valued at $235 million, according to a preliminary report of the Bureau of the Census. This was an increase of 12 percent over 1957. Structural insulation accounted for $70.3 million of the sales, industrial and equipment insulation, $142 million; other mineral-wool insulating products, $18 million; and unspecified, $4.3 million.

A total of 11,936 persons was employed in the mineral-wool industry in 1958, of whom 9,075 were production workers.

Several patents were issued on apparatus for manufacturing mineral-wool fibers.[4]

---

[4] Ebbinghouse, J. A. (assigned to American Rock Wool Corp.), Fiberizing Steam Ring: U.S. Patent 2,869,175, Jan. 20, 1959.

Downey, R. M. (assigned to Midwest Insulations, Inc.; Industrial Products Co., Inc.; The Carney Co., Inc.; and Airseal Insulations, Inc.), Apparatus for Forming Mineral Fibers and the Like: U.S. Patent 2,882,552, April 21, 1959.

Powell, E. R. (assigned to Johns-Manville Corp.), Method and Apparatus for Producing Fibers: U.S. Patent 2,884,659, May 5, 1959.

Firnhaber, M. S. (assigned to Sealtite Insulation Mfg. Corp.), Apparatus for Manufacturing Mineral Wool and the Like: U.S. Patent 2,896,256, July 28, 1959.

Barnett, I. (assigned to Johns-Manville Corp.), Method and Apparatus for Opening and Cleaning Fibers: U.S. Patent 2,897,548, Aug. 4, 1959.

STAUROLITE

Production and value of staurolite continued to increase in 1959. Staurolite was recovered as a byproduct of concentrating titanium minerals (ilmenite and rutile) by E. I. du Pont de Nemours and Co., Inc., who operated the Highland and Trail Ridge plants in Clay County, Fla. Staurolite was marketed as an iron and aluminum additive in portland cement manufacture.

WOLLASTONITE

Output of wollastonite in 1959 increased about 42 percent over 1958. The Cabot Carbon Co., from its Fox Knoll mine, Essex County, N.Y., accounted for most of the production. Several smaller firms in Riverside County, Calif., contributed the remainder.

The largest part of the wollastonite was used in ceramics, such as wall and floor tile, porcelain fixtures, and electrical insulators; as a filler in asphalt tile and plastics; and as a paint extender. California production was used both as an experimental raw material in manufacturing mineral wool and, because some wollastonite resembles driftwood owing to weathering, as an interior and exterior ornamental stone.

Oil, Paint & Drug Reporter quoted the following prices on wollastonite: Fine, bags, carlots, works, $39.50 per ton; less than carlots, ex warehouse, $56 per ton; medium, bags, carlots, works, $27 per ton; and less than carlots, ex warehouse, $44 per ton.

A wollastonite deposit in the Sudan, from which about 40 tons was shipped, was described in an article.[5] The occurrence near Dirbat Well, Khor Haiet, northeastern Red Sea Hills, is about 71 miles from Port Sudan on the Red Sea. An estimated reserve of more than 300,000 tons is contained in the area.

---

[5] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 2, February 1960, pp. 23–25.

INDEX

By Kathleen J. D'Amico

⁂

The index consists of three parts: A commodity index, a company index, and a world-review index.

Because nearly all commodity chapters in Minerals Yearbook, volume I, follow a standard outline (Introductory Summary, Domestic Production, Consumption and Uses, Stocks, Prices (and specifications), Foreign Trade, World Review, World Reserves, and Technology), references to such data have been omitted under the various headings.

Readers seeking information on mine production for States, Territories, or possessions should refer to tables in the Statistical Summary chapter, starting on page 77. These tables show the commodities produced in each area, thus guiding the reader to the appropriate commodity chapters. The reader should refer to volume III, however, for complete area information.

Commodity Index

Company Index

World Review Index

U.S. GOVERNMENT PRINTING OFFICE: 1960