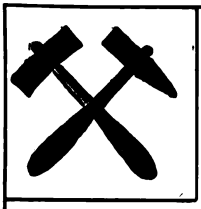
THE MINERAL INDUSTRY

ITS

STATISTICS, TECHNOLOGY & TRADE

1903



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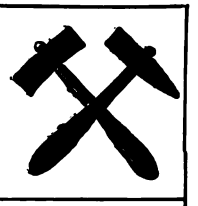

The MINERAL INDUSTRY

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IN THE UNITED STATES AND OTHER COUNTRIES

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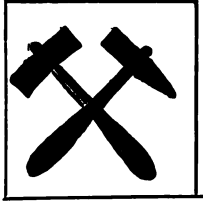

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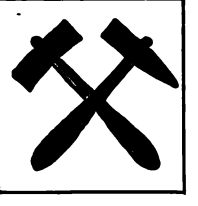

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UNITED STATES AND OTHER COUNTRIES

TO THE END OF

1902

FOUNDED BY THE LATE

RICHARD P. ROTHWELL

EDITED BY

JOSEPH STRUTHERS, PH.D

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1905

GEMS AND PRECIOUS STONES.

By Joseph Struthers and Henry Fisher.

The value of the precious stones produced in the United States in 1902 was $318,300, as compared with $289,050 in 1901. Of the total, the value of the sapphires and turquoises produced aggregated $245,000. In 1902, the imports were as follows: uncut diamonds, $8,230,735; cut diamonds, $13,852,949; other uncut precious stones, $52,025, and other cut precious stones, including natural pearls, $4,641,339; a total of $26,777,048.

The following table gives the value of the production of precious stones in the United States, according to Mr. George F. Kunz:—

Variety.	1901.	1902.	Variety.	1901.	1902.
Agate	$1,000	$1,000	Peridot	$500	$500
Agate (moss)	500	500	Pyrite	3,000	3,000
Amazon stone	200	500	Quartz, crystal	10,000	12,000
Amethyst	500	2,000	Quartz, gold	2,000	3,000
Anthracite ornaments	2,000	2,000	Quartz, rose	150	200
Arrow points	500	.....	Quartz, rutilated	50	100
Beryl (aquamarine, etc.)	5,000	4,000	Quartz, smoky	1,000	2,000
Catlinite (pipestone)	2,000	2,000	Quartz, tourmalinated	1,000	.....
Chlorastrolite	3,000	4,000	Rhodolite	21,000	1,500
Chrysoprase	1,500	10,000	Ruby	500	.....
Diamond	100	.....	Sapphire	90,000	115,000
Emerald	1,000	1,000	Silicified wood	7,000	7,000
Fossil coral	100	.....	Tourmaline	15,000	15,000
Garnet (almandite)	100	.....	Turquoise	118,000	130,000
Garnet (pyrope)	1,000	1,000	Utahlite (variscite)	250	.....
Malachite	100	.....			
Mesolite (thomsonite)	1,000	1,000	Total	$289,050	$318,300

Diamonds.—*United States.*[1]—There were no diamonds found during 1902, as compared with an output valued at $100 in 1901. There was, however, a diamond discovered in a meteorite from Cañon Diablo, at the foot of Crater Mountain, Ariz. The stone is of irregular shape and so hard that when attempts were made to cleave and to polish it, two chisels were broken and an emery wheel ruined.

South Africa.—The report of the De Beers Consolidated Mines, Ltd., for the fiscal year ending June 30, 1902, shows that the value of the diamonds sold amounted to £4,687,194. After deducting expenditures of £2,524,485, the profit balance for the year was £2,162,709. The balance brought forward from the previous year amounted to £1,277,342, which, added to the profit balance, together with interest and revenue from various sources, increased the balance to

[1] The diamond deposits in the United States were fully described by William H. Robbs in The Mineral Industry, Vol. IX., pp. 301-304.

£3,560,280. From this amount dividends and bonuses amounting to £2,445,000, and life governors' remuneration of £316,594 were paid, leaving a balance of £798,696 to be carried forward. The output of blue ground was 4,347,641 loads, equal to 3,478,113 short tons; 3,734,241 loads were washed, yielding 2,025,224 carats of diamonds. There were also 1,151,816 loads of tailings treated, yielding 202,830 carats of diamonds, and 18,728 carats of diamonds were recovered from old concentrates. The average yield per load of blue ground and lumps from the De Beers and Kimberley mines for the fiscal year was 0·76 carat, at an average value of 46s. 5·7d. per carat. The average yield per load for the Premier mine at Wesselton was 0·3 carat valued at 33s. 5·9d. per carat. The average yield from the Bultfontein mine was 0·21 carat, valued at 30s. 4·7d. per carat. At the Dutoitspan mine 4,916 loads of débris were washed producing 218 carats of diamonds. A diamond weighing 67·5 carats was found in the Premier mine, but on account of its irregular shape will be cut down to about 30 carats. Its value is estimated to be $15,000. The stock of blue ground and lumps on the floors of the De Beers and Kimberley mines at the end of the fiscal year was 2,630,040 loads; at the Premier mine, 1,573,914 loads, and at Bultfontein mine, 480,934 loads. Operations at the mines were hindered by the war and the resultant difficulty of getting labor, coal and supplies. The report of the Kamfersdam Mines, Ltd., for the year ending June 30, 1902, states that 517,899 loads of blue and yellow ground were hauled and washed, yielding 51,857 carats of diamonds. The diamonds sold realized £40,513, and the stock on hand was valued at £23,745. The total income was £64,741, and expenditures £58,365, leaving a balance of £6,376, which, with the balance brought forward from the previous fiscal year, makes the present balance on hand £17,448. The Orange Free State & Transvaal Diamond Mines, Ltd., report for the four years ending Dec. 31, 1902, an expenditure of £17,699, and an income of £1,151. At the end of 1902 there was on hand cash amounting to £11,320 and diamonds valued at £45,165, also a large quantity of blue ground ready for washing. The Lace Diamond Mining Co., Ltd., reports that between May 12 and Dec. 31, 1902, 142,060 loads of material were washed, and 16,562 carats of diamonds, valued at £21,412 obtained. The cost of recovering the diamonds was £19,913, leaving a profit of £1,499. The profit and loss account at the end of the year showed a balance of £13,661. The output of diamonds for the second half of 1902 from Christiana, as reported by the Transvaal Mines Department, was 759·25 carats, valued at £1,983. A new plant for the treatment of diamondiferous earth is being erected in the Pretoria district. It is estimated that it will treat 200 loads per day. The diamonds sell for 30s. per carat. Cape Colony in 1901 produced 2,747·2 carats diamonds, valued at £5,259, as compared with 1,803 carats, valued at £3,212 in 1900. The exports in 1902 were valued at £5,427,360, as compared with £4,930,104 in 1901. Diamonds have been found on a farm 24 miles from Griquatown. A reef of blue whitestone rock has been discovered, and two shafts have been sunk. By washing one lot of 20 loads, 40 diamonds have been obtained, and 120 diamonds were obtained from another lot of 50 loads. It is also reported that diamonds have been found at Sydney on the Vaal River.

The phenomena of the diamondiferous deposits have been discussed by

E. F. Heneage in a paper read before the Institution of Mining and Metallurgy, Nov. 20, 1902.

An article on diamond mining at Kimberley appeared in *The Engineer,* Jan. 16, 1903, p. 59, and Jan. 30, 1903, p. 115.

These deposits are also described by G. F. Williams in his valuable book on *The Diamond Mines of South Africa,* The Macmillan Co., 1902.

Australasia.—The output of diamonds in New South Wales in 1902 is estimated at 11,995 carats, valued at £11,326, as compared with 9,322 carats, valued at £9,756 in 1901. The diamonds were chiefly obtained from the Boggy Camp in the Copeton district, the mines in operation being the Star of the South, Malacca, and Elliott's mine. Diamonds were also found by prospectors while searching for stream tin. In October, 1902, the Monte Cristo mine, in the Bingara division, resumed operations after a long period of idleness. The Inverell Diamond Field Co., Ltd., operating on an alluvial deposit which yields per load 1·25 carats of diamonds, valued at 28s., and tin worth 8 to 9s., is in financial trouble, and the future policy of the company is still unsettled. The Soldier's Hill Diamond & Tin Mining Co., having exhausted its mine, has removed the plant to a prospecting area at Staggy Creek. During 1901, a few diamonds were found in an alluvial deposit near the Abercrombie River in the Cowra district, of which some were reported to be of a high value. The Australia Diamond Mining Proprietary Co. was engaged in removing its plant, and did no mining during 1901.

Brazil.—The Brazilian Diamond & Exploration Co., Ltd., capitalized at £225,000, obtained in September, 1902, the privilege of operating for a period of 90 years in the Republic of Brazil. Two-thirds of its capital must be raised within two years from the date of the privilege.

According to H. W. Furniss, the State divides the diamond region into 14 districts: Lençoes, Andarahy, Chique Chique, Santa Isabel, Cravada, Lavrinha, Campestre, Morro do Chapero, Bom Jesus, S. Ignacio, Chapada Velha, Paraguaçu, Sincorá and Cannavieiras, each region taking the name of the town near its center. Geologically there are but two sections, one in the central portion of the State along the Paraguaçu River, and the other in the southern part along the Pardo River. The Paraguaçu region is about 172 miles long and from 3 to 16 miles wide, the most productive area being in the foothills to the southeast of Serra das Lavras Diamantinas. The original rock is granite, frequently broken by gullies and crevasses. Sandstone and a conglomerate composed of round water-washed pebbles and a very hard matrix occur with the granite, and in these diamonds are found. The diamond-bearing material is called "cascalho." One method of mining is by removing the surface disintegration, or mining by tunnels between the boulders into the pockets in the deposit and taking out the cascalho. The cascalho is collected for a week, when it is washed, either by pouring it into ditches of running water and agitating it with a hoe, or by washing small quantities in large wooden basins. In the former case, arrangements are made to catch the heavy mass containing the diamonds, which is then washed in large wooden basins, the rock being hand picked. Another method of mining, carried on mostly on the Paraguaçu River, consists in diving to the bottom of the river and removing the silt till the underlying layer of clay

or stone is reached. This latter method of obtaining the stones is centered near the village of Tamandoá, where six diving machines are located. Two men are employed to a machine, diving alternately. Each man remains below the water three hours and loads the cascalho into sacks. Diving without the use of the machine is also done.

The State owns all the diamond-bearing fields, and leases them from one to ten years to the highest bidder. A claim consists of not less than 29,040 sq. m., nor more than 484,000 sq. m. All diamonds exported are subjected to a tax of 13%. The output averages about 2,500 carats of diamonds a month. Stones of more than 0·75 carat are bought at $24 per carat, between 0·5 and 0·75 carat at $7·20 per carat, and less than 0·5 carat at about $2·75 per carat. In 1901, a stone weighing 577 carats was found and was sold by the miner for $17,380. The stones are classified as: *bons, fazenda fina, mellé, vitriar,* and *fundos. Bons* comprise stones of good color and form; *fazenda fina,* small stones of good quality and various colors; *mellé,* off-colored and imperfect stones; *vitriar,* small stones of good shape and luster, but of various colors, and *fundos,* small, imperfect, and badly colored or broken stones. The diamonds found in the Cannavieiras district are clearer and more perfect than those in the Paraguaçu district. In this district, State concessions of about 9 sq. miles have been granted, three to native Brazilians and one to a French company. There are several cutting factories in the diamond regions and one in the City of Bahia. The diamonds are exported to London and Paris.

British Guiana.—The output of diamonds in 1902 was 173,744 stones weighing 11,518·5 carats. The output in 1901 was valued at $56,050. In 1902 there were exported 12,565 carats, valued at $124,464, as compared with 4,406 carats, valued at $56,057 in 1901. The output is from three districts: in the north on the Barima River, between Jumbo and Five Star creeks and 60 miles southeast at Jauna on the Barima River; in the valley of the Mazaruni and Putareng rivers, and south of Georgetown in the Omai district on the Potaro, a tributary of the Essequibo River. The diamonds are found in a siliceous clay formation. No deep mines have been found, and as yet prospectors have confined their operations to the surface. New discoveries have been made on the Essequibo River, on the Konawaruk Creek, a tributary of the Essequibo, and on the Cuyuni River, but the Massaruni and Potaro are the only fields regularly worked. The question of transportation is still a difficult one, and it was suggested that a tramway be built to extend the Bartica-Caburi road to the diamond fields. The Massaruni Diamond Mines, Ltd., has been capitalized in London at £10,000, in £1 shares, to acquire 45 claims owned by the Lucky Jim Syndicate in the Massaruni district. The Massaruni Co., Ltd., is operating new machinery. The Massaruni British Guiana Diamond Syndicate in the early part of 1903 produced 60 carats of diamonds per week. Other companies operating in the Massaruni district are the Demarara Diamond Co., the Maharba Syndicate, and the Hatton Garden Syndicate. Work, however, has been retarded by litigation in connection with the location of some of the claims.

Dutch East Indies.—The estimated output of diamonds from Western Borneo was 1,972 carats in 1899, and 1,950 carats in 1898.

India.—Very little is being done in the diamond industry in India. Workings are still carried on by the Madras Diamond Co. at Vajrakarur, but this company made no output during 1902, nor did the Bundelkhand alluvial mines of Central India produce any diamonds.

Dr. Albert Ludwig[2] showed that diamonds could be obtained by subjecting carbon to strong gaseous pressure (pressures to 3,100 atmospheres being used) at a low temperature in the presence of iron, or at the melting point of carbon without using such a contact agent. For the purpose, he imbedded an iron spiral in powdered retort carbon and raised it to a red heat in an atmosphere of hydrogen by means of the electric current.

M. Chaumet[3] has discovered that a close relationship exists between the fluorescent property and the brilliancy of diamonds under artificial light, especially candle light, which brings out the quality of the stone. Diamonds which are non-fluorescent when exposed to violet light, become violet themselves, the brilliant stones showing a fluorescence of a very luminous and clear blue.

Technology.—A patent has been granted to F. E. Hilliard[4] for a machine for grinding and polishing gems, which consists of a standard, adjustable both vertically and horizontally, which carries a screwed shaft-support capable of being revolved about the standard and fixed in any position and at any desired angle. Adjustment pins on the side regulate a pointer on a scale or small dial at the top of the machine, showing the exact inclination at which the stone is held by the shaft. It is claimed that it is possible so to adjust the position of a stone that a series of facets, four, eight or more, may be cut on a piece of gem material at any given angle, and each angle and facet be mathematically symmetrical.

EMERALDS.—There was no change in the value of emeralds produced in the United States during 1902, the outputs in 1901 and 1902 being valued at $1,000 each. The Colombian Government during 1901 offered for sale or lease the emerald mines of Muzo and Coscuez. These mines have been worked continuously for more than three centuries. The annual output is not reported by the companies working the mines. The Somondoco Emerald, Ltd., owning mines in Columbia, in its report for the year ending June 30, 1902, states that its operations were hindered by the revolution. Its expenditures during the year amounted to £2,436, and the emeralds on hand were valued at £500. Emeralds are also mined near Minne, Norway, although no statistics of production are obtainable.

OPALS.—The production of opals in New South Wales in 1902 was valued at £140,000, as compared with £120,000 in 1901. About 1,100 miners were employed during 1902. Operations were carried on with extreme difficulty on account of the severe drought, which lasted until the month of November. Several fine specimens were found at White Cliff during 1902; one specimen weighed 17 oz., and another weighing 13 lb. was a solid mass of gems. One part of this specimen, estimated to weigh 22 oz. is brilliant, and after being polished, will be the finest opal extant. There was only a slight decrease in the value of the opals produced in Queensland in 1902, although the conditions

[2] *Chemical News*, LXXXVII., Jan. 1, 1903. [3] *Comptes rendus*, 134, (20), pp. 1139-1140.
[4] United States Patent No. 701,879, June 10, 1902.

under which mining was carried on were unfavorable. The output of opals in 1902 was valued at £7,000 as compared with £7,400 in 1901. Owing to the lack of rain, 200 men were employed in 1902, as compared with 293 in 1901, and no attempts were made to prospect new country. The output was obtained from the districts of Yowah, Eromanga, Jundah, Opalton, Duck and Horse Creeks. Two new discoveries were reported in the Eromanga district; one called Brown's Last Chance is located about 7 miles south of the Mascotte mine, and the other, the Federal mine, 4 miles northwest of the Exhibition mine. The first parcel of opals from the Federal mine realized £150. Transactions between producers and buyers are now almost entirely carried on by mail, as the expense and loss of time experienced by the buyers were too great. This, however, also has its disadvantages, as the New South Wales opal, as mined, is 90% matrix, which greatly adds to the expense of postage. Although milky white, resinous, bluish and brown jasperoid varieties of the common opal are found at Bothwell, on the Clyde River, Tasmania, no specimens of precious opal have as yet been found. The common opal occurs also in the Gelantipy district, Victoria. An opal mine at Niagara, Western Australia, was sold to an English company for £3,500. A parcel of 119 tons was treated and yielded 83 oz. 12 dwt. of gems. As there has been a large output of Australian opals in 1902, and as the cutting and polishing costs but 12s. per gross in Germany, the price of the crude stone has fallen considerably.

RUBY.—In 1901, the production of rubies in India was 210,784 carats, valued at $384,417, as compared with 214,856 carats (value not stated) in 1900. Rubies are produced only in Upper Burma, the mines being at Mogok, where in 1901 the Burma Ruby Mining Co., Ltd., employed 1,237 persons and produced 210,784 carats of rubies ($384,417), 9,786 carats of sapphires, and 10,241 carats of spinel. The dirt is raised to the surface by endless rope from open quarries excavated to a depth of 50 ft. It is crushed in rotary pans and separated by pulsators and hand picking. The power is supplied either directly from Pelton wheels or by electricity generated at a distance of two miles from the mines. A number of workings are operated by natives who pay royalty to the Burma company, the royalty in 1901 amounting to $81,500.

M. Chaumet[8] states that Siamese rubies under the action of violet light scarcely fluoresce, while all Burmese rubies fluoresce intensely and exhibit a clear, vivid red light; by this means stones from the two districts can be distinguished.

SAPPHIRES.—In 1902, the output of the New Sapphire Mines Syndicate, operating the Yogo mines in Fergus County, Mont., was about 200,000 carats of sapphires. The sapphires occur in a dike of trap-rock in white and grey limestone. The dike extends over a distance of five miles. Occasionally stones as large as 5 carats have been found. The stones are obtained by means of sluice boxes fitted with Hungarian riffles, the boxes being given a slight pitch in order to prevent the stones from being carried over the riffles. During the winter of 1902, 15 men were employed at the New Syndicate mines, and extensive development work was done on the property, including the opening up of the

[8] *Comptes rendus*, 134, (20), pp. 1139-1140.

lead and the erection of a new hoist. The largest stone found by this company weighed 9 carats. The stones are sent to New York and London to be cut. The American Gem Mining Co. produced about 50,000 carats of sapphires in 1902, which were cut by lapidaries in Helena, Mont. The Northwest Sapphire Co., of Butte, Mont., is mining sapphires on the Dry Cottonwood placers in Deer Lodge County, Mont., by means of a hydraulic. Stones of various colors are found in the gravel. It is reported that sapphires have been found near Culling's Well, Ariz.

In 1901, the Burma Ruby Mining Co., Ltd., India, produced 9,786 carats of sapphires ($3,768), as compared with 7,239 carats in 1900.

The production of sapphires in Queensland in 1902 was valued at £5,000, as compared with £6,000 in 1901. During 1902, the drought in the Anakie fields retarded the industry, which was further hindered by the low prices obtained for the sapphires. The surface workings are being exhausted, and the deeper deposits will soon have to be worked.

According to B. Dunstan the sapphires from Anakie, Queensland, have certain peculiarities in color, being either parti-colored or of a very deep and non-uniform blue, which by artificial light appears almost black, a characteristic which distinguishes them from sapphires found in other parts of the world. The bright green and yellow shades which are also found in this field have no optical peculiarities. The sapphire fields comprise Retreat, Sheep Station, Policeman, Tomahawk and Central Creeks. In some cases the wash is clayey and requires puddling before the sapphires can be extracted, in other cases it is loose and friable and free from clay, and the sapphires can be obtained by "dry sieving." In these deposits other precious stones are found also, notably ruby, topaz, peridot, chrysoberyl, amethyst, moonstone, cat's eye, cairngorm, diamond and tourmaline.

TURQUOISE.—Turquoises are obtained from more than ten localities in Alabama, California, Colorado, Nevada, New Mexico and Arizona. The most extensive deposits exist in New Mexico; valuable mines occurring in the Burro Mountains near Silver City, and about the Hachitas and Jarillas Mountains as far south as Lascruces. There are six companies operating the mines: The American Turquoise Co., the Azure Mining Co., the American Turquoise & Copper Co., the Toltec Mining Co., the Himalaya Mining Co., and the Silver City Turquoise Co. The formation in which the turquoise is found varies greatly. Near Santa Fé, the matrix is usually a white trachyte stone filled with crystals of pyrite, the matrix in some cases being red sandstone. In the Burro Mountains, the formation is red quartz, slender needles of which penetrate the turquoise deposit. In the Hatchitas Mountains, the matrix is a red granite. The turquoise is mined by sinking a shaft, blasting the rock, breaking it into shape by means of sledge hammers, putting the pieces into buckets, hoisting them to the surface by windlass, sorting the pieces, packing them into boxes and shipping to the cutters. Most of the material is shipped to New York.

In Western Australia, turquoise has been found by a copper company while developing its property in the Murchison district. The stone occurs in pockets in a highly ferruginous sandstone near copper and gold veins, and some blocks have been found weighing 100 lb.

In Egypt, a turquoise deposit is being worked by the Egyptian Development Syndicate in the Sinai Peninsula. The stone usually occurs as a lining to cavities and fissures in sandstone, and it varies both in color and hardness. Small specimens have also been found near Eridia. Turquoise veins are found 40 miles from Nishapur in Khorassan, Persia. The annual rental charged by the Government for the lease of the mines amounts to £4,800, and the value of the gems produced considerably exceeds this sum.

OTHER GEMS.—During the 15 years ending December, 1902, California produced tourmaline valued at $20,500. The San Diego Tourmaline Mining Co., capitalized at $500,000, bought the Gail Lewis tourmaline mines at Mesa Grande, San Diego County, Cal. The company is also establishing a cutting and polishing plant at San Diego. The deposit of chrysoprase in Tulare County, Cal., is being developed, and a new deposit of this stone has been discovered near Sugar Loaf, Cal., and another deposit has been located at Buncombe County, N. C. An amethyst mine has been opened in South Carolina, and two new deposits have been found in Virginia.

GOLD AND SILVER.

By Joseph Struthers, D. H. Newland and Henry Fisher.

The production of gold in the world during 1902 was 14,414,186 fine oz., valued at $297,960,910, as compared with 12,606,183 fine oz., valued at $260,877,429 in 1901. This increase was due chiefly to the United States, Mexico, Rhodesia, Australasia, and the Transvaal.

During the year 1902 the United States was passed by Australasia, which now occupies the foremost position as a gold-producing country, followed by the United States, Transvaal and Russia, in the order named. These four countries produced in the aggregate about 75% of the total world's production of gold in 1902. The largest individual increase in gold output was in the Transvaal, amounting to 1,465,419 oz., valued at $30,310,211, due to the declaration of peace and the resumption of work in the mines. Should the production of gold in the Transvaal continue to increase at this rate, it will require but a year or two for it to attain the record output of the year 1898.

PRODUCTION OF GOLD IN THE UNITED STATES.

State or Territory.	1899.		1900.		1901.		1902.	
	Fine Ounces.	Value. (a)	Fine Ounces.	Value. (a)	Fine Ounces.	Value. (a)	Fine Ounces. (c)	Value. (a)
Alaska	247,944	$5,125,000	364,385	$7,531,835	333,096	$6,885,700	403,780	$8,345,099
Arizona	124,577	2,575,000	131,834	2,725,000	197,515	4,083,000	196,933	4,111,945
California	730,527	15,100,000	757,136	15,650,000	817,121	16,891,400	812,319	16,790,634
Colorado	1,292,471	26,508,675	1,391,486	28,762,036	1,339,673	27,693,500	1,377,175	28,466,207
Idaho	84,664	1,750,000	100,000	2,067,000	90,427	1,869,300	71,353	1,474,846
Montana	233,147	4,819,157	249,153	5,150,000	229,495	4,744,100	211,571	4,373,178
Nevada	107,644	2,225,000	97,910	2,023,803	143,374	2,963,800	140,059	2,895,020
New Mexico	24,190	500,000	36,284	750,000	33,302	688,400	25,693	531,074
Oregon	62,893	1,300,000	79,342	1,640,000	87,950	1,818,100	87,881	1,816,500
South Dakota	282,944	5,848,464	320,513	6,625,000	313,446	6,479,500	336,952	6,964,798
Southern States (b)	8,466	175,000	11,127	230,000	11,402	235,700	15,404	318,400
Utah	166,909	3,450,000	200,296	4,140,000	178,513	3,690,200	178,886	3,594,284
Washington	32,656	675,000	38,703	800,000	28,082	580,500	13,166	272,141
Other States	2,164	44,725	3,145	65,000	2,104	43,500	1,879	38,839
Total domestic	3,391,196	$70,096,021	3,781,310	$78,159,674	3,805,500	$78,666,700	3,870,000	$79,992,800
Foreign	1,423,449	29,422,691	1,948,519	40,275,888	1,730,856	35,776,794	1,689,991	34,932,211
Grand total	4,814,645	99,518,712	5,729,829	118,435,562	5,536,356	114,443,494	5,559,991	114,925,011
Total domestic—kg	105,471	.....	117,611	.....	118,363	.....	120,369	.....
Total foreign—kg	44,274	.....	60,605	.....	53,835	.....	52,564	.....
Grand total—kg	149,745	.....	178,216	.....	172,198	.....	172,933	.....

(a) 1 oz. gold = $20·67; 1 kg. = $664·60. (b) Virginia, South Carolina, North Carolina, Georgia, Alabama and Texas. (c) Estimate furnished by Mr. G. E. Roberts, Director of the United States Mint.

GOLD PRODUCTION OF THE WORLD.

Countries.	1900.			1901.			1902.		
	Fine Ounces.	Kilo-grams.	Value.	Fine Ounces.	Kilo-grams.	Value.	Fine Ounces.	Kilo-grams.	Value.
AMERICA, NORTH:									
United States.....	3,781,310	117,604·6	$78,159,674	*h*3,805,500	118,363·3	$78,666,700	*h*3,870,000	120,369·5	$79,992,800
Canada.....	1,350,176	41,992·4	27,908,153	1,183,465	36,807·4	24,462,222	1,008,447	31,210·4	20,741,245
Newfoundland.....	2,400	74·6	49,608	2,110	65·6	43,613	4,000	124·4	82,680
Mexico (*a*).....	455,204	14,158·3	9,409,063	499,725	15,554·2	10,329,816	546,373	16,994·0	11,293,524
Central America...	38,703	1,203·7	800,000	42,332	1,316·7	*e* 875,000	45,960	1,429·8	*e* 950,000
AMERICA, SOUTH:									
Argentina.....	2,112	65·7	43,655	2,112	65·7	43,655	2,900	90·2	*e* 60,000
Bolivia.....	7,257	225·7	*e* 150,000	7,257	225·7	*e* 150,000	7,257	225·7	*e* 150,000
Brazil.....	127,820	3,975·4	2,642,060	133,636	4,156·5	2,762,248	146,898	4,569·0	3,036,381
Chile.....	43,541	1,354·2	*e* 900,000	21,771	677·1	*e* 450,000	24,189	752·4	*e* 500,000
Colombia.....	111,272	3,460·7	*e* 2,300,000	100,145	3,114·7	*e* 2,070,000	101,597	3,159·8	*e* 2,100,000
Ecuador	9,676	300·9	200,000	12,700	394·9	*e* 262,500	13,304	413·8	*e* 275,000
Guiana (British)....	110,640	3,441·0	2,286,918	92,032	2,862·3	1,902,301	88,492	2,752·6	1,829,137
Guiana (Dutch).....	27,082	842·3	559,793	24,203	752·8	500,276	18,892	587·6	390,498
Guiana (French)....	68,353	2,126·0	1,412,857	101,340	*b* 3,152·0	*b* 2,094,698	115,744	*e*3,600·0	2,392,428
Peru	52,480	1,632·3	1,084,750	80,369	2,499·6	1,661,234	82,245	2,558·0	*e* 1,700,000
Uruguay.....	2,283	71·0	47,187	1,587	49·3	32,799	1,608	*e* 50·0	33,237
Venezuela.....	49,194	1,530·0	1,016,838	38,704	1,203·8	*e* 800,000	38,704	1,203·8	*e* 800,000
EUROPE:									
Austria.....	2,279	70·9	47,120	1,498	46·6	30,970	1,498	*e* 46·6	30,970
Hungary.....	105,143	3,270·1	2,173,308	105,931	3,294·8	2,189,724	105,931	*e*3,294·8	2,189,724
France.....	6,527	203·0	134,914	*Nil.*	.....	.....	*e Nil.*	.....	.....
Germany (*c*).....	3,601	112·0	74,435	2,894	90·0	59,814	2,894	*e* 90·0	59,814
Italy.....	1,849	57·5	38,215	132	4·1	2,725	132	*e* 4·1	2,725
Norway.....	87	2·7	1,794	129	4·0	2,658	129	*e* 4·0	2,658
Portugal.....	84	2·6	1,728	64	2·0	1,323	64	*e* 2·0	1,323
Russia	1,072,434	33,354·2	22,167,201	1,253,592	38,988·5	25,911,744	1,183,379	36,803·8	24,460,044
Spain.....	377	11·7	7,800	515	*b* 16·0	10,645	515	*e* 16·0	10,645
Sweden.....	3,414	106·2	70,580	2,016	62·7	41,671	2,016	*e* 62·7	41,671
Turkey.....	375	11·6	7,751	1,479	*b* 46·0	30,571	1,479	*e* 46·0	30,571
United Kingdom...	12,760	396·8	263,749	5,189	161·2	107,267	5,189	*e* 161·2	107,267
AFRICA:									
Transvaal..	348,760	10,846·9	7,208,869	238,991	7,432·9	4,939,944	1,704,410	53,012·7	35,250,155
Abyssinia.....	33,865	1,053·3	700,000	33,865	1,053·3	*e* 700,000	33,865	1,053·3	*e* 700,000
Rhodesia.....	79,354	2,468·0	1,640,251	148,753	4,626·4	3,074,730	172,899	5,377·7	3,573,822
Soudan.....	2,701	84·0	55,826	2,701	*e* 84·0	55,826	2,701	84·0	55,826
West Coast	36,284	1,128·5	*e* 750,000	30,000	933·0	620,100	19,352	601·9	*e* 400,000
Madagascar.....	33,471	1,041·0	691,849	26,332	*b* 819·0	544,282	26,332	*e* 819·0	544,282
Mozambique.....	8,475	263·6	*e* 175,176	12,377	384·9	255,840	7,257	263·3	*e* 150,000
ASIA:									
Borneo (British)....	19,873	616·9	410,038	12,095	376·2	*e* 250,000	12,095	376·2	*e* 250,000
China.....	208,031	6,470·1	4,300,000	145,138	4,514·0	3,000,000	193,517	6,019·0	*e* 4,000,000
East Indies (Dutch)	26,609	827·5	550,000	27,425	853·0	566,875	31,800	958·0	657,306
India (British).....	512,710	15,946·0	10,597,712	455,870	14,178·2	9,422,855	468,495	14,571·7	9,683,798
Japan	68,485	2,130·0	1,415,508	79,729	2,479·9	1,647,998	*e* 79,729	2,479·9	1,647,998
Korea.....	87,882	2,733·3	1,816,525	111,272	3,460·9	*e* 2,300,000	217,706	6,771·4	*e* 4,500,000
Malay Peninsula...	17,048	530·2	352,382	18,338	570·4	379,037	*e* 18,338	570·4	379,037
AUSTRALASIA (*d*)....	3,568,279	110,978·5	73,756,325	3,719,103	115,676·1	77,174,268	3,989,083	124,073·4	82,454,344
Unspecified (*f*).....	21,771	677·1	450,000	21,771	677·1	450,000	21,771	677·1	450,000
Totals.....	12,522,031	389,453·0	258,829,702	12,606,183	392,096·8	260,877,429	14,414,186	448,331·2	$297,960,910

(*a*) Figures based on exports and coinage. (*b*) As reported by the *Statistique de l'Industrie Minerale.* (*c*) Includes output from domestic ores only. (*d*) Six States and New Zealand. (*e*) Estimated. (*f*) Includes Servia, Persia, West Indies, Formosa, British New Guinea and Philippine Islands. (*h*) Statistics reported by Mr. George E. Roberts, Director of the United States Mint.

NOTE.—The value of gold is $20·67 per Troy ounce, which is equivalent to $664·60 per kilogram.

The production of silver in the world during 1902 amounted to 163,936,704 Troy oz., valued at $85,479,547, as compared with 174,851,391 Troy oz., valued at $102,769,792 in 1901, a decrease in production of 10,914,687 oz. The United States no longer occupies the first position, being passed by Mexico, which during the year 1902 showed an increase in the output of silver of 2,829,995 oz. The United States and Mexico produced collectively nearly 70% of the total output of the world during 1902.

PRODUCTION OF SILVER IN THE UNITED STATES.

State or Territory.	1899.		1900.		1901.		1902.	
	Troy Ounces.	Commercial Value (a)	Troy Ounces.	Commercial Value. (a)	Troy Ounces. (b)	Commercial Value. (a)	Troy Ounces. (b)	Commercial Value. (a)
Alaska	150,000	$89,370	200,000	$122,660	47,900	$28,237	92,000	$47,987
Arizona	2,000,000	1,191,600	1,750,000	1,073,275	2,812,400	1,657,910	3,043,100	1,587,281
California	600,000	357,480	1,170,902	718,114	925,600	545,641	900,800	469,857
Colorado	23,114,688	13,771,781	20,336,712	12,472,500	18,437,800	10,869,083	15,676,000	8,176,602
Idaho	4,800,000	2,859,840	6,100,000	3,741,130	5,542,900	3,267,540	5,854,800	3,053,864
Michigan	.....	.....	.....	.....	81,000	47,750	110,800	57,798
Montana	16,850,755	10,039,680	17,300,000	10,610,090	13,131,700	7,741,137	13,343,800	6,957,966
Nevada	575,000	342,585	1,300,000	797,290	1,612,500	1,068,469	3,746,400	1,954,018
New Mexico	550,000	327,690	550,000	337,315	563,400	332,124	457,900	238,476
Oregon	140,000	83,412	150,000	91,995	160,100	94,379	93,300	48,655
South Dakota	350,000	208,530	210,000	128,793	78,000	45,981	340,000	177,344
Texas	450,000	268,110	535,000	321,983	472,400	278,580	446,200	232,738
Utah	7,183,107	4,279,695	9,569,183	5,868,780	10,700,800	6,343,492	10,831,700	5,649,815
Washington	300,000	178,740	300,000	183,990	344,400	203,023	619,000	322,870
Others	63,284	37,705	100,000	61,330	43,100	25,408	45,100	23,523
Totals	57,126,834	$34,036,168	59,561,797	$36,529,250	55,214,000	$32,458,653	55,500,000	$28,948,800

(a) The average value in 1899, 59·58c.; in 1900, 61·33c.; in 1901, 58·95c., and in 1902, 52·16c. (b) Figures furnished by Mr. George E. Roberts, Director of the United States Mint.

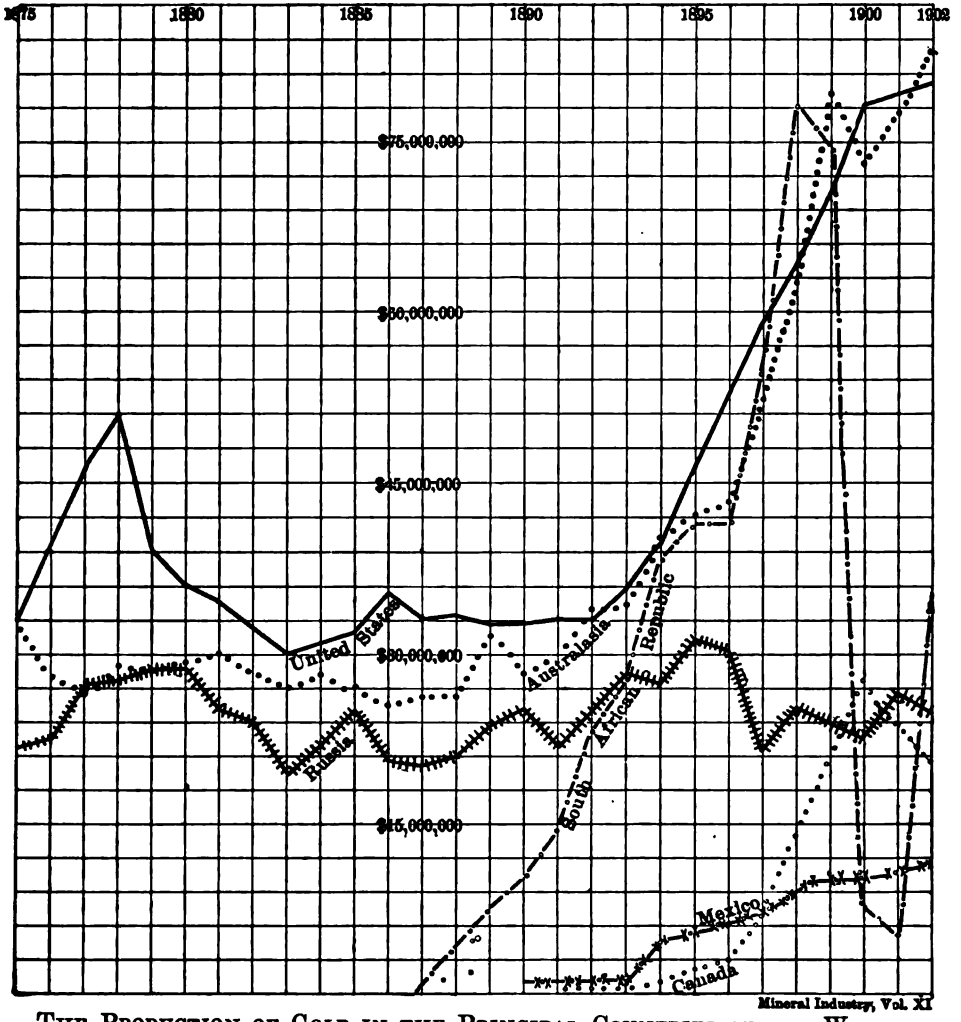
SILVER PRODUCTION OF THE WORLD.

Countries.	1901.			1902.		
	Troy Ounces.	Kilograms.	Commercial Value.	Troy Ounces.	Kilograms.	Commercial Value.
America, North:						
United States	55,214,000	1,717,333·8	$32,458,653	*f* 55,500,000	1,726,229·4	$28,948,800
Canada	5,539,199	172,287·0	3,255,356	4,372,986	136,014·0	2,280,955
Mexico (a)	55,152,340	1,715,416·0	32,512,304	57,982,335	1,803,438·0	30,243,655
Central America	1,072,095	33,345·6	632,000	*e* 1,200,000	37,323·9	625,920
America, South:						
Argentina	*e* 150,000	4,665·4	88,425	*e* 150,000	4,665·4	78,240
Bolivia	9,429,294	293,592·4	5,564,464	*b* 7,500,000	233,274·2	3,912,000
Chile	2,199,003	68,365·0	1,296,312	*b* 1,650,000	51,320·3	860,640
Colombia	2,520,000	78,380·1	1,485,540	*e* 2,520,000	78,380·1	1,314,432
Ecuador	84,818	2,638·1	50,000	*e* 50,000	1,555·2	26,080
Peru (a)	4,276,083	133,000·0	2,520,749	4,276,083	*e* 133,000·0	2,230,410
Europe:						
Austria	1,351,950	40,205·0	762,005	1,351,950	*e* 40,205·0	674,238
Hungary	727,770	22,636·0	429,020	727,770	*e* 22,636·0	379,606
France	384,076	*g* 11,946·0	226,413	384,076	*e* 11,946·0	200,334
Germany (c)	5,522,802	171,777·0	3,255,689	5,522,802	*e* 171,777·0	2,880,700
Greece	1,100,754	34,237·0	648,894	1,100,754	*e* 34,237·0	574,154
Italy	1,043,750	32,464·0	615,290	1,043,750	*e* 32,464·0	544,422
Norway	147,895	*e* 4,600·0	87,184	147,895	*e* 4,600·0	77,143
Russia	157,058	4,885·0	92,595	146,908	4,569·0	76,622
Spain	5,947,935	185,000·0	3,506,305	5,947,935	*e* 185,000·0	3,102,450
Sweden	50,059	1,557·0	29,510	50,059	*e* 1,557·0	26,111
Turkey	480,400	*g* 14,942·0	283,196	480,400	*e* 14,942·0	250,577
United Kingdom	175,287	5,452·0	103,332	175,287	*e* 5,452·0	91,430
Asia:						
Dutch East Indies	85,000	2,643·8	50,107	119,825	3,726·9	62,501
Japan	1,763,135	54,839·2	1,039,367	*e* 1,763,135	*e* 54,839·2	919,658
Australasia	10,848,420	337,420·9	6,395,144	9,724,538	302,464·6	5,072,330
Other countries (d)	48,226	*e* 1,500·0	28,429	48,226	*e* 1,500·0	26,155
Totals	174,851,391	5,438,443·2	$103,769,792	168,986,704	5,097,116·2	$85,479,547

(a) Statistics compiled from exports and coinage. (b) Statistics furnished by H. R. Wagner. (c) Silver produced from domestic ores only. (d) The output is mostly from China and Persia. (e) Estimated. (f) Estimate furnished by Mr. George A. Roberts, Director of the United States Mint. (g) From the *Statistique de l'Industrie Minerale.*

NOTE.—Unless specified to the contrary, the statistics have been taken from official sources or have been collected directly from the producers by THE MINERAL INDUSTRY. The average commercial value of silver for 1901 was 58·95c. per ounce, equivalent to $18·953 per kilogram. The value for 1902 was 52·16c. per ounce, equivalent to $16·77 per kilogram.

During the period from 1875 to 1899 the production of gold in the world increased from $115,576,598 (173,904 kg.) to $311,505,947 (468,695 kg.), a gain of more than 170%. In the fifteen years following 1875 there was little change in the annual output, the totals ranging between the high mark of $123,513,916 (185,847 kg.) for 1878, and the low mark of $95,185,564 (144,727 kg.) for 1883. From 1890, when the production was $119,600,000 (181,256 kg.), the

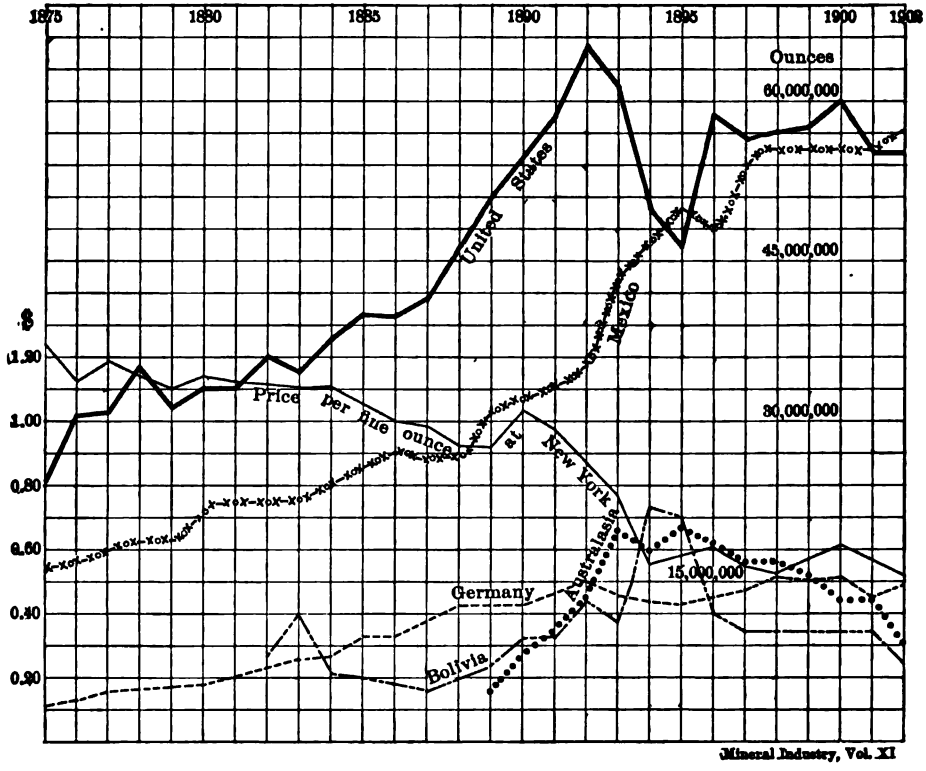


THE PRODUCTION OF GOLD IN THE PRINCIPAL COUNTRIES OF THE WORLD.

growth has been very rapid, owing to a variety of causes, chief among which are the application of the cyanide and chlorination processes in treating refractory ores, the development of the South African fields and the discovery of the gold placers of Alaska. A marked decline in the output occurred in 1900, when operations in the Transvaal mines were suspended by the war, and some time must elapse before the production in this country again reaches normal proportions.

Prices of Silver.

The average prices of silver in New York and London, as computed by the *Engineering and Mining Journal,* are shown in the subjoined table. The lower



THE PRODUCTION OF SILVER IN THE PRINCIPAL COUNTRIES OF THE WORLD.

average in 1902 was due to the smaller demand for silver for coinage purposes in the Far East.

Month.	1900.		1901.		1902.		Month.	1900.		1901.		1902.	
	London. Pence.	New York. Cents.	London. Pence.	New York. Cents.	London. Pence.	New York. Cents.		London. Pence.	New York. Cents.	London. Pence.	New York. Cents.	London. Pence.	New York. Cents.
January	27·30	59·30	28·97	62·82	25·62	55·56	August	28·13	61·14	26·94	58·37	24·23	52·52
February	27·49	59·76	28·13	61·06	25·41	55·09	September	28·85	62·63	26·95	58·36	23·68	51·33
March	27·59	59·81	27·04	60·63	25·00	54·23	October	29·58	63·83	26·62	57·59	23·40	50·57
April	27·41	59·59	27·30	59·29	24·34	52·72	November	27·66	64·04	26·12	56 64	22·70	49·07
May	27·56	59·96	27·43	59·64	23·71	51·31	December	29·68	64·14	25·46	55·10	22·21	48·03
June	27·81	60·42	29·42	59·57	24·17	52·36							
July	28·23	61·25	26·96	58·46	24·38	52·88	Year	28·17	61·33	27·11	58·95	24·09	52·16

NOTE.—The New York prices are per fine ounce; the London quotations are per standard ounce, which is 0·925 fine.

COINAGE OF THE MINTS OF THE UNITED STATES.

Year.	Gold.	Silver.	Minor.	Total.
1898	$77,985,757	$23,034,033	$1,124,835	$102,144,626
1899	111,344,290	26,061,590	1,837,452	139,243,192
1900	99,272,943	36,345,321	2,031,137	137,649,401
1901	101,735,188	30,838,461	2,120,122	134,693,770
1902	47,109,852	30,028,167	2,447,796	79,585,816

UNITED STATES: IMPORTS AND EXPORTS OF GOLD AND SILVER.

	1901.			1902.		
	Exports.	Imports.	Difference.	Exports.	Imports.	Difference.
Gold:						
Coin and bullion	$56,771,350	$33,287,629	Exp. $23,533,721	$35,722,885	$22,710,957	Exp. $13,011,878
In ores	1,012,589	21,524,251	Imp. 20,511,662	307,756	21,482,360	Imp. 21,174,604
Totals	$57,783,939	$54,761,880	Exp. $3,022,059	$36,030,591	$44,193,317	Imp. $8,162,726
Silver:						
Coin and bullion	$55,526,975	$12,957,987	Exp. $42,568,988	$49,228,303	$8,502,614	Exp. $40,725,689
In ores	111,388	18,188,795	Imp. 18,077,412	44,651	17,900,321	Imp. 17,855,670
Totals	$55,638,358	$31,146,782	Exp. $24,491,576	$49,272,954	$26,402,935	Exp. $22,870,019

AUSTRIA-HUNGARY: IMPORTS AND EXPORTS OF COIN AND BULLION.

Year.	Gold.			Silver.		
	Imports.	Exports.	Difference.	Imports.	Exports.	Difference.
	Crowns.	Crowns.	Crowns.	Crowns.	Crowns.	Crowns.
1898	44,966,000	117,216,000	72,250,000	1,898,000	2,284,000	396,000
1899	39,876,000	62,711,000	22,835,000	3,189,000	5,353,000	2,164,000
1900	41,094,000	57,686,000	16,592,000	3,734,000	6,165,000	2,431,000
1901	163,657,000	34,114,000	134,543,000	4,716,000	4,897,000	181,000
1902	150,459,000	66,548,000	83,911,000	15,416,000	12,833,000	2,583,000

FRANCE: IMPORTS AND EXPORTS OF COIN AND BULLION.

Year.	Gold.			Silver.		
	Imports.	Exports.	Difference.	Imports.	Exports.	Difference.
	Francs.	Francs.	Francs.	Francs.	Francs.	Francs.
1898	198,715,221	312,858,950	114,143,729	195,418,221	189,985,299	5,432,922
1900	459,111,000	125,568,000	333,543,000	145,840,000	205,786,000	60,946,000
1901	428,425,000	154,443,000	273,982,000	97,788,000	140,515,000	42,727,000
1902	440,457,000	127,041,000	213,416,000	96,717,000	119,614,000	22,897,000

GERMANY: IMPORTS AND EXPORTS OF COIN AND BULLION.

Year.	Gold.			Silver.		
	Imports.	Exports.	Difference.	Imports.	Exports.	Difference.
	Marks.	Marks.	Marks.	Marks.	Marks.	Marks.
1898	326,208,000	221,769,000	104,439,000	8,303,000	27,811,000	19,508,000
1899	271,275,000	135,745,000	135,530,000	7,284,000	23,964,000	16,680,000
1900	241,243,000	113,860,000	127,383,000	13,955,000	23,885,000	9,930,000
1901	256,883,000	51,591,000	205,242,000	15,878,000	26,544,000	10,666,000
1902	138,993,000	106,032,000	32,961,000	20,091,000	26,645,000	6,554,000

UNITED KINGDOM: IMPORTS AND EXPORTS OF COIN AND BULLION.

Year.	Gold.			Silver.		
	Imports.	Exports.	Difference.	Imports.	Exports.	Difference.
1898	£43,723,960	£36,590,050	£7,132,910	£14,677,799	£15,623,651	£945,852
1899	32,533,497	21,536,052	10,997,445	12,727,989	13,955,132	1,227,143
1900	26,190,873	18,397,459	7,793,414	13,322,300	13,574,580	252,280
1901	20,715,628	13,965,265	6,750,363	11,501,678	12,049,837	548,159
1902	21,629,049	15,409,088	6,219,961	9,764,296	10,716,118	951,822

Gold and Silver Mining in the United States during 1902.

Alaska.—The gradual exhaustion of the rich placers in the Klondike and Cape Nome fields has been followed by increased activity in prospecting for new territory, and by the development of low-grade deposits which under former conditions could not be worked at a profit. Many new discoveries have been made in the interior of Alaska, particularly in the region lying between the Yukon and Tanana rivers. Glenn Creek, a tributary of Baker Creek, which joins the Tanana about 80 miles from the Yukon, and Chena River, some 200 miles further up the Tanana, are the sites of the most recent discoveries. Operations are still conducted on Fortymile River, and the Copper River district is being actively developed.

Nome District.—The Nome district, according to reliable estimates, produced gold to the value of $5,050,000 in 1902, an increase over the preceding year. Work during 1902 was retarded owing to the small supply of water, it having been the dryest season for several years. A pumping plant was completed in the middle of the year by the Wild Goose Mining, Transportation & Trading Co., and water was pumped from Snake River, near the town of Nome, over Anvil Mountain to Nikola Gulch, 45 miles distant, where it was used on several claims. The daily delivery was 4,500,000 gal. The expense of operating the pumping station was large, coal costing $15 per short ton. This company, working 120 days, produced $1,076,000 gold from its claims in the Nome district and on Ophir Creek in the Council City district. The Ophir Creek claims produced $1,250,000 during 1902. The Miocene Ditch Co. has constructed two ditches to carry water from the Snake River to Dexter Creek, and is also building a ditch to supply Anvil Creek with water from Snow Gulch. The company was operating an hydraulic lift at Snow Gulch, and will erect four more in 1903. Its plant has already cost about $300,000. Several other companies are being supplied with water by the Miocene Ditch Co. The cost of mining with the sluice-box has been from $1 to $2 per cu. yd. The Hot Air Mining Co. has been one of the largest producers, extracting gold to the value of $250,000 during six weeks of operation. Of the other regions during 1902, that around Boulder Creek, in the Kugruk district, produced approximately $7,000 and Candle Creek in the Fair Haven district, produced about $150,000. The Iron Creek district produced $100,000, and the Solomon River district about $200,000.

Juneau and Other Districts.—The Alaska Treadwell Gold Mining Co. reports for the year ending May 15, 1902, that it mined and treated 682,893 tons of ore yielding $665,591 in free gold and $639,129 in sulphurets, a total of $1,304,720 or $1·9106 per ton as compared with $1,153,368 or $2·07 per ton in the preceding year. The profits on merchandise, etc., were $34,799, which made a total earning of $1,339,519 ($1·9615 per ton). There were 12,408 tons of sulphurets saved from the mill tailings by concentration, of which 368 tons remained on hand at the close of the year. The working expenses were $823,087 ($1·2053 per ton), and the construction expenses $52,942 (7·75c. per ton), making a total expenditure of $876,029, which left a net profit of $463,490 (67·87c. per ton) as compared with $352,559 (77·01c. per ton) in 1901. Dividends of

$300,000 or 6% on the capital stock were paid, leaving a balance of $163,490. Adding to this the sum of $650,458 carried forward from the previous year the total surplus for 1902 was $813,898. Three mines in the Arbacoochee district were under development in 1892; the Woodward, the Pinetucky, and a third near Goldburg. No mills or smelters have been erected.

Arizona.—The output of gold and silver in 1902 was about the same as in 1901. The Socorro Gold Mining Co. is building a 20-stamp mill at the Socorro mine to which is to be added a cyanide plant. The ore assays about $20 gold per ton. The Congress mine has been sold to the Development Co. of America, which also owns the Poland mine in the Big Bay mining district. The mine is now being actively developed; a 20-stamp mill and eight concentrating tables have been installed, and a tunnel 8,000 ft. long is being driven, which will tap the veins at from 600 to 800 ft. below the outcrop.

California.—The output of gold was greater in 1902 than in 1901. This was due to the increase of milling facilities at established mines and to a larger use of the cyanide process, many old beds of tailings being treated. The utilization of electric and water power and oil for fuel has materially cheapened the cost of mining, and ores are now worked which were formerly too low grade for profitable treatment. Several new mills of from 10 to 20 stamps are either being erected or have been placed in operation. In Butte County in 1902, nine dredging companies operated 22 dredges, and six new dredges are being built. The Feather River Exploration Co. and the Boston & Oroville Co. each operate three dredges. The dredges have a capacity of 2,000 tons of gravel daily, the gravel carrying from 30 to 40c. in gold per cu. yd., and costs 4c. to work. The California Débris Commission in its annual report for June 30, 1902, states that 836,500 cu. yd. of gravel were hydraulicked in the San Joaquin and Sacramento River districts. Its engineers are to be employed in the construction of dams across the Yuba River to hold back the mining débris, the dams to be built jointly by the Federal and State Governments. In addition, each individual mine will have to construct and maintain its own dam. Hydraulic mining in California has received a setback due to a decision of the court that the Caminetti law, under which the California Débris Commission acted, is not absolute, and that the permits granted by this commission are no bar to injunction suits, when the débris from the hydraulic mines is injuring the rivers and valley lands, even though the miners have constructed impounding dams in accordance with the commission's plans. According to W. E. Thorne, the working cost of moving material hydraulically at Georgetown by the Gold Bay Mining Co., was 18·3c. per cu. yd. A controlling interest in the North Bloomfield hydraulic mine, the largest of its kind in the world, has been sold to the W. B. Bourn Co. There are 11,000 ft. of tunnels and 45 miles of ditches, the entire cost being over $1,500,000. The blue gravel is about 135 ft. deep. At the Fremont mine a 60-stamp mill is being erected. The California Gold King Mines Co., operating the Picacho mines, is treating 300 tons of ore per day and intends to double its milling capacity early in 1903. The cost of mining is 10c. per ton and the ore is mined, crushed, and leached for less than $1 per ton. Two new veins are being developed, the ore in one averaging $5 per ton and the other, which is 20

ft. wide averaging $6 per ton. The Eagle-Shawmut mine added 60 stamps to its 40-stamp mill and began operations with the enlarged plant in August, 1902. It is treating 500 tons of ore daily. The North Star Mines Co., during the first eight months of 1902, treated 3,678 tons of ore yielding about $146,000 at a cost of $40,000. The North Star Mines Co., Grass Valley, Nevada County, reports that it mined 17,399 tons of ore, realizing $411,148. Total receipts for the year were $431,149. The operating costs were $154,228, and total expenses were $340,630, leaving a balance of $90,519. The balance on hand at the close of the year was $99,001 in cash and $14,711 in supplies at the mine, making a total of $113,712. The Bay Counties Power Co. transmits power from the Yuba River, a distance of 30 miles, and the Butte Creek Power Co. transmits power from Butte Creek, a distance of 20 miles, with which to operate the dredges. The Valley Power Co. is building on French Creek, and at Nimshew, Butte County, another supply is being developed. Power is sold at approximately $5 per H.P. per month.

Colorado.—Mining progress was hampered by the decline in the price of silver and the exhaustion of several of the large gold mines without a commensurate development of new districts. The Cripple Creek mines gave a largely increased tonnage, but the total yield of gold was only slightly in excess of that for 1901, which shows that a much lower grade of ore was handled than in the previous year. This was made possible by a reduction in treatment charges; a number of companies contracted at the rate of $5·75 per ton, including freight charges, for ore up to 0·5 oz. With the depletion of the rich ore bodies the future of the district depends upon the possibility of new discoveries, and the lowering of the working costs. From the numerous developments that have been made in the outlying territory, it would appear that no extension of the ore-bearing district beyond the present limits can be expected. There remains, however, a large field for exploration within the district proper, and some of this ground is known to contain good ore. Rich discoveries were reported during the year in the lower workings of the Last Dollar and Blue Bird mines, which are now below the 1,200-ft. level. Plans have been formulated for a drainage adit to be driven in a northeasterly direction from the junction of Arequa Gulch and Cripple Creek for a total distance of about 6,000 ft. It will be 235 ft. below the present water level, and will drain an area extending from Gold King on the north to El Paso and Elkton on the south. Heavy shipments of ore were made from Stratton's Independence mine, particularly from the low-grade ore reserves in the upper levels. The Portland Gold Mining Co., reported a production during 1902 of $2,334,024 from 89,664 tons of ore, out of which the net earnings amounted to $471,920. A reduction of about $1·20 per ton was made on the ore treated by the company's new mill at Colorado City. The most important development in the Leadville district was the discovery of an extension of the old bonanza ore-shoots in Fryer Hill. The sinking of the El Paso shaft has made possible the unwatering of a large area on this hill and opened much valuable ground for exploitation. At the present time the bulk of the ore tonnage of Leadville is in the form of fluxing iron ores, so that the output is largely dependent upon the rates allowed by the smelters. The Tomboy Gold Mines, Ltd., during the fiscal year ending June 30, 1902,

mined 85,726 tons of ore for a yield of $856,065; the net profits were $354,317. In the San Juan district, the Camp Bird gold mines, which were purchased by English capitalists for $3,500,000, have given most satisfactory returns. The ore reserves have been largely increased under the new management, and it is planned to sink a new shaft which will be equipped for reaching a depth of 1,500 ft. Owing to the decline in ore shipments from the Colorado and Utah mines, the Philadelphia smelter at Pueblo was closed down.

Georgia.—According to W. H. Fluker, the vein of the Parks mine varies in thickness from 2 to 11 ft., and assays from $10 to $200 per ton, the average free-gold value of the ore being $32·60 per ton. The National Mining Co., of Chicago, has a 20-stamp mill at its mine. The shaft has been sunk 150 ft., at which depth the vein is 4 ft. thick and assays $21·40 per ton. The Landers mine, newly discovered, has two veins varying from 5 to 18 in. and assaying from $20 to $30 per ton. The Columbia mine operated by the Columbia Mining Co. is still the largest producer in the State, the ore from the vein at the 140-ft. level assaying about $34 per ton. The geology of the Dahlonega Gold district is described by E. C. Eckel in the *Engineering and Mining Journal,* Vol. LXXV., 1903, p. 219.

Idaho.—According to the report of State Mine Inspector, three counties produced over $300,000 in gold; Owyhee County, $753,277; Boise County, $396,864; and Lemhi County, $320,385. The Thunder Mountain district where gold was discovered in 1901, did not produce as much gold as was expected, Idaho County, in which it is located, producing in all but $264,452. The Dewey mine owned by the Thunder Mountain Gold & Silver Mining & Milling Co., has a 10-stamp mill and is erecting another of 100 stamps. The gold mines near Wardner are being developed by a New Jersey company, which will use water power to operate 40 stamps. The De Lamar Co., Ltd., reports that during the year ending March 31, 1902, it milled 35,469 tons of ore, shipped 23 tons of ore, and cyanided 937 tons of coarse tailings and 22,985 tons of old tailings. Its income was $519,879 and expenditures $307,793. The output amounted to 23,846 oz. gold and 39,867 oz. silver. The average recovery was 84·2% in the mill and 69·7% in the tailings plant.

Montana.—(By W. H. Weed.)—There has been increased activity in the development of the gold deposits, due chiefly to the successful investments in the Judith district of Fergus County. The operation of the silver mines, however, has been retarded on account of the low price of silver during the year, although the demand for silver-lead ores by the smelters has kept many producing properties in operation. The development of electric power for mining purposes has continued and Butte is now supplied from dams on the Missouri 72 miles away, on the Madison, and the Big Hole rivers. The first named also supplies power to the East Helena smelter, and to various mining and industrial plants. In Fergus County several large cyanide mills are in operation or in course of construction, notably the Kendall property in the North Moccasin Mountains, which was treating 350 tons of ore daily at the end of 1902, and the adjacent Barnes-King mill, which has been enlarged to a daily capacity of 240 tons. There are also several minor cyanide plants operating in the State. In October, 1902, the Winscott mine near Helena under control of the Big Indian Gold Mining

Co., started with 60 stamps driven by electric power from the Canyon Ferry on the Missouri River. The mill and cyanide plant of the Columbia Gold Mining Co. at York was destroyed by fire during the summer. In the Marysville district the Bald Butte mine yielded a steady output of high-grade gold ore during the year. The Drumlummon mine is practically worked out, and on the exhaustion of the old stope-fillings now treated will probably be permanently abandoned. A 500-ton cyanide mill was operated at Empire on old tailings from the Empire mine. In the Phillipsburg district, the Sunrise Gold property is again operating mine and mill; and the Granite Bi-Metallic Co. has decided to double the capacity of the new 600-ton concentrator which was completed late in 1901. A new 50-drill Rix compressor has been installed, and electric haulage introduced in the mine, the power for this purpose and for the mill being furnished by the newly completed electric power plant at Flint Creek Falls. The Bear Gulch mines, near the Yellowstone Park boundary, were tied up by litigation, which is said to be now settled, with a prospect of a re-opening and working of the property on a largely increased scale. The Mayflower mine is to be abandoned. In the Rochester district the Watseca mine is opened up to the 500-ft. level, and a 125-ton concentrator will be added. The Cable mine, near Anaconda, is being re-opened by a Butte syndicate. The Jeannette Mining Co. stopped working on the 100-stamp mill last spring at the Boss Tweed-Clipper group of mines, near Pony, and is awaiting the results of development work. Six dredges have operated during the season, three at Bannock, two near Virginia City and one on French Gulch, near Anaconda. Two of the Bannock dredges will be removed, having entirely exhausted the pay ground. The French Bar dredge has handled gravel profitably at a cost less than 5c. per cu. yd., inclusive of interest on investment, and all fixed charges. The two Bannock dredges were the pioneers in this work in the country, and have extracted over $600,000 from an abandoned placer field. Near Virginia City the boats operating on the old Alder Gulch placers have cost nearly $500,000, but have operated so successfully that other boats, it is reported, will be built. The Montana Mining Co., Ltd., for the half year ending June 30, 1902, reported a net profit of £1,780. This company owns the Drumlummon mine at Marysville, which during the half year treated 13,200 tons of ore for a yield of $61,631. The tailings plant between April 12 and June 30, 1902, treated 31,649 tons of tailings from which $66,310 were realized. The total income was $127,941, and expenses $115,501, leaving a profit of $12,440. The ore and tailings contained 5,622 oz. gold and 31,462 oz. silver.

Nevada.—Development work has been done in the Tonopah district, and new companies have been formed. The Dexter Tuscarora Gold Mining Co. for the 11 months ending Nov. 15, 1902, reports that it treated 30,093 tons of ore at a cost of less than 72c. per ton and extracted $2·88 gold per ton. From 22,930 tons of tailings treated by cyaniding at a cost of $1·10 per ton, it obtained $1·89 gold per ton. Its total receipts were $130,713, and expenses $125,021, of which sum $18,000 were expended in new development work. The Bamberger De Lamar Gold Mines Co., capitalized at $5,000,000, has bought the De Lamar's Nevada Gold Mining Co., Magnolia Gold Mining & Milling Co., Boston De Lamar Gold Mining & Milling Co., Mono Gold Mining & Milling Co., April Fool Gold Mining

& Milling Co. and the Rose and Pleides group of gold claims. The De Lamar's Nevada Gold Milling Co., which has produced over $13,000,000 in seven years, has an estimated ore reserve of 314,000 tons. The April Fool mill is being improved, and the De Lamar mill is being increased from 200 tons to 500 tons daily capacity. The Nevada Keystone Mining Co., with two Huntington mills and a 30-ton cyanide plant is reported to be producing $40,000 a month. The Lucky Girl group of mines at Edgemont, owned by the Montana Mining Co., Ltd., during the half year ending June 30, 1902, treated 8,165 tons of ore in its 20-stamp mill obtaining bullion valued at $30,438. The tailings will be treated in a cyanide plant which is being erected.

New Mexico.—Mining properties were under development in 1902 in the districts about the Sierra de Mogollon, the Black Range and the Sierra Blanca. Large bodies of medium grade ore are said to exist, which can be treated by the cyanide process. Apart from several mills now being erected to treat those ores four mills are in operation near the Mogollon Range. The Mogollon Gold & Copper Co. has a 35-ton mill, and ships the concentrates to the El Paso smelter. At the Hopeful mine in the White Oaks district a 1,000-ton pneumatic cyanide plant is in operation, and the Alamo Reduction Co. will erect a 500-ton concentrating plant in the Bland district. Placer mining has been carried on in the Nogal and Elizabethtown districts. The Lake Valley and Polomos Chief silver mines, after lying idle for several years, have again been worked. At Chloride, two mills are treating ore containing 12 oz. of silver per ton. The Kodoc Mining Co. has seven Hooper pneumatic dry concentrators of 10 tons capacity operating on ore assaying 20% Pb, and from 3 to 10 oz. silver per ton. The American Gold Mining Co. and the Eagle Co. are developing claims at Nogal and Parsons, and at the Old Abe and Somestake mines. The Helen Rae and American mines are being connected by a tunnel and a 50-stamp mill and cyanide plant are being erected.

North Carolina.—According to Mr. J. H. Pratt, gold occurs in an area of from 8,000 to 10,000 sq. m. in the middle and western part of the State, either in quartz fissure veins, carrying free gold or gold-bearing sulphurets; impregnations of free gold and finely-divided sulphurets in schists and slates; or in placer deposits. The mines in operation are situated in six counties. Several of them were sold during 1902, and are being developed. The Iola Gold mine with a 10-stamp mill, between June and October, produced $15,000 in gold. The Russell, Fentress and McMackin mines, the latter operated by the Whitney Reduction Co., each had a 10-stamp mill in operation.

Oregon.—In the Sumpter district, which is the richest in Oregon, the greatest amount of development work was done. The Maxwell mine and 10-stamp mill were sold for $140,000; the mill is being repaired and is expected to become operative early in 1903. The Pole Consolidated Mining Co., capitalized at $5,000,000, has acquired the Oregon Clipper, Deer Lodge, Hansen and half of the Yankee Jim mines. Four tunnels have already been started, and a compressor plant will be installed. The North Pole mine with 10 stamps will increase its mill by adding 20 stamps. In all there are 758 stamps in eastern Oregon. The placer deposits of Josephine County were actively exploited. The

placer ground gives returns of from 10 to 12c. per cu. yd., the cost of working being about 1·5 per cu. yd., the water being supplied by the Rouge River. The Golden Drift Mining Co. is building a power dam across the river, and will install ten 600-H.P. turbines, and operate three or four giants. The Galice mines operated by the Old Channel Mining Co. has three 6-in. giants, which obtain their supply of water by means of 18 miles of ditches and flumes. The Eureka mine in the Soldier Creek district owned by the Oregon & California Gold Fields Co. is developing a vein from 8 to 10 ft. wide, which assays from $20 to $35 gold per ton. The Greenback mine on Grave Creek has 35 stamps, and a 60-ton cyanide plant in operation.

South Dakota.—The satisfactory condition of the gold mining industry in the Black Hills during 1902 is evidenced by the increase in output, which was brought about by the enlarged operations of old producers, and by the contributions from mines recently developed. The steady advance recorded in the last few years may be attributed to the introduction of the cyanide process, for with its aid enormous bodies of mineralized material formerly regarded as too low grade for profitable working have been made available for treatment. Full details of the progress in the cyanide process in this State will be found on page 310 of this volume. The Homestake Mining Co. during the year ending June 1, 1902, treated 1,218,089 tons of ore, which yielded bullion valued at $4,314,059. Deducting mint charges the net bullion return was $4,303,977, while the income from miscellaneous sources amounted to $72,453, making the total working receipts, $4,376,427 or $3·60 per ton. The working expenses were $4,017,131, so that the net profits of operation were $359,296, or $0·29 per ton of ore milled. A dividend of $1,260,000 was paid. During the year the stamp mill was increased by 100 stamps, making a total capacity of 900 stamps, and a 900-ton cyanide plant was erected, which increased the cyaniding facilities to 1,900 tons. The Horseshoe Mining Co. was reorganized during the year. The company purchased the 300-ton smelter of the National Smelting Co., at Rapid City, and began construction on a new 1,000-ton cyanide plant. When the improvements and additions are completed the plant will be able to treat 1,600 tons of ore per day. The smelter of the Golden Reward Consolidated Mining & Milling Co., at Deadwood, was in continuous operation, treating ore principally from the company's mines.

Texas.—Although this State produces very little gold, its output of silver is quite large, almost the entire quantity coming from the mine of the Presidio Mining Co., at Shafter in Presidio County. The ore is silver chloride carrying traces of gold, with isolated pockets of lead ore. Three or four carloads of this high-grade lead ore are shipped yearly to the El Paso smelter. The gold ore is treated at the 15-stamp mill of the Cibolo Creek Mining & Milling Co., one mile from the mine. The pulp is ground for three hours with salt, mercury, and copper sulphate in amalgamation pans, of which there are twelve. The amalgam is collected in six settlers, and retorted. The tailings are again milled. The process requires six hours for completion, the mill treating 62 tons of ore per diem, and the average extraction being 85%.

Utah.—There was no material change in the mining situation during 1902.

The large copper and lead mines shipped bullion containing gold and silver throughout the year. The American Smelting & Refining Co. had in operation at its two plants four and six furnaces respectively, and treated 1,400 tons of ore daily. The United States Mining Co. with four furnaces treated 1,000 tons of ore a day. A 300-ton mill for the cyanide treatment of the slimes of talcose ores by a method patented by G. Moore[1] has been erected at Sunshine. The extraction varies from 77% to 95·6%. The South Swansea mine during the year treated 15,715 tons of ore, realizing $363,331, out of which $39,000 in dividends were paid. The Horn Silver Mining Co. during 1902 mined 12,159 tons of ore, of which 4,549 tons were shipped and 7,610 tons milled. The cost of mining was $7·45 per ton, and of milling $1·47 per ton. There was realized from the sales of ore $109,707, and from other sources $7,001, a total of $116,708, while the disbursements amounted to $137,406. The balance carried forward from 1901 was $87,448, leaving a surplus of $66,750 at the close of 1902. The ore shipped contained 203 oz. gold, 112,813 oz. silver, 1,829 tons lead and 717,353 lb. copper. The Park City district, in which are located the Daly-West, Ontario, Daly, and Silver King mines, maintained its output of smelting ores, and some encouraging developments were reported. The Daly-West Mining Co. during the year shipped 3,575,796 oz. silver, 1,202 tons copper, 14,953 tons lead, and 9,738 tons zinc, for which it received the sum of $1,827,586. Receipts from other sources were $4,052, making the net revenue $1,831,638, while the total mining expenses amounted to $625,654. Out of the surplus of $1,477,127, which included $271,143 brought forward from the previous year, the sum of $1,049,000 was distributed in dividends, and $255,516 carried forward to the next year's account. The company purchased the property of the Quincy Co. paying therefor 30,000 shares of its stock, which were provided by increasing its capital to 180,000 shares. The contract with the American Smelting & Refining Co. fixing the price of $3·50 per 100 lb. for the lead content of the company's ores was renewed to run until March 1, 1904. The Anchor and Judge properties in this district have been combined to form the Daly-Judge company. The Daly-Judge mine up to Dec. 31, 1902, produced 94,639 tons of concentrates valued at $25·54 per ton. The crude mill ore assayed Pb 10·29%, Zn 16%, and silver 9·85 oz. per ton. The new mill has a capacity of from 300 to 400 tons per day. In the early part of 1903, 100 tons of ore per day were being milled, making 25 to 30 tons of silver-lead concentrates, and about 25 or 30 tons of iron-zinc middlings, which were sent to the zinc plant of the Park City Metals Co. In the southern end of the district, in Thaynes Cañon, the California Co. has enlarged its mill, and the Comstock is now building a large mill. A new mill is also being started in Park City to handle the zinc middlings by the combined roasting and magnetic separation process, which will ship high-grade blende to the Eastern refineries. The Tintic district consists of the Eureka, Mammoth, Robinson and Silver City. The principal mines of the Eureka district are the Bullion Beck, Eureka Hill, Gemini and Centennial Eureka. The first two have been closed down during the year. The Gemini has been shipping steadily during 1902. The Centennial Eureka has completed its contract with the American Smelting

[1] *Engineering and Mining Journal*, July 12, 1902, p. 42.

& Refining Co., and has shut down its plant pending the completion of the smelter of the United States Mining Co., which now owns this mine. The Mammoth mine is engaged in litigation with the Grand Central mine, and until a settlement has been made the work on both will be retarded. The ores of the Tintic district are subject to high smelting charges, and ores up to $15 value do not pay to treat. The largest mines in the Mercur district are operated by the Consolidated Mercur Gold Mines Co., which during the year ending June 30, 1902, produced gold to the value of $1,457,064. The company's working expenses were $1,116,692, and the net profits $342,085. Six dividends amounting in all to $235,000 were distributed during the year.

Washington.—It is estimated that the total production of the Republic district in Ferry County up to Jan. 1, 1902, is about $1,400,000 in gold and silver, the silver being only a small percentage of the whole. The ore averages from $12 to $16 per ton, and the present cost of mining and smelting is $10 per ton. The Republic mill treats 200 tons of ore per day, but like most mines in this State, the smelting ore is shipped to the Granby smelter, at Grand Forks, or to the Northport smelter, near the Canadian boundary. The California mine in Ferry County from July 15 to Dec. 30, 1902, produced 3,411 oz. gold and 4,346 oz. silver. The Hollyhock group, also in this county, mined ore which assayed on the average 0·3 oz. gold, 5·3 oz. silver, 10% Cu, and 9% Pb per ton. The San Poil mine, Ferry County, shipped ore to the Granby smelter, and showed a net profit of $8·80 per ton on ore, which assayed $17·80 per ton. The reserve ore of this mine on Oct. 4, 1902, was estimated at 22,000 tons. The Park City claim of the Cliff group, is developing a vein of galena 700 ft. long and 22 in. wide, which assays 69% Pb, 33 oz. silver, and 0·2 oz. gold. In the Pride and Mystery mines in the Monte Cristo district, the ore varies from 0·6 to 0·95 oz. gold and from 7 to 12 oz. silver. In the Independent mine, at Silverton, Snohomish County, the low grade ore assays $7 per ton, while the high-grade ore varies from $40 to $50 per ton. The ore consists of pyrite and löllengite with a little galena and zinc blende. A mill of from 100 to 200 tons capacity is to be erected.

Wyoming.—(By Wilbur C. Knight.)—There was no marked advancement made in gold and silver mining during 1902. As usual, the Sweetwater district furnished nearly all of the gold and silver ore produced during the year. At South Pass, Atlantic, and Lewiston, considerable property changed hands in the fall and a number of new companies entered these fields. The indications are that these camps will be very active during 1903. In November the Home Placer mine on Douglas Creek near Laramie passed into the control of a company which expects to install a dredge to work the property. In the Wood River district, near Kirwin, Big Horn County, several companies have done sufficient work to patent many claims. The ores of this camp are lead and silver chiefly, and assays showing upward of 100 oz. silver per ton are not uncommon. At present this camp is too far from transportation to handle the ores successfully. In Crook County there has been much activity in the vicinity of Welcome, and not far from the Interocean mine. Several companies have bonded property, and expect to inaugurate extensive plans for work in 1903.

GOLD AND SILVER MINING IN FOREIGN COUNTRIES DURING 1902.

NORTH AMERICA.—*Canada.—British Columbia.*—(By Samuel S. Fowler.)—According to returns made to the Provincial Mineralogist, Mr. William Fleet Robertson, the combined output of alluvial and lode gold for 1902 was 290,148 oz., equivalent to $5,961,409, being an increase in value of $642,706 above the output of 1901. Alluvial gold is derived chiefly from the central and northwestern districts of Cariboo and Cassiar (Atlin), these districts alone furnishing 90% of the production in 1901. The output for the year amounted to $1,073,140, an increase of about $100,000 over 1901, which was less than was expected owing to the shortage of water. Considerable expenditure was made on ditches and flumes, and it is anticipated that 1903 will show a material gain. The output of lode gold was 236,491 oz., valued at $4,888,269. This was derived, geographically, as follows: West Kootenay, 79%, Yale, 18%, other districts, 3%. As to classes of ores, 79% was from copper ores, 13% from free-milling ore and 2% from lead and dry smelting ore. The output of silver in the Province was 3,917,917 oz., valued at $1,941,328, a decrease of about 24% in quantity, and nearly 33% in value as compared with 1901. This loss was perfectly natural, in view of the low range of prices for silver, as well as for lead, with which so great a part of the silver is associated. Most of the large silver-lead mines were closed during a large part of the year, although many of the smaller and richer ones remained in operation. West Kootenay provided 87·6% of the silver, Yale 5·6%, elsewhere 6·8%. Lead ores contained 57% of the silver, gold-copper ores 18%, and milling and dry ores 25%.

Southern British Columbia presents an enormous development of igneous rocks, and it is from these that the bulk of the lode gold is derived. The vicinity of Rossland is the center of greatest gold production, its few large mines having contributed over 68% to the total for 1902. The Rossland ores are essentially iron and copper sulphides, and their chief value is in gold, the silver and copper being of minor import. The output of this district in 1902 was nearly 330,000 tons, an increase of about 45,000 tons over 1901. The ore was smelted either at Northport, Wash., or Trail, B. C., at both of which points are large, modern, well-equipped plants. For various reasons the matte is shipped elsewhere for conversion. The increased tonnage from the mines was due chiefly to reduced smelting charges, and it would have been much larger except for the fact that the smelters were compelled to curtail operations because of the shortage in coke supplies, due to strikes and accidents at the mines of the Crow's Nest Pass Coal Co. As in former years, the larger producers were Le Roi, Le Roi No. 2, Center-Star and War Eagle; these mines exploit a low-grade ore, on some of which apparently successful experiments in the direction of preliminary concentration have been made. The ultimate commercial success of these experiments means much to the district. The "Boundary" portion of the Yale district lies about 40 miles west of Rossland. This is the second chief mining center of gold-copper ores, but the gold value is generally much inferior to that of copper. The deposits are of enormous size, of very low average grade in gold and silver, and of self-fluxing composition. The chief producers are the

Knob Hill, Old Ironsides, and Snowshoe, near Phœnix, and the Mother-Lode and Sunset, about three miles west of Greenwood. These mines in 1902 shipped to three smelters in the vicinity over 500,000 tons, an increase of 125,000 tons over 1901, due to increased smelting facilities. At the three plants are seven furnaces having a daily aggregate capacity of about 2,500 tons. Three other

OUTPUT OF TRAIL CREEK MINES FROM 1898 TO 1902.

Year.	Tons of Ore.	Gold. Oz.	Value.	Silver. Oz.	Value.	Copper. Lb.	Value.	Total Value.
1898.....	111,282	87,343	$1,746,861	170,804	$94,539	5,232,011	$639,411	$2,470,811
1899.....	172,665	102,976	2,127,482	185,818	105,173	5,693,889	996,431	3,229,086
1900.....	257,636	111,625	2,306,172	167,378	97,648	2,071,865	335,435	2,739,300
1901.....	283,360	132,333	2,735,323	970,460	543,458	8,333,446	1,342,518	4,621,299
1902.....	329,534	162,146	3,351,558	373,101	184,871	11,667,807	1,356,966	4,893,395

furnaces are in course of construction. Free-milling gold ores are found at only a few widely separated points. The Ymir mine, 20 miles south of Nelson, is the largest mine of the class, and last year produced over $300,000 in gold, together with silver and lead valued at about $45,000. The Cariboo-McKinney mine at Camp McKinney in the south-central portion of Yale district, is the next largest free gold producer, and has been a steady profit payer since 1894. The Granite-Poorman and Athabasca-Venus, near Nelson, run regularly, and the Stemwinder, near Fairview in the western part of the Yale district, is about to be added to the list of producers. The gold derived from this class of ores amounted in 1902 to approximately $650,000. Some of the lead ores of Slocan and Lardeau carry appreciable values in gold, and there are also dry smelting gold ores at various localities in southern British Columbia. The latter class of ores has not as yet been largely produced.

Silver-lead mining under former conditions has been a profitable industry owing to the high ratio of silver to lead in the ores which last year was slightly over two ounces to each unit of lead. The low prices that prevailed during 1902, together with the fact that the shortage of lead has lessened the demand for dry ores, and also that many former clean ore mines have had to resort to concentration, have tended, however, to extinguish profits except in a few instances. Silver mining at present is in an unsatisfactory condition. The gold-copper ores of Rossland and Boundary carry respectively, about 1 oz. and 0·5 oz. silver per ton; and although this is a small average the aggregate output from these districts was nearly 593,000 oz. The gold-milling ores also carry small amounts of silver, *e. g.*, the Ymir mine bullion contains about 40%, and the concentrates about 12 oz. silver per ton. Under improved conditions East Kootenay is capable of producing much silver, but because of the low ratio of silver to lead in the ores low prices have affected that district possibly more seriously than they have West Kootenay. The Slocan portion of West Kootenay continued to furnish the greater part (nearly 65%) of the total output of silver.

Dawson.—According to official authorities, the production of gold in the Yukon district during 1902 amounted to about $18,000,000, a decrease of $4,000,000 from the output of the previous year. In arriving at these statistics there are two uncertain factors, one the quantity of gold which is carried out of the country

by individuals, thus escaping record, and the other the quantity retained in the country as circulating medium. The Yukon district has now entered the transition period common to all new placer mining countries. The decreased production has resulted chiefly from the dearth of new discoveries of placer deposits, augmented by the scarcity of water. At All Gold Creek, 50 miles from Dawson, which was abandoned in 1899 because of the uncertain character of the gold-bearing ground, a pay streak was found during the summer reported to be from 120 to 200 ft. wide and 2 ft. in thickness. The shipments from Dawson for the year is recorded as $11,655,000, a decrease which is partly due to the change from a direct royalty of 5% on the gross output of gold to a tax of 2·5% on the exports. A feature of the usual development of a gold-bearing district is shown in the number of quartz claims that have been recorded. The properties are adjacent to Bonanza, Eldorado, Gold Run and Hunker creeks in the Indian River slope, and on the hills near Dawson. The Munger Mill Co. has installed a stamp mill on Gold Run Creek. A dredge 25×80 ft. has been built at White Horse to operate on the Stewart River; its daily capacity is rated at 1,000 cu. yd. Piping has been laid on Excelsior Creek above Dawson for a hydraulic plant. The Yukon Goldfields, Ltd., for 15 months ending Dec. 31, 1902, reports sales of gold amounting to £12,003, and an income from other sources of £937, a total of £12,940, against a total expenditure of £26,239, a loss for the year of £13,299. The company intends to increase its property by the addition of 5 sq. miles of territory situated on Russel Creek, 450 miles from Dawson City.

Newfoundland.—According to James P. Howley, the production of gold in Newfoundland in 1902 is estimated at 4,000 oz., valued at $82,680. Almost the entire output was contained in copper ores treated by the Nichols Chemical Co. in the United States and the Cape Copper Co. in England. During the year some promising gold finds have been made, and two mines are now in active operation, one at Rose Blanche on the south coast, and the other at Sop's Arm in White Bay on the northeast coast. At the latter, machinery for stamp mills is now on the ground, and a cyanide plant is under construction which will begin operations in March, 1903. The ore at Rose Blanche assays from $4 to $5 per ton, while that at Sop's Arm assays as high as $15 per ton.

Nova Scotia.—The production of gold during the fiscal year ending Sept. 30, 1902, was 28,279 oz. as compared with 30,537 oz. for the previous fiscal year. The quantity of gold reported to the Mines Office during the calendar year 1902 amounted to 31,141 oz.; of which the Brookfield Mining Co. contributed 4,692 oz.; the Boston-Richardson Gold Mining Co., 3,408 oz.; the Waverly Gold Mining Co., 2,836 oz.; the Royal Oak Gold Mining Co., 2,394 oz.; and the Bluenose Gold Mining Co., 2,391 oz. The Brookfield Mining Co., at North Brookfield, stamped 6,475 tons of ore; the mining operations were confined to ground below the sixth level. At the Waverly mine development work was carried on actively, and an average of 20 stamps were in operation in the latter part of the year. The Boston-Richardson Gold Mining Co. at Country Harbor stamped 30,405 tons of ore, yielding about $3 per ton by amalgamation. The Wilfley tables have been abandoned, as better results are claimed by treating the tailings at the cyanide plant and the concentrates by the bromo-cyanide process. The Royal

Oak Mining Co., at Goldenville, operated mainly at the western end of its property. The Baltimore and Nova Scotia Mining Co. was very active. The main shaft of the mine is now 700 ft. deep, intersecting at the 500-ft. level the lenticular fissue vein in the form of a chimney. The 40-stamp mill is well arranged. Although inoperative at present the St. Anthony mine is being kept unwatered.

Ontario.—In Eastern Ontario the principal properties are the Belmont mine operated by the Cordova Exploration Co. and the Deloro mines of the Canadian Goldfields, Ltd. The Belmont veins consist of free milling quartz which is treated in the 30-stamp mill and amalgamation plant, the pulp being subsequently cyanided. At Deloro, the ore is mixed quartz and mispickel, from which the gold is extracted by leaching with bromo-cyanide solutions, and the arsenic by a process of sublimation (see "Arsenic" elsewhere in this volume). In the Lake of the Woods district the Black Eagle mine, formerly known as the Regina mine, has been actively operated during the past two years, and the mill thoroughly overhauled. The present equipment includes a 30-stamp mill. A 250-ton cyanide plant is being constructed for which about 1,500 tons of concentrates, valued at from $35 to $50 per ton, have been accumulated. The Sultana mine, operated by the Sultana Mine of Canada, Ltd., has not proved very successful. During the fiscal year ending Sept. 30, 1901, 7,000 tons of ore were milled, which yielded an average of only $5·15 per ton. Although the mining costs of the Mikado Gold Mining Co. averaged but $3·50 per ton of ore during 1901, a debit balance of £5,052 is given in the report of the company. Operations at the Sakoose mine, owned by the Ontario Gold Mining & Milling Co., were suspended in March, 1902, owing to the exhaustion of the ore in the levels under development. In all 7,735 tons of ore have been removed from the stopes. Prospecting was actively carried on in the Sturgeon Lake region, and several companies have developed mines or erected mills, notably, the United States Gold Mining Co., the Sturgeon Lake Mining Co., the Jack Lake Gold Mining Co., Ltd., and the Anglo-Canadian Gold Estates, Ltd. A deposit of gold-bearing gravel similar to that of the Vermilion River was discovered at Savant Lake, 150 miles north of Ignace, and an examination over an area six miles long by one mile wide, showed an average value of from 8 to 10c. per cu. yd. The gold is in small rounded particles. Robert H. Ahn, of Toronto, reports satisfactory experimental treatment of Vermilion River gravels by a combined amalgamation and cyanide process.

Mexico.—(By James W. Malcolmson.)—(The output of gold and silver is derived largely by smelting gold and silver ores with those of copper and lead, and it is practically impossible to classify the subject under the heads of the respective metals without causing duplication. Therefore reference should also be made to the "Progress of Mining in Foreign Countries," under the sections devoted to "Copper" and "Lead," elsewhere in this volume.)

Owing chiefly to the cheap mining and the absence of labor troubles, there has been a large influx of foreign capital seeking investment in silver, gold, copper and lead mines. From a wage standpoint, a ton of ore can be mined in Mexico for 40% of the cost of mining similar ore in the United States, assuming that the miner in the latter country does twice as much manual labor

as the one in Mexico. Development has progressed mainly along the railroad lines, and is due to the growth of the smelting industry. In the smelters of Mexico, copper seems to be displacing lead as a vehicle for the concentration of silver and gold values, and it is probable that recent improvements in the metallurgy of copper together with the large deposits of copper ore being exploited will increase considerably the quantity of gold and silver so treated.

Aguascalientes.—The copper mines of Tepezala, operated by M. Guggenheim's Sons, have maintained a steady production of siliceous silver-copper pyrites. The Aguascalientes Metal Co., at Asientos, has maintained a steady output, and in the same camp the American Smelting & Refining Co. purchased the Santa Francisca mine in March, after uncovering a very large body of siliceous silver-lead-zinc sulphides.

Chiapas.—The copper-gold mines of Santa Fé have been worked steadily, and an excellent record has been made by the management.

Chihuahua.—The extension of the Mexican Central Railway into Parral and Santa Barbara has resulted in lasting benefit to the mining camps, which now supply all the smelters in northern Mexico with siliceous ores. The Hidalgo Mining Co., of Pittsburg, reopened the old San Juanico mine, and discovered a siliceous vein in shale containing high gold and silver values. The Pedro Alvarado in the porphyry overlying the shale produced regularly throughout the year. The Veta Grande and Verde mines in the Veta Colorado ledge were acquired by the Guggenheim Exploration Co., and a rich ore body was cut in the Morena mine in the same ledge by the Hidalgo Mining Co. Near Chihuahua City, the Kraft mine yielding fluxes containing gold, silver, manganese and lime was closed down during the first of the year on account of the fire at the El Paso smelting works, but later it was reopened, and ore was produced from the open cuts at a rate of 3,000 tons per month. In the Sierra Madre Mountains the gold-silver quartz ores are receiving considerable attention. In the Jesus Maria district the ore is treated by pan amalgamation solely, with a probable loss of from 25 to 30% of the silver and gold contents. This camp is 60 miles from a railroad, and the cost of mule freighting is $60 per ton. The ore is high grade, and the value of the monthly production is $100,000, the bullion averaging above $1 per ounce. The Concheno Mining Co. is successfully treating the ore by crushing it and passing it over Wilfley tables, which effects a 2,000 to 1 concentration, cyaniding the sands in the usual way, and the excessively fine slimes by agitation and filtration. During the year the Dolores mine shipped several hundred tons of ore, which assayed over 500 oz. silver and 6 oz. gold per ton. The problem of the local treatment of ores in this district is receiving merited attention, as the best work so far shows an extraction in cyaniding of but 80% of the gold and 55% of the silver. The camps at Barranca de Cobre, Batopilas, Urique, Guazapares and Palmarejo received much attention from investors, and a valuable silver bonanza was uncovered at the Batopilas mine. The Ardagas mines near Jimenez producing gold, silver and lead ore, reduced its shipments during the second half of the year. The value of the ore produced annually in Chihuahua is greater than that of any other State in Mexico.

Coahuila.—The blowing in of the Torreon smelter stimulated mining consider-

ably in the southern part of the State, and a number of good lead-silver prospects are being developed. At Viesca a smelter has been erected to treat the low-grade siliceous copper carbonates, which carry some silver. The output of the Sierra Mojada was greatly reduced owing to the burning of the El Paso smelting works. The Fortuna mine has been actively worked, due to the discovery of a rich deposit of silver-lead carbonates. The fire in the San Salvador mine continued throughout the year—the mine contains 30,000,000 ft. of lumber and immense quantities of native sulphur. In the Fronteriza mine, a valuable extension of the main ore zone has been discovered, but operations here and in the adjoining Encantada mine of M. Guggenheim Sons were hindered by the fire in the San Salvador mine. The Norias de Banjan, Cerralvo and Cuatro Cienegas silver-lead camps were operated in a small way throughout the year.

Durango.—The silver-lead-copper mines and smelter of the Velardena Mining & Smelting Co., of Omaha, were sold in November to the American Smelting & Refining Co., an action which will have a radical effect on the smelter situation. The Compañia Minera de Peñoles, at Mapimi, mined 171,000 metric tons of ore in 1902, and produced 92,000 kg. silver and 24,000 metric tons lead. The ore occurs in a series of irregular pipes which have been explored by diamond drills to a depth of 2,300 ft. Thirty electric hoists from 1 to 50 H.P. are used successfully in opening up the ore reserves. A complete reverberatory roasting plant has been installed. Due to the extension of the International Railroad to Chinacates, the Promotono silver-gold siliceous mine has installed a concentrator and a 100-ton smelter. The Lustre Mining Co., of Pittsburg, operating the Magistral mine near Inde, is experimenting with the treatment of the ore which assays 0·5% copper and 0·5 oz. gold per ton. Guanacevi, which is probably the most important siliceous district in the country, continues to be handicapped with high freight rates and heavy milling losses—the work on the extension of the International and Central railroads having been suspended. Development work at the Avino Mines of Mexico, Ltd., has shown the presence of copper oxide with native copper in the lower leads. The concentration works has been superseded by a thiosulphate leaching plant which extracts 85% of the silver and 30% of the gold. The Vacas mines shipped high grade silver-lead concentrates low in silica. The ancient Rosario mine is being reopened, and the old workings contain large quantities of silver-gold ore amenable to profitable treatment by leaching processes. The San Andres de la Sierra silver-lead mine ships $100,000 of base bullion monthly. The Bacis Gold and Silver Mines, Ltd., operates 40 stamps, and concentrates and amalgamates its ore. The Cushing & Walkup Co., at Trinidad smelts siliceous gold-silver-copper ore, and ships to the Aguascalientes smelter, which yields copper matte assaying 20% copper, 350 oz. silver and 8 oz. gold per ton. The Candelaria Consolidated Mining Co., at San Dimas, increased its yearly output, which is obtained by stamps and pan amalgamation. At La Puerta a large body of gold-silver ore has been uncovered and a mill is under construction. The value of the ore produced annually in the State of Durango is second only to that of Chihuahua.

Guanajuato.—The ancient siliceous silver-gold mining district of Guanajuato has been actively operated. These mines are believed to have produced one-sixth

of the silver of the world; one of them, the Valenciana, having an established record of production of over 300,000,000 oz. silver. The gold in these ores varies from 15 to 50% of the total values, and in the patio process 75% of this gold is lost. At the Sirena mine during October, the Guanajuato Consolidated Co. with 40 stamps, milled and treated by pan amalgamation, 100 tons of ore daily. The extraction was 85% of the gold and silver values at a cost of mining and milling of $10·11, Mexican, per ton. Enormous bodies of ore in sight carry values of over $20, Mexican, per ton. The Aparecida, La Luz, Cubo, Refugio, Carmen and Bolanitos mines have been taken up by Boston, Chicago and New York interests, with the object of introducing American methods of mining and milling, and a partnership mill capable of handling 1,000 tons of ore daily is under consideration. The native owners of Esperanzas, Cedro, and other famous properties are alive also to the need of reorganization, and there is no doubt that this camp will resume the premier position it has held for 200 years in the silver mining industry. No matter to what price silver may fall, the gold content of the ores will continue to sustain profitable operations for many years. Exploration work has demonstrated that the deeper mines were abandoned on account of the cost of unwatering, and very valuable ore deposits have been revealed in the bottom of the old workings. Power in Guanajuato under the most economical conditions cost during 1902, $350, Mexican, per H.P. per year. The Guanajuato Power & Electric Co. has completed arrangements to transmit 6,000 H.P. from the Duero River, near Zamora, in the State of Michoacan, a distance of 100 miles, which will reduce the cost per horse-power per year at the mines to less than $200, Mexican currency. At Pozos, operations have been very active and considerable interest is again being taken in mining operations.

Guerrero.—The ancient camp of Taxco is again receiving some attention. The ore bodies are large in extent, but usually do not exceed 15 to 20 oz. silver per ton. The ores contain silver, lead, zinc, and iron sulphides in such proportions that it is difficult to find a process to treat them profitably. A large body of pyrrhotite is being developed in the Campo Morado. The ore lies on a contact between black shale and igneous rock, and assays 2% copper, 40% iron, 5% silica, 45% sulphur and 0·2 oz. gold and 6 oz. silver per ton.

Hidalgo.—The Pachuca mines treat more than 7,000,000 oz. silver annually. The Santa Gertrudis Mining Co. and the Guadalupe mill have been amalgamated. The electric power plant operating from a distance of 21 miles has been of great advantage to the camp, and fair profits have been obtained. The patio process has perhaps reached its highest efficiency in this camp, 90% of the silver and 20% of the gold being extracted from ores assaying 25 oz. silver and 0·08 oz. gold per ton, although the rise in the cost of treatment points to its early abandonment. In Zimapan considerable work has been done in the silver-lead carbonate and copper properties, the English company having been bought out by Colorado capitalists.

Jalisco.—Work has been started on the extension of the Guadalajara branch of the Central Railway to the Pacific. This railway, from Sayula to Colima, passes through an almost virgin copper-gold country. Labor is cheap, and on account of the proximity to the Aguascalientes smelter, ore can be readily

marketed. On the Santiago River the Castellanos gold-silver mine has been purchased by the Mexican Gold & Silver Recovery Co.

Mexico.—The El Oro gold mines have been operated successfully, but the scarcity of fuel is becoming a serious feature. The owners of the Dos Estrellas mine have cut a rich and productive ore body. El Oro Mining and Railway Co. has acquired a large number of claims adjoining its properties. This camp is the richest gold mining district in the Republic. The ore occurring as gold quartz in shale is crushed, carried over plates, and the residues cyanided yielding 80% of the total values. The adjoining camp of Tlalpujahua is a silver camp, and the change to gold mining in this district resembles the similar change in Colorado after 1893.

Michoacan.—The operations of the Inguaran Copper Co. have not increased during the year. The French owners have not yet decided to build the contemplated electric power transmission plant. In Angangueo 2,000 tons of silver-bearing iron pyrites have been mined monthly. The ore carried over 20 oz. silver per ton, 8% zinc blende, with some galena and 30% sulphur. This ore was formerly roasted in open heaps and shipped as an iron flux to Aguascalientes, but the crude ore is now shipped to the same point, and used in the copper plant.

Oaxaca.—The Oaxaca and Ejutla Railway has been extended into the district of Taviche, and the operations in the Ocotlan mining camp have been very active. The principal mine in the district, the Escuadra, containing siliceous silver-gold ore, has been purchased by Omaha capitalists. About 1,500 tons of ore, assaying 90 oz. silver, and from 0·2 to 0·5 oz. gold per ton is being shipped monthly, and a local treatment plant is under construction by the Taviche Milling Co. The gold-silver ore bodies of Ixtlan are being worked very actively, and large profits are being made by the owners of the Natividad mine.

Puebla.—The pyritic deposit of basic, silver-gold, zinky copper ore at Tezuitlan has been actively worked throughout the year. The ore is now being smelted at the rate of 5,000 tons per month, and the copper matte converted into blister copper. Power is obtained from a 1,000-ft. water fall and transmitted five miles to the mines and smelter.

San Luis Potosi.—A new bonanza has been found in the sulphide zone of the La Paz silver mine in Matchuala, which assures the future of the mine for a long time. The monthly production is 4,000 tons of ore assaying from 45 to 50 oz. per ton. The Guggenheim Exploration Co. has secured in Matahuala, the Trinidad mine and the stock of the Azul mine, both adjoining the Dolores property, which is a producer of copper ore carrying silver and gold. In Charcas the Tiro General silver-zinc mine is being developed, and a considerable tonnage of ore was shipped.

Sonora.—The Yaqui Indian uprising has disturbed conditions in the southern portion of the State, and freighting has almost ceased in the central portion from the lack of pasture. The Picacho mine north of Arispe, belonging to Phelps, Dodge & Co., made regular shipments of high-grade siliceous gold ores, and the Chispa mine, south of Arispe, again commenced to ship high grade gold-silver ore. The development of mining in the Sonora, Oposura and Yaqui valleys is greatly retarded by the excessive cost of transportation to the Sonora Railroad.

In the northern portion, the extension of the El Paso & Southwestern Railroad to Douglas, Texas, and the extension of the Mexican Central Railroad to Nacosari has considerably stimulated mining which has been further aided by the entrance of Phelps, Dodge & Co. into custom smelting on a large scale. The Pilar de Teras, a siliceous camp, is producing high-grade ore. On account of their location the Lampazos silver mines and the lead properties in Sahuaripa have received but limited attention. Shipments of lead-copper-silver concentrates have continued from the Dura and the Bufa mines. Progress in the Minas Prietas gold district, south of the Batuc district, has been interrupted; the Grand Central mine is reported to have been closed down permanently, and the cyanide mill has treated all of the tailings available. The Creston Colorado mines seem to be the only properties in successful operation around Alamos, the Predras Verdes and Quinteras copper-silver mines continue to produce the bulk of the values and ship matte assaying 40% copper, 20% lead and 200 oz. silver per ton. The Colorado de Ures property of the Mexican Gold & Silver Recovery Co. has been closed down. The Dos Cabezas mine has opened up a very large siliceous silver-gold deposit, and the problem of local treatment is receiving the attention of the leading mill-men of the United States. So far, the best work shows an extraction of 80% of the gold and 55% of the silver content by a combined cyanide process.

Zacatecas.—The San Rafael group of mines in Zacatecas City has been acquired by English capitalists. The Boti mine continues to produce gold-silver ore, and operations at the Veta Grande silver mines have been very successful. Attention has been paid to the Zacatecas gold belt, and the introduction of the cyanide process will materially aid the work during 1903. Development on a large scale at the Mala Noche mine has demonstrated the value of the ore deposit in depth. At Concepcion de Oro and Mazapil the building of a smelter and a railroad into this gold-copper camp by the Mazapil Copper Co., has been the cause of increased activity. The production of copper and lead ores from this district is approximately 7,000 tons monthly. The Minillas camp produces lead sulphides with high silver content. The San Carlos and Santa Maria de Guadalupe properties have paid very large dividends during the past two years. At the Sombrerete mines the lixiviation plant has been running steadily, and the shipments of high-grade ore were maintained throughout the year.

Territory of Baja California.—Renewed activity is taking place in the gold mines of this Territory, and large profits have been made in the Ensenada country. The scarcity of fuel and water is a great drawback.

Territory of Tepic.—At La Yesca the siliceous lime-manganese ores carrying 40 oz. silver and 0·3 oz. gold per ton have been treated successfully by roasting with salt and cyaniding. The erection of a large plant is now under consideration.

Central America.—*Costa Rica.*—The Bella Vista and Thayer mines equipped with 20-stamp mills, were worked during 1902. The present capacity of the Thayer mine is 100 tons per day, which yields from $8,000 to $10,000 per month. The ore is low grade, but is easily mined. The Abengarez goldfields include the Tres Amigos, Tres Hermanos, and Boston mines. The

Abengarez Co. is substituting water power (300 H.P.) with electric transmission, for steam power, enlarging its mill and cyanide plant, and putting in air compressors for drilling. The ore averages 15 dwt. gold per ton. The average value of the ore of the El Porvenir mine, now owned by the Rio Grande Gold Mining Co., is from $40 to $60 per ton. A new 1,000-ft. main tunnel was to be built and power drills were to be installed in May, 1902.

Honduras.—The production of precious metals during 1902 was 23,234 oz. gold and 1,010,204 oz. silver. The report of the New York & Honduras Rosario Mining Co., for the fiscal year ending Nov. 30, 1902, states that dividends amounting to $105,000 (7% on the capital stock of the company) have been paid during the year, making the total dividends to date $1,800,000. The expenditures for the year including dividends amounted to $631,245, while the income from interest and sale of bullion amounted to $490,274. The surplus at the end of the fiscal year was $842,294. The ore in sight is estimated to be about 30,000 tons. The company is now shipping the concentrates to the United States. A Herreshoff roaster and a reverberatory furnace are being erected in order to reduce the quantity of concentrates to be shipped. The Aramecina mines continued in operation. The Ulna Co. is surveying a road in order to develop the Olancho gold mining district. It is believed that the line can be built in two years.

Nicaragua.—In Nueva Segovia and Prinzapulca, placer mining on a small scale is being done. In the vicinity of Rama there are rich mines. The El Mico mine employs a 20-stamp mill, the ore vein being 22 ft. thick.

Salvador.—The Loma Larga mine has a 3-ft. vein, which averages $20 in gold and silver. The main shaft is 394 ft. deep, and the main level is 1,640 ft. long. About 30,000 tons of ore have been taken from this vein, but water now prevents further working. The San Francisco vein is 6·5 ft. wide and assays $10 per ton of ore in gold and silver, the gold being free. The main shaft is 230 ft. deep with 1,640 ft. of drifts. The Mantos del Socorro and De la Senora mines yielding ores which assay $12 gold per ton, are operative, 600 tons of ore were treated by the cyanide process. The capacity of the plant is 40 tons per day, and 150 men, all natives, are employed. The exports of gold in 1901 were $192,735, a large increase over the exports for the previous years.

SOUTH AMERICA.—*Argentina.*—The Famatima Development Corporation, Ltd., capitalized at £400,000, has been formed to take over the Famatima Copper and Gold Syndicate, Ltd. The mines are in the Mexicana spur of the Famatima Range. There are 14 lodes of ore averaging 4 ft. in width and two miles long. An aërial tramway is being built to the town of Chilecito, a distance of 25 miles, which will reduce the cost of carrying ore to the smelter from 35s. to 2s. per ton. Water is abundant, and the cost of labor 2s. 2d. per day. The ore, which contains gold, silver, and copper, on smelting 30-ton sample lots, gave results varying from £7 15s. per ton to £22 10s. per ton. The Rosario Co. is operating a 36-in. water-jacket blast furnace for copper in the Calamuchita district, 60 miles southwest of Cordoba City. The ore smelted consists of chalcopyrite and pyrite in quartz, yielding from 5 to 6% Cu. The 65% matte product containing 30 oz., silver per ton is exported. In the Rioja province, an Otto overhead wire rope tram-

way 22 miles long is being installed to transport the rich ores of the Mexicana district to the four copper smelters near Chilecito. This will also revive work in the silver mines of the range which have been inoperative since 1893. The Upolongos mine in the Mexicana district, which has been in continuous operation for many years yields ore assaying 15·3% copper, 65·5 oz. silver and 1·2 oz. gold per ton. The 65% matte produced by smelting contains 271·4 oz. silver and 4·9 oz. gold per ton. The Andueza mine in this district produces ore containing from 5 to 7% copper, 2 oz. gold and 30 oz. silver per ton, while the San Pedro shipping ore assays up to 30% copper, 15 oz. silver and 0·5 oz. gold per ton. The gold and silver ores are smelted with copper ores in the four furnaces in that district, and the matte containing from 60 to 65% copper, together with the precious metals, is crushed and shipped to Europe. The Carranza-Lafone Copper Smelting Corporation of London, capitalized at $3,000,000, has acquired the mines and smelters in the Capillitas and Atajo districts, and a thoroughly modern plant is proposed which is to utilize power from an electric plant at Huason, 10 miles distant. In the Santa Catalina district the new railroad from Jujuy City to Bolivia will aid the development of gold mining. There are several quartz veins containing 2 oz. gold per ton, which, owing to the elevation of 12,000 ft. and lack of fuel cannot now be profitably worked.

Bolivia.—The California, Sallfria and Socorropata mines are situated in Yani County, State of La Paz, about 100 miles from the coast, and at an altitude of 12,690 ft. The lode consists of quartz between walls of slate, varying in width from 35 to 400 cm. and carry from 25·5 to 54·5 oz. gold per cajon (two tons). Lumber and water power are abundant, and the native Indian receive 25c. per day wages. At the Huanchaca mine an electric plant of 2,000 H.P. run by water power has been installed, the current being transmitted a distance of 80 km., and many improvements in the reduction works are under way.

Brazil.—According to Antonio Olyntho, the output of gold in Minas Geraes for 1902 was 4,469 kg., valued at $2,722,780, of which 4,063 kg. were from mines operated by foreign companies. For the half year ending Aug. 31, 1902, the Morro Velho Co. reports an output of 41,044 oz. gold bullion which sold in London for £137,953. The quantity of ore raised amounted to 79,141 tons, of which 72,700 tons were crushed. The total expenses amounted to £88,872. The Ouro Preto Gold Mines of Brazil, report an output during the fiscal year ending June 30, 1902, of 21,258 oz. fine gold, valued at £89,664, which with the receipts from rents and from the sale of arsenic increased the total income to £90,169. The total expenses amounted to £83,642, leaving a balance of £6,527. The amount of ore milled was 67,792 tons as compared with 64,082 tons for the previous 12 months. The new cyanide plant was completed in January, 1902, and the company no longer uses the chlorination method, but treats all its concentrates by the cyanide process. An extraction of 89·1% was obtained as compared with 83·5% for the previous year. Development has now reached a depth of 2,210 ft. The vein which is 13 ft. wide at this level consists of good milling ore. No work has been done upon the Santa Anna property owned by the same company.

The gold fields of the State of Minas Geraes have been well described by

H. Kilburn Scott in a paper read before the American Institute of Mining Engineers, May, 1902. Veins of gold in quartz, assaying 470 g. per ton (equivalent to $235 in value) are reported to have been found in Tassaras, 2 km. distant from the Ouro Preto mines. Dr. Timothes Da Costa reports the results of 10,500 pan washings of gravels from the Carno River to average 3·13 g. gold per ton.

Chile.—The South Chilean Syndicate, capitalized at £32,000, operated placers near San José, but the Valdivia Co., with a capital of £15,000, which started operations at Panquinlahue, suspended work. A gold mine is being operated at Quinco. During 1902 a company operating the cyanide process on old mill tailings, extracted and shipped gold precipitate to the value of $80,000, and the Anglo-Chilean Exploration Co. at Huasco produced from 10 to 11 kg. gold per month from its stamp mill. The principal silver mines which produce about 7,000 oz. per month, are located in the district of Caracoles, 150 miles inland from Antofagasta. Operations are carried on by the leasing system, the lessees paying the owner of the property a royalty of from 15 to 30% upon the net value after deducting mining expenses. The silver-lead smelting works are at Antofagasta, one being in the suburb Bella Vista, owned by the Antofagasta Smelting Co., and the other at Playa Blanca, owned by the Compañia de Minas de Huanchaca. American and French capitalists are interested in the Huanchaca company. Up to March 1, 1903, the Chilean Government melted and sold in the London market 3,300,000 silver soles, replacing the coinage by imports of gold —a step necessary in order to maintain the gold standard.

Colombia.—The continuation of the civil war has hindered the active development of mining, although in the interior of the country operations have been conducted successfully. The Province of Antioquia produces 90% of the total output of gold, which during the past few years has exceeded annually $2,000,000 in value. Silver ore is exported chiefly to Germany and England, in value amounting annually to about $1,500,000. The Zaucudo mines operated entirely by native management employed nearly 2,000 people in 1902, and produced about $20,000 in bullion per month. The Frontino and Bolivia Gold Mining Co., Ltd., which owns the Salada and Silencio mines, operates three California and several native wooden mills. The Leristales and San Nicolas mines, with a 35-stamp California mill, are in operation again after having been closed during the revolution. The Colombian Mines Co. has a native 24-stamp mill at its Venecia mine, and will erect a California mill. The Bramadora mine is being developed, and a Californian 80-stamp mill will be erected. At the San Andres mine, there are over 26,000 tons of ore reported in sight, valued at $42·63 per ton, and 5,000 tons of tailings, valued at $28 per ton. The ore is iron pyrites carrying a little galena and zinc blende, and the vein averages about 5 ft. wide.

Ecuador.—The South American Exploration Co., of New York, continues to operate successfully the mines in the Zaruma district, Province of El Oro. The principal veins vary from 15 to 16 m. in width. The work is through tunnels, the lowest and principal tunnel being 2,300 ft. in length, reaching a depth of 650 ft. The ore is chiefly blue and white quartz, containing about 10% of iron, copper, zinc and lead sulphides, with occasional free gold. The ore is extracted chiefly by stoping large chambers and filling with surface rock, although small

chambers are sometimes stoped, and left open until convenient filling is obtainable. Timber is excessively costly, and the common timber of the vicinity becomes decayed in a few years. The mill is equipped with 40 stamps, each of 850 lb. weight. The pulp passes over three 5-ft. copper plates for amalgamation, and thence to steel cyanide vats. Amalgamation yields 30% of the product, and subsequent cyanide treatment of the mill pulp, to which discarded slimes are added, yields 70%. The slimes are impounded in large reservoirs adjacent to the vats. The strength of the cyanide solution is 0·075%. Freight from the coast by mule back costs from $1 to $2 per 100 lb., according to the class of material and the time of the year, travel being very difficult from January to April. Native labor costs $0·50 gold per diem and native contract miners from $0·50 to $2 per diem.

Guiana.—The quantity of gold entered at the Department of Lands and Mines, British Guiana, during 1902 amounted to 103,050 crude oz. (about 900 fine) as compared with 105,945 crude oz. in 1901, while the exports for 1902 were 108,522 crude oz., valued at $1,898,672, as compared with 101,014 crude oz., valued at $1,771,620 in 1901. A large hydraulic plant has been installed at the Omari mine, which promised very satisfactory returns. The cessation of dredging by the British Guiana Co., on the Barima River, is reported to have been due to the unwarranted large scale of operations. A foreign syndicate has been formed to operate a dredging concession in the Peruni district. The British Guiana Consolidated Gold Mines, Ltd., organized Nov. 29, 1902, has acquired the Barima mine and works four miles southwest of Arakaka, in territory recently awarded to Great Britain. The property aggregates 322 acres, and the mill is equipped with a 20-stamp battery and accessories, 75-H.P. vertical boiler, 60-H.P. engine, etc. The ore is free milling quartz assaying about 1 oz. gold per ton. A grant of 500 acres of Crown land and freedom of royalty for 10 years is offered by the Government to any one who discovers platinum, silver, copper, coal or petroleum in the colony before January, 1907.

In French Guiana the higher tax rate on gold (8%), as compared with 5% in Dutch Guiana, is accountable for the difficulty in obtaining exact statistics of production. The reports of organized companies which cannot evade the tax give an aggregate output of from 90 to 100 kg. gold per month, while the actual monthly exports amount to from 250 to 280 kg. This shows that the greater part of the output is derived from the operations of the small workers or "marauders," who are not particular as to the ownership of the territory from which the stock of the precious metal is obtained. According to David Levat in his excellent work *La Guyane Française en 1902,* the tax is evaded by the presentation of a sworn statement that the gold was derived for the most part from beyond the frontier, paying perhaps the 8% tax on a small portion only. This is especially true of the workers in the Inini placers. Furthermore, the statistics of exports of gold from Dutch Guiana during 1901, which amounted to 23,270 oz., valued at £82,630, include 13,139 oz. of gold obtained from French Guiana, the difference in the tax rate of the respective governments causing shipments through Dutch Guiana.

The production of gold in Dutch Guiana during 1902 is officially reported to

have been 587·6 kg. as compared with 752·8 kg. in 1901. The statistics of export include a portion of the production of French Guiana, which passes through Dutch Guiana on account of the lower Government tax rate in the latter country. The development of the gold mining industry is seriously hampered by the difficulties of transport, an obstacle which will be removed by the construction of the proposed railroad from Paramaribo to the Lawa district.

Peru.—The production of gold during 1900 was 52,480 oz., valued at $1,084,750. The Nimrod Syndicate has acquired the Chuquitambo gold mines near Cerro de Pasco, formerly worked by the Spaniards. A large quantity of ore is available which though not rich is of sufficiently high grade to be treated with profit. A New York syndicate has purchased practically all of the productive properties in the Cerro de Pasco district at a price of $2,650,000, thereby controlling at least 80% of the mines. A railroad from this district to Oroya is under construction, and will probably be completed before the end of the year, which will lower the freight rates to 24 soles ($11·66) per ton from the present rate of from 70 to 80 soles ($34 to $39) now paid for transportation on the backs of llamas. The Caylloma Silver Mining Co., Ltd., operating the San Pedro, Santa Isabel tunnel, Bateas and Eureka mines report for the fiscal year ending June 30, 1902, gross receipts from ore and bullion amounting to £47,541; deducting £2,000 for depreciation the net loss was £3,421. The year's work showed 730 tons of ore shipped, of an average assay of 416 oz. 6 dwt. silver and 1 oz. 1 dwt. gold per ton, the total value being £29,837. Bar silver sold during the year contained 166,051 standard oz. silver and 154 oz. gold of an aggregate value of £17,703. Owing to the decline in the price of silver, it is reported that the company is seriously contemplating a shut-down of the works. The Inca Mining Co., owning mines in the interior of the country, has recently purchased from an American company a $40,000-milling plant, consisting of a 30-stamp mill, 8 Wilfley concentrators, engines, boilers, etc. The machinery was packed in 300-lb. lots as the only means of transportation is on the backs of llamas. During 1902 Barkis & Johnson Co. shipped to London 3,000 tons of copper matte containing from 40 to 50% copper and from 225 to 235 oz. silver per ton. The company is developing rapidly and expects to produce more than double its present output during 1903. The Alpa Mina in the Yauli district, produced 250 tons of ore assaying 40% lead and from 30 to 100 oz. silver per ton.

Uruguay.—The quartz mines of Cunapiru, San Gregorio and Santa Ernestina in the Rivera department, have been operated by a French company, which during 1901 treated 6,183 tons of ore, yielding 72 kg. gold, valued at $47,815, as compared with 7,345 tons, yielding 71 kg. gold, valued at $47,342, in 1900. The cyanide process recently adopted has given better results. The mines are small—mostly surface work—and assays from 12 workings range from 6·75 to 30·79 g. ($4·50 to $20·50) per ton. During 1901, 25 new applications for mining privileges were filed in the departments of Cerro Largo, Minas, Maldonado, Canelones and Florida. A serious obstacle to the development of the mines is the lack of water. A percentage of the total output of gold is paid to the Government.

EUROPE.—*Russia.*—Reports of operations at the so-called "Finnish Klondyke"

on the banks of the Iraljoki and Tolosjoki in Lapland, state that several hundred men are engaged in working the deposits. The severe climate is a serious obstacle to development. The gold mining region of Primorski, Siberia, is divided into two parts—the northern, on the Amur River and the Okhotsk Sea, and the southern, on several small rivers along the South Ussuri district and the island of Askold. Mining has increased in the former since the construction of the Ussuri and Transbaikal Railroad. Trial excavations are made at a distance of 1 verst (0·653 mile) apart. The ground is stripped by hand digging, the turf being removed by horse cars; but recently ground sluicing has been introduced for this purpose. A workman is paid from 61·2 to 92·7c. a day. The richest gold placers in the South Ussuri region have been worked by ancient Chinese processes, which limit the quantity to be washed in 24 hours to 375 cu. m.; for this reason no deposit is worked which yields less than 1·65 mg. gold per cu. m. For washing 900,000 cu. m. sand per year, 2,000 men and 500 horses are required. The Russian Ministry of Finance is projecting a railroad 600 miles in length from the upper reaches of the Angara River to the River Vitim across the richest gold-bearing district of Siberia, lying to the northeast of Lake Baikal. It has also decided to establish four new gold refineries in Eastern Siberia; two to be installed by the Ministry of Finance at Blagovestchensk and Krasnoïarsk, one at Nicolaïevsk, and one at Badaïbo.

Servia.—The Rusman gold mine at Glogowitza on the Timok River is still in its preliminary stage. A mill consisting of 10 stamps weighing 550 kg. each, together with an amalgamation and concentrating plant, was set in operation toward the end of 1900. The ore consists of pyrite averaging 30 to 40 g. gold per ton. Two Servian companies prospected for gold in the valley of the Pek River, near Kutchevo, where alluvial deposits containing fine and coarse grains of gold have been found. A large number of quartz veins were found showing free gold, galena, chalcopyrite and pyrite.

Spain.—English capital has become interested in alluvial mining in the provinces of Lugo, Orense and Leon on the rivers Sil and Miño and tributaries; in all 33 properties of an aggregate area of 4,179 acres have been acquired. The nature, value and depth of the alluvial is common to all, and covers almost the entire area of each concession, its depth varies from 10 to 25 ft. of a minimum value of 5 dwt. gold per cu. yd. The cost of working the deposit by small machines of a daily capacity of 25 cu. yd. is stated to be 2·5d. per cu. yd.

AFRICA.—*Egypt.*—During 1902 the Egyptian Mines Exploration Co., Ltd., the Egyptian Development Syndicate, and the Egypt & Soudan Mining Syndicate have explored the property granted to them by the Egyptian Government. The first of these companies has been working on its mines at Um Rus, the main shaft now being 250 ft. in depth. The vein varies in width from 4 to 40 in., and assays from 1 dwt. to 5 oz. gold. Native labor is in abundance at wages from 1s. 6d. to 1s. 8d. per day, while the cost of fuel is 35s. per ton. At the Fatira mine the vein varies in width from 8 to 40 in., and samples assay from 1 dwt. to 3 oz. 15 dwt. gold. Both mines had been worked in ancient times. The Central Egypt Exploration Co., Ltd., which is a subsidiary company

of the Egyptian Exploration Co., has been capitalized at £150,000. The district owned by the company occupies 1,200 sq. miles. Two ancient gold mines have been rediscovered—the Fowkir and the Um Esh. The quartz vein in the latter is half a mile long and from a few inches to a foot thick. A part of the ore assayed 11 dwt. 12 gr. gold per ton. In the Fowkir mine samples assay from 1·5 to 5 dwt. gold per ton. Labor is abundant and cheap, but fuel and timber will have to be imported; the mines, however, are easily accessible from the coast. The Nile Valley Co. in its report of March 5, 1903, states that it has received a concession of 6,000 sq. miles from the Egyptian Government. At the Um Garaiart mine, owned by this company, there is a complete hoisting and pumping plant and a small battery is being erected. Three shafts have been sunk, the reef varying from 18 in. to 9 ft. in thickness, and the ore assaying from 20 to 250 oz. gold. Ore valued at £11,000 has been taken out of the mine. The Egypt & Soudan Mining Syndicate, Ltd., for the year ending September 30, 1902, reports that its concessions in Egypt comprise an area of 2,000 sq. miles, and in Soudan about 20,000 sq. miles. On its Egyptian property at Hamesh three shafts have been sunk, the ore assaying from 12 gr. to 1 oz. 4 dwt. per ton, and at Samut three other shafts show the vein to vary from 0·5 to 1·5 ft. in width and to assay from 2 dwt. to 2 oz. 18 dwt. per ton. On its Soudan property investigation and development work have been carried on at Om Nabardi and Nabi, and it has been found that the ore assays from 5 dwt. to 1 oz. 16 dwt. gold per ton.

Gold Coast.—According to the Controller of Customs at Accra, the exports from the Gold Coast Colony during 1901 amounted to 6,163 oz. bullion, equivalent to 5,224 oz. fine gold, valued at £22,187, as compared with 10,557 oz. bullion, valued at £38,007, in 1900. The Asiakwa Hydraulicking & Mining Corporation, Ltd., owns 20 sq. miles of territory; a test on 338 cu. yd. of gravel gave by hydraulic mining 20 oz. 1 dwt. gold assaying 930 fine. A plant is to be built to produce 40 oz. gold per day. The New Gold Coast Agency, Ltd., has acquired the Gold Coast Agency, Ltd., and obtained large concessions in the Tarkwa district belonging to the Nassau Gold Coast Mining Co., Ltd., and the Gold Coast Pioneer Syndicate, Ltd. The new company has formed two subsidiary companies—the Adjak Bippo Deep, Ltd., and the Cinnamon Bippo Co., Ltd.—both capitalized at £100,000. Both of these latter companies are developing their properties. The reef of the first varies in thickness from 10 to 44 in. and assays from 2 to 23 dwt. gold per ton, while the reef of the second varies from 2·5 to 18 in. and assays from 3 to 24 dwt. gold per ton.

Ivory Coast.—The Consolidated Goldfields of the Ivory Coast, Ltd., increased its capital to £1,000,000 after taking over the property of the New Austral Co., Ltd. The concession owned by the company covers 2,000,000 acres. The New Austral properties are situated in the districts of the Baoulé, Sanwi, Indénié, Attie and Biano rivers. The sample of the ore taken from the Amangara reef assayed from 1 to 18 oz. gold, and from 0·5 to 2 oz. silver. Engineers have been sent out to investigate the property. On the bank of the Menzan River quartz has been found which assays from 2 to 30 dwt. gold per ton. At Assikasso,

where the work has reached a depth of 60 ft., assays show gold throughout the deposit.

Madagascar.—The exports for 1901 were gold dust, 2,374 lb., valued at $590,765, and gold in bars, 245 lb., valued at $46,073, as compared with gold dust, $641,355, and gold in bars, $51,114 in 1900. The property of the Suberbieville Co. is to be developed by the South African Gold Dredging Co., the former company to receive 2 fr. for every hectare exploited, and a royalty of 20% of the value of the gold recovered from the placers and 25% of that from crushing. Three years ago the Suberbieville Co. erected a dredging plant at Majunga, but it was not placed in operation. It is reported that placer gold has been found near the port of Manangary. According to the mining regulation, which went into effect February, 1902, a 5% tax of the value of all mineral extracted is levied, being calculated on the quarterly production. In no case can the quarterly tax be less than $50.

Portuguese East Africa.—The exports of gold in bars and gold dust, domestic or foreign, in 1901, amounted to 1,136 lb., valued at £52,577. New regulations were made for the mining fields by which the reef claims have been doubled in size, runing 100 m. along the reef and 200 m. across. Companies floated on properties must pay to the Mozambique Co., either 10% (a reduction from the former 50%) of their nominal capital, or 20% of the vender's shares fully paid up. Claim holders may pay four times the tax above specified and dispose of their claims without any revision of share to the Mozambique Co. Concessions have also been granted on the rivers of the Mozambique Co.'s territories and dredges have been installed. Some work has also been done on the Richmond, Braganza, Revue and Guy Fawkes mines. Boys for working the mines are provided by the company at £1 per head per month. More than 2,000 boys are at work in the mines. Rich discoveries have been made in Mozambique. The Macequeci promises good results, and a valuable discovery has been made in the Uanetz district. The formation is the true conglomerate, as in the Witwatersrand. The reef extends for a long distance, 7 miles having been prospected. The district is north of Incomati, near the Transvaal. It is healthy, and there is an abundant supply of water and timber. A syndicate recently formed is prospecting the field.

Rhodesia.—The ore crushed in 1902 was 142,037 tons, yielding 194,268 crude oz., as compared with 172,150 crude oz. in 1901. The number of stamps in operation during the year was 370, of which 60 represent prospecting batteries. There are in course of erection 68 additional stamps, and 240 additional stamps have been ordered. The Selukwe mine, which during 1902 paid a 20% dividend, produced from 2,566 to 3,685 oz. of gold per month in its mill, while its cyanide plant produced 1,200 to 1,812 oz. per month. About 1,000 natives are employed. The working of all the mines in Rhodesia has been hindered owing to the difficulty of obtaining native labor. Then again the laborers, from no apparent reason, take a strong dislike to certain mines, which in consequence find the greatest difficulty in obtaining labor. For this reason the mines are now employing Shangaans from Portuguese territory, who are more disposed to settle down and work for a longer period. In the Geelong and Geelong Valley mines

it is estimated that there are 53,000 tons of ore in sight averaging 15 dwt. gold per ton. In the West Nicholson mine the ore in sight is estimated at 70,000 tons, assaying from 8 to 12 dwt. per ton, in addition to large tonnage of low grade ore. The 10-stamp mill is to be increased by the addition of 50 new stamps. The Red and White Rose mine has erected a 20-stamp mill and cyanide plant. Its ore assays 12 dwt. gold per ton. The Rhodesia Exploration & Development Co., Ltd., during the fiscal year ending June 30, 1902, was engaged in devoloping its six mines, excavating 12,635 yd. material at an average cost of £2 18s. 2·6d. per running foot. The Ayrshire Gold Mine & Lomagunda Railway Co., Ltd., for the year ending June 30, 1902, reports that the railroad from Salisbury to the mine has been completed. Its mine is being developed, 62,100 tons of ore averaging 10 dwt. having been blocked out. Its 5-stamp mill, which crushed 7,033 tons of ore yielding 3,895 oz. of bullion between April, 1900 and August 31, 1901, will be increased, and a cyanide plant added. The V. V. (Gwanda) Syndicate, Ltd., is also developing its ten properties and a 10-stamp mill is to be erected. It has sold three of its properties to the Imani Gold Mining Co., Ltd. The Selukwe Gold Mining Co., Ltd., for the year ending March 31, 1902, reported that it crushed 62,301 tons of rock yielding 38,049 oz. bullion, and treated in its cyanide mill, which was completed in October, 1901, 28,160 tons, yielding 6,472 oz. bullion. It realized from the sale of gold £159,862, and its total income was £160,101. The net profit for the year was £43,898, which with £52,275, the balance brought forward from the previous fiscal year, made a total balance of £96,171. A dividend of 10% was paid in August, 1902.

Transvaal.—(We are indebted to W. Fischer Wilkinson[1] for valuable information contained in this review.)—The opening of the year 1902 found the war still in progress, although the British troops were able to maintain tranquil conditions throughout most of the colony. By December, 1901, only 11 companies had taken advantage of the order issued in May granting permission to resume operations on a small scale, and the number of stamps dropping was only 653 out of the 5,970 at work before the war. As the difficulties incident to repairing damages, procuring supplies and getting a sufficient quota of native laborers were overcome, the list of operative mines was gradually increased. In January, 1902, 21 companies with 1,075 stamps were working; in April, 33 companies, 1,760 stamps; in June, 37 companies, 2,130 stamps; in August, 39 companies, 2,395 stamps; in October, 41 companies, 2,570 stamps, and in December, 45 companies, with 2,845 stamps. Hostilities ceased on May 31, 1902, when the peace negotiations were signed by the two parties. The losses sustained by the mining companies on account of the war were heavy, although little wilful damage was committed by the Boers. The largest item—the costs of care-taking, unwatering, repairs, salaries and wages—amounted to £3,400,000; while the gold appropriated by the Boer Government from the mines was £2,475,178. Exclusive of interest on capital the total loss may be placed at about £6,000,000. In some respects the changed conditions under the new rule have been for the benefit of the mining companies. The latter have profited

[1] *Engineering and Mining Journal*, Jan. 8, 1903, p. 16.

by a material reduction in the price of explosives and coal, and also by the removal of certain import duties. The high railway rates, however, have not been altered. As an offset to the concessions granted, account must be taken of the increase in the profit tax to 10%, which will directly affect the dividend distribution upon mining shares. The greatest difficulty in the way of rapid progress at the present time is the scarcity of native labor. Of the 100,000 natives employed before the war less than half that number returned to the mines in 1902, despite the best efforts of recruiting agents in all the native districts. The experiment of replacing their labor by unskilled whites has been unsuccessful, and there are serious objections to the importation of Asiatics. The scarcity of natives has been due to several causes—the employment of large numbers in the army, the abundance of harvests and the reduction in the wages paid at the mines. Under the present stringent administration of the liquor law, it is stated that the natives give much more efficient service than formerly. The output of gold for the year ending June 30, 1902, according to the report of the Commissioner of Mines, was 891,999 fine oz., valued at £3,788,968. Of this amount, the mines on the Witwatersrand contributed 851,799 fine oz., valued at £3,618,206, while the output of the reduction works amounted to 40,200 fine oz., valued at £170,762. Of the tailings treated during the year 1,092,369 tons of sand and 220,997 tons of slimes were treated by the zinc process, and 71,302 tons of sands and 41,675 tons of slimes were treated by the Siemens-Halske process. The percentage of waste rock sorted on the surface before milling averaged 19·012%, and for each ounce of fine gold produced, 2·457 tons of ore were raised. The total output of gold for the Witwatersrand in 1902 was 1,690,101 fine oz., valued at £7,179,074, as compared with 238,995 fine oz., valued at £1,014,687 in 1901, an increase of 1,451,106 fine oz., valued at £6,164,387. The increase was divided as follows: Mill yields, 897,231 oz.; concentrates and by-products, 48,836 oz.; tailings, 458,243 oz.; slimes, 46,283 oz., and other sources, 512 oz. The gold exported during 1902 amounted to £7,239,888. The mining companies of the Transvaal, excluding investment and land corporations, represent an investment of 200 millions sterling, or about a billion dollars. This is approximately equal to the cost of the Boer war. The number, nominal capital and market valuation of the companies are as follows:—

Description.	Number.	Nominal Capital.	Market Valuation.
Mining	301	$460,440,000	$979,090,000
Investment	36	124,000,000	495,000,000
Land	13	38,550,000	90,000,000
Totals	350	$622,990,000	$1,564,090,000

Messrs. Læggett and Hatch estimate the ore lying within the depth of 6,000 ft. and length of 46·9 miles at £1,233,560,709. The output should average £30,000,000 per year, and at this rate it would take 42·5 years to exhaust the fields. During 1902 the mining companies paid dividends amounting to £1,442,375. The Consolidated Goldfields of South Africa, Ltd., for the year ending June 30, 1902, reports a profit of £893,385, out of which £124,629 for dividend and tax were paid, leaving £663,722; this, with amount brought for-

ward from the previous year, £1,512,206, makes £2,175,928, out of which a dividend of £500,000 is to be paid, leaving £1,675,928 to be carried forward. The Robinson Deep Gold Mining Co., owned by this company, re-started in March, 1901, with 50 stamps, and between March 1 and August 30, 1901, the company milled 48,615 tons of ore, yielding 23,934 fine oz. gold, valued at £99,452. The working expenses amounted to £81,355, leaving a profit of £18,097. The Glen Deep, Ltd., for the year ending July 31, 1902, states that operations were resumed in March, 1902, and between March and July 31, 1902, it crushed 27,328 tons of ore with 35 stamps, yielding 9,380 fine oz. gold, valued at £39,336; the expenditures during the same period amounted to £32,682, leaving a profit of £6,653, from which must be subtracted interest charges of £2,481, making the net profit £4,173. The ore reserves were estimated at 383,694 tons. The Simmer and Jack Proprietary Mines, Ltd., for the year ending June 30, 1902, reports a resumption of operations April 23, 1902, with 50 stamps, which were increased to 100 in June. The total tonnage crushed was 28,404, yielding 8,225 fine oz. gold, valued at £34,642, and the working expenses were £35,608. The 40 additional stamps started before the war were completed, increasing the capacity of the plant to 320 stamps, and a drying and a reverberatory furnace were built for drying and smelting the gold slimes. The Jumpers Deep, Ltd., for the year ending September 30, 1902, reports that it resumed operation in February, 1902, and in eight months treated 74,146 tons of ore, yielding 26,115 fine oz. gold valued at £109,152, and expended £95,090, leaving a net profit, after paying interest charges of £966, of £13,096. The ore reserves on September 30, 1902, were estimated at 619,137 tons. The Langlaagte Deep, Ltd., for the year ending July 31, 1902, reports that during seven months it milled 66,531 tons, yielding 25,433 fine oz. gold, valued at £106,448, and expended £81,284 for operating its property, and £25,161 for interest. The ore reserves on July 31, 1902, were estimated at 762,317 tons. The Nourse Deep, Ltd., for the year ending July 31, 1902, reports that during five months it milled 36,008 tons of ore, yielding 10,484 fine oz. gold, valued at £43,637, and expended £40,905 for operating its property, and £316 for interest, leaving a net profit of £2,416. The ore reserves on July 31, 1902, were estimated at 495,126 tons.

West Africa.—In January, 1903, the Prah Gold Mines, Ltd., the Clinton's Gold Concessions, Ltd., the United Gold Mines of West Africa, Ltd., the Atomé Mines, Ltd., and the Bakrobo Mines, Ltd., were consolidated. The consolidated company owns 1,000 sq. miles in West Africa. The nominal capital at the time of consolidation was £900,000, of which £694,000 had been paid in. The name of the present company is the United Gold Mines of West Africa, with a nominal capital of £500,000, of which £464,000 were issued at once, leaving £36,000 to be issued as required.

ASIA.—*China.*—The Syndicat du Yunnan, Ltd., has obtained a concession from the Chinese Government for a period of 60 years to exploit the mines and mineral deposits in 35 districts of the Province of Yunnan. These districts cover 40,000 sq. miles and contain 59 mines:—25 copper, 27 silver, 6 gold and one tin mine. Of the net profits of the company, 10% is to be paid to the Provincial

Government of Yunnan, 25% to the Imperial Chinese Government, and 65% to the Syndicate of Yunnan. The annual output of silver in Mongolia averages from 80,000 to 100,000 oz., and is obtained by the natives in a very primitive manner. Modern methods of treatment recently introduced were unsuccessful owing to the high cost of coke and machinery unsuited for concentrating the galena, which is very finely disseminated throughout the ore. The principal silver mines are 45 miles northeast of Jehol, the capital of Mongolia, first worked by the natives 50 years ago. There are two mines, the Ku Shan Tze and Yen Tung Shan, about five miles apart. The vein in the upper levels is composed of galena in iron ore from 2 to 4 ft. thick, while in the lower the silver-lead ore occurs between quartz porphyry walls. The deepest workings are 400 ft. below the surface. The ore is hand concentrated and roasted for a week in a primitive furnace 6 ft. in diameter and 5 ft. high, constructed of blue bricks. The roasted ore is then continuously smelted with fluxes in a brick furnace 1 ft. in diameter and 3 ft. high, until 100 lb. of lead has accumulated when the metal is quenched with water and cupelled in a furnace having a muffle 18×12×8 in. in size with a hearth of wood ashes. Ten hours are required to cupel 100 lb. of charge. When the product is 995 fine the silver is cooled in water, removed from the furnace and cut into pieces varying in weight from 5 to 50 oz.

Dutch East Indies.—(For a general description of the gold resources of the Dutch East Indies consult THE MINERAL INDUSTRY, Vol. X., p. 319.)—The development of the mining industry in Borneo, Sumatra and Celebes, where active exploration work has been carried on for several years, has not been attended thus far with financial returns. In the period 1893-1901 inclusive, 53 mining companies were organized with an aggregate capitalization of about $12,500,000, and more than $2,500,000 were expended in exploring various properties; of these ventures three have reached the producing stage, but as yet have not earned sufficient profits to warrant the payment of dividends. The Redjang Lebong mine in Sumatra has a 40-stamp mill and exploits a reef carrying about 2 oz. gold, and from 7 to 10 oz. silver per ton. During the year 1902 the mill treated 16,435 metric tons of ore for a yield of 21,982 oz. gold and 118,225 oz. silver, while 6,021 tons of ore were reserved for further treatment. Some difficulties were experienced in operating the slimes plant, and the production was greatly reduced by lack of water which necessitated an almost complete suspension of operations during September and October. At the Lebong Soelit mine, now owned by the Mynbouw Maatschappij Katahoen, a 20-stamp mill has been placed in operation. In northern Celebes, the Palehleh mine, which is located on an irregular vein averaging about 6 ft. in width, during the first nine months of 1902, produced 118 kg. gold and 43 kg. silver from 17,655 metric tons of ore. The production for the year 1901 was 143·5 kg. gold from 15,618 tons of ore. This property is operated by the Nederlandschindische Gold Mining Co. The Soemalata Co., whose mine is located 40 miles west of Palehleh, reported for 11 months of 1902 an output of 5,430 oz. gold; in 1901 its output was 8,460 oz. The most promising developments in Borneo have been made in the southern part near the Kahajang River, but as yet no mines have reached the producing stage.

India.—The quantity of gold produced from the Kolar field during 1902 was 513,220 oz. crude gold, valued at £1,959,268, as compared with 504,732 oz., valued at £1,921,000 in 1901. During the year the Government works for supplying electrical power to the mines was completed, and the full 8,000 H.P. will soon be available. Of the 15 operative companies in the Mysore district, five paid dividends amounting to £874,158, five produced gold but paid no dividends, while five were non-producers. The Coromandel, Nine Reefs, and West Balaghat mines are no longer producers; the first of these, however, will probably resume crushing in 1903. The production of gold decreased considerably during April, May and June, 1902, due to the scarcity of water. At the Hutti (Nizam's) Gold Mines, Ltd., at Hyderabad, a 10-stamp mill has been erected. The report of the Champion Reef Gold Mining Co., Ltd., for the fiscal year ending September 30, 1902, shows an income from the sale of gold of £571,705, and a total income of £543,326 after deducting the royalty paid to the Government, as compared with £576,329 in 1901. The expenditures amounted to £259,489, leaving a net balance of £288,293, out of which £130,075 in dividends were paid, or at the rate of 110%. The quantity of ore crushed amounted to 134,088 tons yielding 138,872 oz. bar gold, an average yield of 1 oz. 17 gr. per ton, while the tailings and slimes amounting to 115,411 tons treated by the cyanide process, yielded 11,873 oz. bar gold, an average of 2 dwt. 1 gr. per ton. The total production of bar gold was 150,745 oz. A new 120-stamp mill was placed in operation. The scarcity of water during the dry season (April to July) caused a large decrease in the output. A new cyanide plant with a capacity of 8,000 tons of tailings per month was started in August, which increases the total capacity of the plant to 20,000 tons of sand per month. The Mysore Gold Mining Co., Ltd., during 1902 milled 140,306 tons of ore yielding by amalgamation 154,905 oz. bar gold, an average of 1 oz. 2 dwt. 2 gr. per ton. The cyanide works treated 114,549 tons of tailings, from which 12,927 oz. gold were obtained, an average of 2 dwt. 6 gr. per ton. The plates yielded 672 oz., making a total output of 168,504 oz., as compared with 164,581 oz. in 1901. The gold realized £657,918, upon which £32,610 in royalties were paid. Receipts from various sources amounted to £3,131. Expenditures amounted to £253,704, and £344,500 were paid in dividends, a rate of 130% for the year. The balance on hand at the end of the fiscal year was £376,145. Since January, 1898, the company has paid £3,175,152 in dividends on a capital of £265,000. In November, 1902, the capital was raised to £290,000 by the issue of 50,000 shares of 10s. each, 15,000 of these shares and £20,000 being paid to the Gold Fields of Mysore & General Exploration Co., Ltd., for their 342-acre block. The capacity of the cyanide plant is 15,000 tons of tailings per month. The new 60-stamp mill was started in October, which increases the total number of stamps to 210; of these, 150 are operated by electric power. The ore reserve is estimated to be over 340,000 tons. The Ooregum Gold Mining Co., Ltd., milled 106,930 tons of ore during 1902, yielding 88,069 oz. gold valued at £327,846. The ordinary expenditure amounted to £164,675, and the profit to £148,937. The mills contributed 68,942 oz., the cyanide works 16,239 oz., and 2,888 oz. were obtained from skimmings, dismantling old mills, etc. The new 120-stamp

mill has been in operation for the greater part of the year. The Nundydroog Co., Ltd., during 1902 produced 58,034 oz. gold, valued at £218,171. The mills treated 55,940 tons of quartz, yielding 52,677 oz. gold, and 60,409 tons of tailings were cyanided for a recovery of 5,357 oz. gold. The Balaghat Gold Mining Co., Ltd., during 1902 produced 23,762 oz. gold from 25,635 tons of quartz crushed, and 2,635 oz. gold from 24,030 tons of tailing cyanided, a total of 26,397 oz., valued at £102,021. The expenditure amounted to £65,988. A dividend of £8,945 was paid, leaving a balance of £14,211 to be carried forward.

Japan.—The placer fields of Hokkaido, which cover some 20 sq. miles, made an output estimated at 10,000 oz. in 1901. Many of the individual operators have combined into small companies for the purpose of adopting American methods and working the sections more thoroughly. The development of the district is hampered by governmental restrictions, owing to which the actual working period in the year does not exceed three months.

Korea.—The development of gold mining in Korea has been hindered by the Government restriction, whereby but one concession is granted to each prominent power; so far, subjects of the United States, United Kingdom, Germany and Japan have located workings, and of these the American concession only has arrived at a producing stage. This property of from 400 to 500 acres in extent, is located in the northwestern section near the border of Manchuria. The principal mines with stamp mill equipment in operation are in three groups—Chittabalbie (20 stamps) and Maihong, 40; Kuk San Dong, 20; Tabowie, 40, and Taracol, 80. The groups are 22 miles apart, and each one is under a superintendent. In addition, prospecting and development are being carried on, and several mines are let to native tributors. The ore is quartz in granite, and the mills are equipped with vanners, but have no cyanide plant for the tailings. Very rich concentrates are shipped to the United States. With regard to the local conditions, water is plentiful except during a short period in winter; lumber is cheap, though not plentiful, and labor is cheap. Japanese are largely employed as carpenters, blacksmiths and engineers at about 3s. per day; Chinese mainly as surface coolies at the mills, although some are employed underground at 10·5d. per day; Koreans as miners or carpenters at 1s. 3d.; coolies at 7·5d. per day. Satisfactory results are obtained by having the natives work under direct supervision of a white man without an intermediate native foreman. The ground is not hard, but requires dynamite and timbering, square sets being used in large stopes, which vary from 4 to 15 ft., averaging 8 ft. The somewhat complicated occurrence of ore shoots is not conducive to cheap systematic mining. S. J. Speak estimates mining costs at from 4s. to 5s. per ton, with a width of stope not less than 4 ft. and moderate dead-work. Recent milling and concentrating costs at the Tabowie mill of 40 stamps with vanners and canvas plant, run by steam power using wood fuel were as follows: May, 1902, treating 4,008 tons, 1s. 8·8d. per ton; June, treating 4,130 tons, 1s. 7·5d., and July, treating 4,589 tons, 1s. 7·1d. The average working cost of a 40-stamp mill in this district varies from 1s. 9d. to 2s. per ton. The satisfactory work accomplished in Korea by Chinese labor under the supervison of white men

is an indication of what may be hoped for in mining in the temperate zones of the Far East.

Malay Peninsula.—The output of gold in Pahang in 1901 amounted to 23,948 oz., valued at £77,831, as compared with 17,048 oz. (£65,229) in 1900. The Kedana Co., which owns a mine near Mt. Ophir, Malacca, has erected a mill and has crushed ore for six months of 1902. The mill at Ketchau was not in operation during the greater part of the year, as it had no ore to crush. The Punjum Gold Mining Co. and the Tin Concession & Batu Bersawah Mining Co. are still prospecting. The Raub Australian Gold Mining Co. increased its output from 12,477 oz. in 1900, to 18,901 oz. in 1901. Four companies began exporting gold in 1901—the Malaysian Mining Co., 1,315 oz.; Queensland Raub Syndicate, 75 oz.; Malaysian Mining Co., 1,164 oz., and Bentong, 114 oz. In the Bentong mine a shaft was sunk 105 ft., but no defined lode was discovered; at the Raub mine samples assayed 11·5 dwt. gold. No deep shafts have been sunk; it is not known, therefore, if any of the mines continue in depth. The country is covered with heavy jungle, transportation facilities are inadequate, and means of communication are lacking, and although alluvial deposits are known to exist from Budu to Sepan, from Benta to Lipis, and along the Semantan and Krau rivers, and the tributaries of the Jelai River, the deposits have not been worked.

AUSTRALASIA.—(Through the courtesy of F. Danvers Power, special notes on the mining industries of the States have been incorporated in the following review.)—The year 1902 was one of depression throughout Australasia, principally on account of the low price of metals and the prevailing drought. The latter has acted directly by forcing certain mining operations to cease temporarily for want of water, and indirectly by its effect on the general prosperity of these States, inasmuch as the wool clip was a failure and the output of wheat did not suffice for domestic consumption, so that export was out of the question. Mining legislation did not encourage the investment of foreign capital. Despite the baneful effects of the drought development work has been carried on actively in some cases. That the present depression is not due to anything radically wrong with the mines themselves is indicated by the increased yield of gold in the principal States over that of last year, and the fact that other mines are ready to recommence work as soon as the prices of copper, lead and silver rise, or a sufficient supply of water is obtained. The combination of adverse conditions has caused a few mines to try to meet them by increasing their output with the same management, while being satisfied with smaller profits. By this means,

PRODUCTION OF GOLD IN AUSTRALASIA.

States.	1900.		1901.		1902.	
	Fine Oz.	Value.	Fine Oz.	Value.	Fine Oz.	Value.
New South Wales	281,616	$5,821,003	216,888	$4,488,076	254,435	$5,259,171
New Zealand	339,395	7,015,293	412,875	8,534,126	458,933	9,486,145
Queensland	677,024	13,994,086	598,382	12,368,556	640,463	13,238,370
South Australia (a)	19,376	400,502	21,946	453,624	24,082	497,775
Tasmania	74,552	1,540,990	69,491	1,436,789	70,996	1,467,487
Victoria	752,284	15,549,710	730,449	15,098,380	720,866	14,900,300
Western Australia	1,354,343	27,994,270	1,669,072	34,799,718	1,819,308	37,605,096
Totals	3,498,590	$72,315,854	3,719,103	$77,174,268	3,989,083	$82,454,344

(a) Includes Northern Territory.

as also by effecting other economies, the Broken Hill Proprietary Co. has been able to pay a half-yearly dividend. A proposal was made to amalgamate the principal Broken Hill mines in order to save expenses in administration, but it did not meet with a favorable reception.

New South Wales.—The increase in the output of gold is considered to be due to the gold extracted by smelters from ores received from other States and included in the returns as the actual produce of the colony. The industry has been severely affected by the drought, and many of the mines have been shut down from six to nine months. The Cobar district still continues to be the chief producer, the output for 1902 being 26,956 oz.; Wyalong contributed 20,718 oz.; Adelong, 14,414 oz., and Araluen, 13,909 oz. Seven suction and 22 bucket dredges were in operation in 1902, the Araluen Valley, Araluen Central, Tulloch's, Perry's, Jembaicumbene and Kiandra being the most successful. These dredges during 1902 produced 25,473 oz. gold, valued at £97,891, against 23,585 oz. gold, valued at £89,628 in 1901. The Araluen district contributed 52% of this total. At Nerrigundah, the Red Creek Gold mine has two veins, one 2·5 ft. wide and developed to a depth of 120 ft., the ore averaging 2 to 3 oz. gold per ton, and the other 6 in. wide, and averaging 10 oz. gold per ton. The Cobar Gold Mines, Ltd., reports for the year ending September 30, 1902, that it treated 30,730 tons of ore, 18,291 tons of tailings, and 9,965 tons of slimes, yielding 11,216 oz. gold, valued at £32,641. The total expenditures for the year amounted to £31,930, and the income amounted to £32,648. Besides adding to the plant and machinery, some development work was done. The company could only operate during five months of the year on account of the drought. The King Conrad Silver & Lead mine, situated at Inverell has gone into liquidation, while the Prince of Wales mine, at Gundagai, and the Post Office mine, at Stuart Town, the latter belonging to the Emma Co., have closed down. The Lachlan Gold Fields, Ltd., crushed and concentrated 7,192 tons of ore, and obtained from the sale of gold bullion, slag, and concentrates a net return of £17,906. The total output of silver, concentrates, ores, etc., in 1902, was valued at £1,440,179. The low price of silver caused the temporary closing of all the Broken Hill mines with the exception of the Proprietary, Central, Block 10 and South mines. The Federal tariff is felt more in New South Wales than in any other State, as in the past most goods were entered free. Its effect upon the mining industry is illustrated by the Broken Hill mines, where Oregon timber is used for the square sets. A duty is now levied of 6d. per 100 ft. on large timber, and 18d. per 100 ft. on smaller sizes.

New Zealand.—The exports of gold during 1902 were 508,043 oz., valued at £1,951,430, an increase of 52,482 oz., of the value of £197,647 over the preceding year. The quantity of silver exported during 1902 amounted to 673,986 oz., valued at £72,001, as compared with 571,134 oz., valued at £65,258 in 1901. The greater portion of the silver has been obtained from the mines in the Hauraki district. The gold produced by the Otago dredges during 1901 amounted to 65,227 oz. from an average number of 46 working dredges, while 63 dredges in 1902 produced 105,786 oz. According to C. E. Turner, the cost of operating a dredge designed to lift 2,000 cu. yd. per day of 24 hours is

£53 10s. per week. The total dividends paid by New Zealand mines, but not including the West Coast, during 1902, amounted to £145,967. On the West Coast 44 dredges produced 30,000 oz. gold, valued approximately at £120,000. Hydraulic sluicing is receiving increased attention, both in the Otago and West Coast districts. The Waitekauri Gold Mining Co., for the year ending May 31, 1902, produced 55,413 oz. bullion, valued at £46,728. The New Zealand Crown Mines Co., Ltd., during the year ending August 31, 1902, treated 32,561 tons of ore, obtaining 16,994 oz. gold and 13,266 oz. silver, valued at £74,238. The expenditures amounted to £53,521, leaving a profit of £20,717, which, with £5,236 brought forward from previous account, gave a surplus of £25,953, out of which a dividend of £15,000 was declared. The balance carried forward was £10,203. The 60-stamp mill now in operation is to be enlarged for 20 additional stamps. The Waihi Gold Mining Co., Ltd., during 1902 treated 179,487 tons of ore, yielding gold bullion valued at £520,138, and a dividend of £250,000 was paid. The company acquired the mines and 40-stamp mill owned by the Union-Waihi Co., so that it now operates 330 stamps. It is converting its dry crushing into a wet crushing plant. On the average 17,000 tons per month are crushed, and when all the stamps are converted the capacity will probably be raised to 20,000 tons per month. The Progress mine treated 55,976 tons of ore, yielding £106,996, the expense being £44,670, leaving a profit of £62,526. An important discovery of gold is reported from Kawhia, where the Government has withdrawn the land from sale on the ground that it contains minerals. All kinds of mining machinery in this colony are driven by electric power generated by the water supplied by rapid streams and rivers, the current in many cases being carried a considerable distance. The cyanide process has now been introduced in the Hauraki gold fields with an 85 to 90% extraction, where formerly an extraction of only 65% was obtained by amalgamation. The New Zealand Government, having bought the patent rights to the cyanide process from the Cassel Gold Extraction Co., received £4,577 as royalties for the fiscal year ending March 31, 1902. As soon as the Government is paid a sum equal to its outlay for the patent rights, all royalties will cease.

Queensland.—The dividends paid by the Queensland mines in 1902 amounted to £987,541. The report of the Mount Morgan Gold Mining Co., Ltd., for the year ending May 31, 1902, shows an output of 213,907 tons of ore, 120,641 tons of which were oxidized ore and 93,266 tons were sulphide ore. The plant treated 232,953 tons, 19,046 being tailings, and obtained 147,628 oz. gold valued at £570,337. The total income was £574,573, and expenditures £313,690, leaving a profit of £260,883. To this is to be added £22,279 brought forward from the previous year, making a total of £283,162. Dividends of £204,167 were paid, leaving a balance to be brought forward of £78,995. The cost of treating the oxidized ore was $2·68 per ton, and the sulphide ore $4·07 per ton. The Charters Towers mines for the year 1902 produced 378,194 oz. gold, against 336,431 oz. in 1901. The dividends paid by the various companies amounted to £415,564 in 1902, against £319,944 in 1901. The New Queen Gold Mining Co., Ltd., for the year ending August 31, 1902, treated 2,889 tons of ore, obtaining by crushing 3,367 oz. gold, valued at £11,359, and by cyaniding 1,044 oz., valued at

£3,474. Its total expenditures amounted to £31,882 and income £25,830, a loss of £6,052. The Queen Cross Reef treated 16,578 tons of ore for 42,136 oz. gold, and paid dividends of £116,667; the Brilliant Central obtained 31,020 oz. gold from 30,889 tons of ore, and paid dividends of £68,750; the Brilliant and St. George United obtained 18,225 oz. gold from 26,232 tons of ore and paid dividends of £52,200, and the Day Dawn Block and Wyndham obtained 26,510 oz. gold from 40,730 tons of ore and paid dividends of £49,840. The Croyden field in 1902 produced 44,200 oz. gold from 27,600 tons of quartz crushed, against 49,468 oz. gold from 26,277 tons in 1901. There was a great decrease in the yield from cyaniding due to the scarcity of water, no rain having fallen for eight months. The Brilliant Gold Mining Co., Ltd., during the year ending October 9, 1902, crushed 11,540 tons of ore, yielding 13,497 oz. gold, valued at £46,046. For the half year ending October 9, 1902, this company treated 5,010 tons yielding 5,615 oz. gold, valued at £19,059, an average of 1 oz. 2 dwt. 10 gr. gold per ton. From the tailings gold to the value of £1,020 was obtained, a total of £20,080.

South Australia.—During 1902 the Government expended £32,017 on five plants at a loss of £26,370, each plant showing a deficit for the year. Gold has been discovered in Arltunga, a northern district of this colony 1,000 miles from Adelaide. In the White Range gold mines, Northern Territory, no defined lodes have been found but the gold occurs in cellular quartz which crops out in irregular shaped masses and blocks. This quartz occurs also in irregular crevices and fissures, whose course changes in being followed downward, so that the workings assume a very irregular shape. The lowest depth reached is from 50 to 60 ft. and the width from 2 to 15 ft. Samples taken from the different parts of the field assay from 2 dwt. to 8 oz. 16 dwt. gold per ton. The Government has erected a stamp mill, which in the latter half of 1902 treated 424 tons of ore and obtained 741 oz. gold. The Northern Territories Mining & Smelting Co., Ltd., capitalized at £175,000, owns properties at Iron Blow, Mount Ellison, Mount Bonny, and on Howley, Yarn and Brocks Creeks. At the Iron Blow mine the lode has been developed 100 ft. deep. It is 20 ft. wide, and the oxidized ore averages £4 1s. 8d. per ton, and the sulphide ore averages £7 2s. 10d. per ton in copper, gold and silver. At Mount Ellison the ore varies from 10 to 20% Cu. At the Howley mine there is a 40-stamp mill, the ore varying from 3 to 5 dwt. gold per ton. At Yarn Creek there is a 20-stamp mill, and at Mount Bonny the ore body, which is 28 ft. wide, assays from a trace of gold and 19 dwt. silver to 1 oz. gold and 4 oz. silver per ton. A 60-ton water-jacket furnace and two reverberatory furnaces are to be erected, and are expected to be in operation before the end of 1903.

Tasmania.—Gold and tin in combination have been found at the Royal Tasman mine, near Gladstone. The Tasmania Gold Mining & Quartz Crushing Co., at Beaconsfield, one of the principal gold mines of this colony, has been offered to an English company. There are silver-lead mines working on a fairly large scale. The Mount Lyell Mining & Railway Co., for the half year ending September 30, 1902, mined 159,634 dry tons of ore, of which 154,152 tons were from open-cut, and 5,482 tons from underground workings. The smelter treated 240,999 tons of ore. There were 8,858 tons of matte treated in the converter,

yielding 11,681 oz. gold and 341,346 oz. silver. The total cost of treating the ore was $4·73 per ton, as compared with $5·10 in the preceding half year. The metal obtained was valued at £268,569; the total receipts were £284,325, and expenditures £207,211, leaving a net balance for the half year of £77,114. The company has absorbed the Mt. Lyell Reserve copper and gold mines, the Glen Lyell copper mine, South Tharsis flux mine, Royal Tharsis and the King Lyell mines.

Victoria.—The gold in this colony was obtained both from alluvial workings and from lode mining. Of the seven districts, Ballarat and Bendigo still continue to be the largest producers of gold, their output amounting to about two-thirds of the total yield. The output of gold in Ballarat in 1902 was 62,712 oz. gold. The Long Tunnel Extended, Walhalla, is the most productive mine. On January 1, 1902, there were 27,777 men engaged in gold mining, 12,886 of them working on the alluvial deposits, and 14,891 working in the quartz mines. The receipts of the Melbourne branch of the Royal Mint during 1902 amounted to 1,016,682 oz. gold. By an act of the Government all gold buyers are obliged to take out a license.

Western Australia.—There was a large increase in the production of gold in this colony in 1902, the mines treating 1,888,950 tons of ore for a yield of 2,117,241 oz. gold, as compared with 1,572,951 tons of ore yielding 1,841,498 oz. gold in 1901. The gold entered for export or sent to the Perth Mint in 1902 was 2,177,442 crude oz., or 1,871,037 fine oz., valued at £7,947,662, as compared with 1,703,417 fine oz., valued at £7,235,653 in 1901. The greater portion of this output was obtained from the Kalgoorlie district, but there were substantial increases in the output of the Murchison, East Murchison, Mount Margaret and North and East Coolgardie; many of the other gold fields showed a decreased output, especially the gold fields from Peak Hill northward. In the Ashburton, Gasgoyne and Kimberley fields the alluvial deposits are being worked out, and at Pilbarra and West Pilbarra the workings have reached water level and the mine owners, having no capital to provide for machinery for sinking deeper, have had to abandon their properties. The Phillips River gold field, which was declared in 1901, has developed slowly, owing to the absence of crushing facilities, but several batteries are now being erected. The cost of mining in the Kalgoorlie district has been steadily reduced, and will be further reduced as the Coolgardie water works are now completed. These works bring water to a district 1,300 ft. above and 350 miles from the source of supply by means of 8 pumping stations, and supply daily over 6,000,000 gal. of water. The Government operates several batteries and cyanide works to enable miners to treat their ores independently of the large mines. According to Mr. Alfred James the roasting (called the Marriner process in Western Australia) and Diehl processes have been successfully employed on the telluride ores at Kalgoorlie. On low-grade ores, roasting is not required, but with rich ores, the ore must first be roasted and then bromo-cyanided. At the Great Boulder Main Reef mine an extraction of 90% has been obtained with this process, at a minimum cost of $5·25, and an average of $6·25 per ton for the year. On the richer ores of the Hannan's Brownhill and Lake View mines the cost was $8·19 per ton.

The companies operating in the Kalgoorlie gold fields during 1902 paid £1,086,250 in dividends, and 13 of them together produced 1,057,132 oz. gold from 787,188 tons treated, an average of 1 oz. 9 dwt. 9·5 gr. gold per ton of ore. Of these 13 companies, four produced over 100,000 oz. each—the Golden Horseshoe, 190,119 oz. gold from 116,276 tons of ore; the Great Boulder 166,510 oz. gold from 104,231 tons of ore; the Ivanhoe, 142,291 oz. gold from 131,810 tons of ore; and the output of the Great Boulder Perseverance. The Great Boulder Perseverance Gold Mining Co., Ltd., during 1902 treated 140,642 tons of ore and 41,392 tons of oxidized tailings and slimes, yielding 193,383 oz. bullion, valued at £693,215, as compared with £487,733 for the previous year. The gross profits for the year, after deducting administration charges amounted to £412,683. The balance to the credit of profit and loss was £357,115, out of which four dividends amounting to £350,000 were paid, leaving £7,115 to be carried forward. The cost of mining and treating the ore was less in 1902 than in 1901. There were 383,600 tons of ore in sight at the end of the year. Two new furnaces began operations at the beginning of the year, and the plant has been greatly improved. It has been proposed to form a new company with a capital of £1,500,000 to take over the present company. The Kalgurlie Gold Mines, Ltd., for the year ending July 31, 1902, reports that it treated 22,060 tons of ore, obtaining 24,842 oz. gold, valued at £95,648. Its total income was £95,822, and expenditures £81,454, leaving a balance of £14,367, which, with balance of £23,253 brought forward from the previous year, after paying a dividend of £15,000, leaves £22,620 to be brought forward. The cyanide works of the Cumberland Niagara Gold Mines, Ltd., were completed and operations commenced in February, and from that date to June 30, 11,408 tons of tailings were treated, yielding 1,549 oz. of bullion. The Bayley's Gold Mines, Ltd., for the year ending June 30, 1902, reports a gold production during 18 months from all sources of 5,923 oz. gold. Its reduction works, cyanide and slimes plant were shut down during the greater part of the year. Alluvial deposits have been discovered near the Lady Mary mine, Norseman.

New Guinea.—In 1901 New Guinea produced 7,685 oz. fine gold, valued at £32,646. No new discoveries have been made in the Yodda gold fields. The ground now being worked is quite poor and requires an abundance of water. The drought during the year dried up many of the smaller streams from which the water supply for the mines was obtained. Many of the dry beds have been worked, and a few have yielded fair quantities of gold. The dry weather also affected mining at Woodlark Island. The Woodlark Island Proprietary Co., Ltd., reported for the fiscal year an income from the sale of gold of £10,073, and an expenditure of £8,623. The debit balance is £6,036, as against £6,504, brought forward from the previous half year, showing an increase of £468.

Progress in Gold Milling during 1902.

By R. H. Richards.

Gold Milling.

Stamp Mill Construction.[1]—J. J. Deming discussed this subject in an interesting manner, the following being a few of the observations made: The *back knee frame,* while it has some faults, is considered best for a battery frame. The *iron battery frame* has gradually come into general use in Australia, experience having shown the fallacy of the idea that the iron work became crystallized by repeated shock. No serious effects have resulted in mills using iron frames for years. The *mortar* should be designed to suit the ore, *i.e.,* along the lines of inside amalgamation, or speed of crushing, or both. It is better to put more metal in the *stem* and less in the *boss-head;* with a steel *tappet* there is less vibration in the stem and consequently longer life; with a steel tappet, and the end of the cam chilled, there will be less friction and little wearing of cams. *Shoes* and *dies* should not be of the same hardness; the best results being obtained with steel shoes and chilled cast iron dies. *Stamps* vary in weight up to 1,250 lb. according to the work to be done. It has been demonstrated at the Alaska-Treadwell mill that a stamp heavier than 1,000 lb. is a good pulverizer, but not a good amalgamator. For rapid crushing, the order 1, 5, 2, 4, 3 will work well, while for the long, slow drop, the order, 1, 5, 3, 2, 4 will give an even distribution of the ore in the battery. The order 1, 4, 2, 5, 3 for heavy stamps and inside amalgamation will give good results. The order, 5, 1, 3, 4, 2, commonly used in Australia, is a very good system. The order of the drop, however, is more or less a fancy of the mill man; rarely do two use the same order. *The Muntz metal plate,* 60% copper and 40% zinc, used in Australia is in some instances superior to the silver-plated copper plate, being more easily cleaned as verdigris is absent, but its absorbent power for mercury is limited. In general, the silver-plated copper plate is considered to be superior to all others.

Mortar Foundations in Oregon.[2]—According to W. H. Washburn, it became necessary to place at a mill in Oregon a set of mortar blocks on what is known as webfoot, *i.e.,* a sort of indurated clay. The pits for each 10 stamps were 3 ft. 2 in. wide × 13 ft. 2 in. long × 20 ft. deep. Beginning 3 ft. from the bottom, each pit was undercut at an angle of 45° to a point level with the bottom and undercut 1 ft. at the ends. A layer of sand was spread over the bottom, and a row of timbers 10×12 in.×7·5 ft. was laid crosswise, being well pounded down and leveled. On these were laid lengthwise three timbers, each 10×12 in.×14 ft. long and a series of 2-in. planks was spiked lengthwise along the top row to prevent the presence of sand between the timbers, and also to serve as an additional binder. The upper surface of the timber was made level and the mortar blocks put in place. The blocks were built of 2·5-in. plank, 24 ft. long, one layer being of three planks, each 10 in. wide and the next of two planks, each 15 in. wide, in alternate layers. These foundations have proven satisfactory, and no settling was noticed after a three weeks' run. (See Fig. 1, on next page.)

[1] *Mining and Scientific Press,* Vol. LXXXV., (1902), p. 188.
[2] *Ibid.,* Vol. LXXXIV., (1902), p. 246.

Mortar Foundations in California.[3]—Two years ago at the North Star Mill, Grass Valley, the old wood foundation blocks were replaced by a concrete base with granite foundations. As a result the stems do not break as often as formerly, the mill crushes more ore and the mortars are absolutely solid. When the mortars were first erected, sheet lead 0·0312 in. ($\frac{1}{32}$) thick was placed between the mortar and the granite in order to fill the interstitial space, but it worked out and left the mortars loose. Furthermore, the mortars had become somewhat dished as a result of the pounding on a soft foundation, to counteract which the granite surface was made slightly concave.

The Individual Mortar Stamp Mill.[4]—This arrangement consists of three

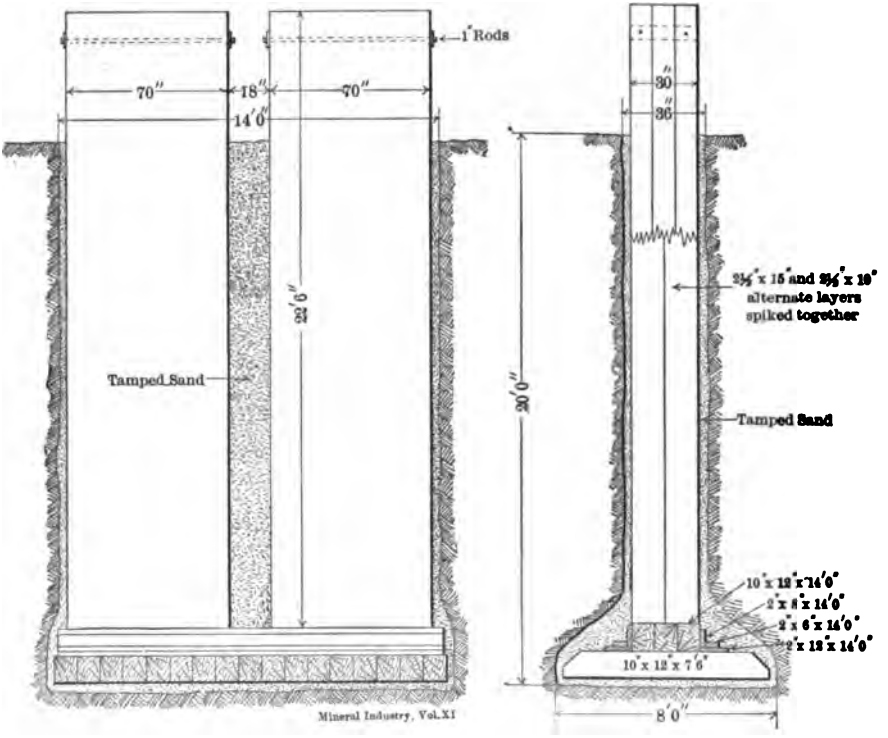


FIG. 1.—MORTAR FOUNDATION, SPECIAL CONSTRUCTION.

parallel mortars, designed for the independent action of each stamp in its separate mortar, as well as to secure the largest area of screen discharge.

Sluice Plates.[5]—According to W. J. Adams, sluice plates should not be as wide as the apron plates, a width of 20 in. being preferable. They should have a less grade (about 1·25 in. in 1 ft.) owing to the greater clearance of the sulphurets, and the concentration of the pulp; and as no free gold should be found at this distance from mortar, it is not necessary to turn the pulp over in waves.

[3] *Mining and Scientific Press*, Vol. LXXXIV., (1902), p. 157.
[4] *Ibid.*, Vol. LXXXV., (1902), p. 247.
[5] *Ibid.*, Vol. LXXXV., (1902), p. 268.

Morison's Open-Front Mortar Box.[6]—The front of the mortar in the Morison box is entirely open from the discharge lip upward; that portion of the box above the screen opening being closed by means of a removable pressed steel door, which is dished and flanged for strength and rigidity; when closed the end flanges seat themselves upon suitable ledges on the main casting and are secured thereto by studs fitted with wing nuts.

Theory of the Patio Process of Amalgamation.[7]—Miguel Bustamente, Jr., calls attention to the difficulties experienced in extracting the gold from Mexican ores composed principally of decomposed iron pyrites in quartz with native gold in irregular grains; the metallic value in some portions, however, being in calcite and siderite. At first the extraction of gold by amalgamation from 1-oz. ore was about 10%, and was attended with an excessive loss of mercury. Direct amalgamation combined with cyaniding of the concentrates gave an extraction of 32%. Occasionally during amalgamation, the odor of hydrogen sulphide gas was noticed, which accounted for the great loss of mercury. A preliminary roasting and washing of the ore raised the extraction to 63%, with a mercury loss of 11%. Upon investigation, the gold which had escaped amalgamation was found in a spongy state, similar to "platinum sponge," and in contact with the mercury it caused an energetic electrochemical action, which decomposed a relatively large quantity of water; the oxygen set free being absorbed by the sponge while the hydrogen combined with the sulphur of the pyrite, and produced hydrogen sulphide of which a part escaped and a part attacked the mercury causing the heavy loss of the metal. The actual chemical reactions are quite complicated, but the formation of mercury sulphide was proved by an analysis. The loss of gold is explained thus: Whenever the sponge or black gold is present under such conditions that it will act as the electro-positive element, it will receive, condense, and hold oxygen which will be returned when the gold is made the electro-negative element of the couple. Mr. Bustamente perfected a method by which the loss of mercury was reduced to 0·03%, and the extraction of gold raised to 95% of the assay value, at the low cost of $0·42 per ton for crushing, and $0·19 for amalgamation, including the electric current. At first the ore was roasted in a reverberatory furnace and washed abundantly with water; it was then passed through the mortars where it was pulverized and the amalgamation begun. The mortars were fitted with inside plates, connected with the poles of a dynamo that produced a current of 150 amperes and 14 volts. The two stamp batteries discharge into a common channel, in which, side by side, were placed the large amalgamating plates, one connected with the positive pole, and the other with the negative; an arrangement which gave encouraging results; but, in view of the energetic decomposition of water, the electro-motive power was lessened by subdividing the amalgamating plates and uniting them in parallel, thereby diminishing the liberation of gases and reducing the loss of mercury to an insignificant quantity. Similar arrangements were made for the pans and the washers. An average of 9 tons of ore was treated in 24 hours with an

[6] *Engineering*, Vol. LXXIV., (1902), p. 145.

[7] *Transactions of the American Institute of Mining Engineers*, November, 1901.

extraction of 94% of the gold. The preliminary roasting was abandoned later, and a maximum gold extraction of 95% was obtained.

Mill Practice in Arizona.[8]—At the Commonwealth mill at Pearce, the ore consisting of hard, decomposed quartz and talc carrying silver chloride and free gold, is coarsely crushed by a Blake breaker and roughing rolls, thence it is passed to 80 stamps each of 950 lb. weight which drop 102 times per minute, and crush 210 tons of ore per day through a 35-mesh screen. There is no battery or plate amalgamation, the pulp passing direct to settling tanks and thence to the amalgamating pans. The tailings are impounded for future treatment. Crude oil is used for power purposes.

Mill Practice in Colorado.[9]—At the Portland mine, Cripple Creek, the fine portion of the ore is separated by a screen; the coarse portion, which constitutes the bulk of the ore, being hand sorted. Formerly the fine material with a value in gold of about $4 per ton was rejected, but at present a saving of 50% of the contained value is effected by a simple washing process. The washer consists of an inclined iron plate perforated with holes 0·625 in. ($\frac{5}{8}$) in diameter, on the upper surface of which numerous jets of water impinge in various directions. The waste is passed over a screen which removes the dry fines; the coarser portion, which forms the bulk of the waste, is then passed over the perforated plate, the adhering fines being washed off by the jets of water, and collected and dried on a sheet iron box, heated by exhaust steam. The small quantity of water used is circulated through a boiler-feed pump operated by exhaust steam. In this way the final waste is reduced in value to an average of about $2 per ton.

Mill Practice in South Dakota.[10]—The Wasp No. 2 Mill, at Kirk, has been in operation since September, 1900. The gold in the ore, which varies in value from $4 to $20 per ton, is on the cleavage planes of quartzite; very little pyrite is present, with an occasional trace of stibnite. Crushing and screening is done as follows: (1) Ore; to (2). (2) Ore bin; to (3). (3) Grizzly; 4×8 ft., with 1·5 in. spaces; oversize to (4); undersize to (5). (4) No. 3 Gates breaker, set to 1·25 in. ring, to (5). (5) Storage bin, to (6). (6) Coarse rolls, 14×24 in., to (7). (7) Stationary inclined screen, 7 ft. long, 1 ft. wide, 2 mesh, oversize to (8); undersize to (9). (8) Finishing rolls, 40×24 in., to (9). (9) Bucket elevator, to (10). (10) Shaking finishing screen, 2·5 mesh; oversize to (8); undersize to (11). (11) Finished product bin. The ore is cyanided.

Mill Practice in California.[11]—At Hedges the crushed ore is conveyed to the mill bins by a hoisting tram line, and is fed automatically to the batteries of the 100-stamp mill which is in two sections, 50 stamps on a side, the ore bins being above and between them. Each stamp weighs 1,000 lb. and drops 96 times per minute, crushing 4·5 tons of ore per 24 hours. The screens are No. 10 diagonal slot-punched, equivalent to 40-mesh. Below each battery is a copper amalgam plate, 28 ft. long, with a fall of 1·5 in. to the foot; 70% of the total saving is reported as made on the plates.

Mill Practice in Bendigo.[12]—H. C. Boydell states that the ore treated is

[8] *Mining and Scientific Press*, Vol. LXXXIV., (1902), p. 103.
[9] *Mining Reporter*, March 6. (1902), p. 252.
[10] *Mining and Scientific Press*, Vol. LXXXIV., (1902), p. 232.
[11] *Ibid.*, Vol. LXXXIV., (1902), p. 50.
[12] *Australasian Institute of Mining Engineers*, Vol. VIII., Part II., p. 236.

essentially free milling, and carries 1% of sulphides in a quartz gangue, the gold being coarse. Hand breaking is the common practice except in three mills, where Gates breakers are in use. The lack of uniformity resulting from hand breaking is given as the cause of the low efficiency per stamp. Hand feeding is used except in four mills equipped with mechanical feeders. The cost of a local mechanical feeder is $121·75, while the cost per day of feeding 10 stamps by hand is from $1·22 to $1·46. The mortar boxes weigh from 2 to 3·25 tons, the bottoms being 5·5 in. thick. No liners are used, because the ores being mainly custom, their removal at the frequent clean-ups would entail too much labor; therefore, the box is of greater thickness than usual. Inside copper plates are not used. The discharge is vertical, and with new dies is less than 3 in. in depth, sometimes being but 1·5 in. Chock blocks are not used, and the height of discharge increases with the wear of the dies. Punched screens with from 12 to 16 holes per linear inch are generally used. The stamps weigh from 600 to 1,000 lb. The average height of drop is from 6 to 8 in. with from 75 to 80 drops per minute. In each head of five stamps, the middle stamp drops first, and both end ones next. The stems are of best hammered iron generally 12 ft. long and from 2·75 to 3·125 in. in diameter. With one exception screw tappets are in use. The weight in the stamp is distributed approximately as follows: stem, 43%; head, 23%; shoe, 25%; and tappet, 9%. In all cases the cam shaft is driven by gearing. The "horse" battery frame is most common although in a few of the smaller batteries the "A" frame is used. The frame is generally constructed of wood although sometimes of cast iron. The reason for the use of the horse frame is that the cam shaft being driven by gearing necessitates the counter shafts on the same level. The output per stamp per 24 hours averages but 2 tons, the low efficiency results from the absence of breakers and automatic feeders; however, the mining conditions in Bendigo do not require a maximum output. The main ore supply is not sufficient to keep the mills in continuous operation, and it is supplemented by custom ore. While increased capacity per stamp would reduce labor charges per ton, it would involve increased first cost which is not warranted by existing financial conditions. Clean-ups are made weekly, the retorted gold being sold without refining. The copper plates of an average length of 10 ft. are inclined 1 in. per foot, and have several steps with a riffle between each set. In a few cases the last plate is not amalgamated. Mercury is fed into the mortar at regular intervals from which a large portion of the total amalgam is obtained. The loss of mercury per 100 tons of ore averages one pound. The plates are usually scaled every six months by being heated to redness; this oxidizes the copper and causes spots to form, which tarnish readily, and require constant attention. To within 18 months ago, concentration by blanket strakes and Halley tables was common. Recently, however, Wilfley tables have been introduced. Apparently but little attention is paid to the production of clean concentrates as they contain 50% silica. The concentrates are roasted and amalgamated in crude pans. At one plant the cyanide process is used.

Mill Practice at the Kalgurli Gold Mines, Limited.[18]—The percentages of gold

[18] *Australasian Institute of Mining Engineers*, Vol. VIII., p. 51.

contained in sands and slimes by dry separation and by hydraulic separators are as follows: *Dry Separators with 110-mesh sieve.*—The sand contained 27·27% and the slimes 72·73% of the total gold content. *Hydraulic Separators*—(average for three months).—The sands, including free gold and concentrates, contained 56·67% and the slimes 43·33% of the total gold content of original ore.

Hydraulicking and Placer Working.

Hydraulic Mining.[14]—Wm. H. Radford gives the cost of hydraulicking low-grade gravel in northern California. The grade of the sluices was 7 in. in 12 ft., the boxes being paved with 12-in. block riffles. Long bedrock cuts extended from the heads of the sluices to within a few feet of the banks, and were kept to grade as the work advanced. During 9 months, 1,251,399 cu. yd. of material were washed, averaging 1·91 cu. yd. per miner's inch of water with a yield in value of 2·52c. per cu. yd. of gravel. The average height of bank washed was 63 ft. The itemized cost is given as follows:—

	Cost.	Cost per Cubic Yd.
Care of ditch, reservoir, and siphon: labor and supplies	$3,786·54	$·00223
Washing (piping)	2,401·05	·00192
Drilling in bedrock cuts	1,320·53	·00105
Timbering bedrock cuts	157·89	·00012
Electric lighting	598·62	·00047
Sluice building and repairing: labor and supplies	1,081·20	·00086
Blacksmithing	644·02	·00051
Cleaning up	968·79	·00077
Moving pipes and "giants"	898·85	·00071
Breaking rocks and clays	6,124·91	·00490
Clearing ground for piping (cutting brush)	158·37	·00013
General expenses, watching sluices, and odd jobs	3,088·69	·00250
Supplies used in mine	3,015·37	·00241
Taxes, office expenses, legal expenses, surveying and salaries	4,267·31	·00341
Totals	$27,511·64	$0·02198

The Gold Bug Mining Co., Georgetown, Eldorado County, Cal.[15]—W. E. Thorne states that this company worked the ground through bedrock sluices, 8 ft. wide on the bottom, and laid in a cut having a maximum depth of 25 ft. at the lower end and a minimum depth of 4·5 ft. at the upper end. At the lower end each 12-ft. box has a fall of 4 in., while at the upper end the fall is but 1 in. The sluices are paved with 6-in. blocks set on end. The working costs per cubic yard of material hydraulically moved were:—

Water	$0·080	Blacksmithing	$0·008
Labor	0·015	Lumber	0·030
Débris dams (*a*)	0·030	Labor on sluices	0·040
Moving of pipe, etc.	0·005	Powder, fuse, etc.	0·017
"Crevicing" and cleaning bed-rock	0·006		
Taxes, salaries, etc. (*b*)	0·007	Total	$0·183

(*a*) Represents the total cost of the work divided by the total capacity in tons of the reservoirs thus created.
(*b*) This item is exceptionally large owing to the short season of operation—15 days.

The results were not financially satisfactory. Two undercurrents were tried, but were unsuccessful, and a hydraulic elevator is now being installed.

Distribution of Gold in Sluice Boxes.[16]—At a low-grade gravel property in

[14] *American Institute of Mining Engineers*, Vol. XXXI., p. 617.
[15] *Ibid.*, (1902).
[16] *Mining and Scientific Press*, Vol. LXXXV. (1902), p. 394.

California, the distribution of the gold as caught in the sluice boxes, 6 ft. wide × 4·5 ft. deep × 12 ft. long was:—

	Boxes.	Per Cent.
First section	15	73·6
Second section	30	13·4
Third and fourth sections	71	1·6
Undercurrent		11·5

Under the conditions that prevailed a long sluice was unnecessary, the coarse gold being caught in the first boxes, and the fine in the undercurrent. The gravel averages from 4 to 6c. per cu. yd., and from 2·5 to 3 cu. yd. of material were moved per miner's inch of water at a total cost of $0·08219 per inch.

A "Crown Gold" Dry Concentrating Plant.[17]—The capacity of the 80-ton concentrating plant of this type which has been erected at Tintic, Utah, is claimed to be fully up to the requirements.

Dry Blowers in Australian Gold Placers.[18-19]—According to B. Dunstan, the types of dry blowers in use at the Clermont gold field are constructed on three principles: (1) the separation of the larger pebbles from the finer portion by a coarse punched plate; (2) the delivery of the material which passes through the coarse screen to a fine punched plate; and (3) the forcing through the screen of a blast of air sufficiently strong to remove the earthy particles, but not the gold. The machines are not suited to clayey earth, although this difficulty can sometimes be overcome by heating the earth and then powdering it on a flat sheet. The losses of gold are generally due to the presence of clay. Fans are not suited for producing the blast as it must be pulsating. The cost of a machine varies from $32·50 to $50, and the daily capacity under normal conditions is from four to five loads. Dry jigs also are used successfully on gravels carrying coarse gold.

The Placers of La Cienega, Sonora, Mex.[20]—R. T. Hill calls attention to the importance of underground water in arid districts.

Hydraulic Practice in Oregon.[21]—In Josephine County, along the Illinois River, ground sluicing is being replaced by hydraulic operations on a large scale. The gold is coarse, and is generally saved by the ordinary pole or block riffles in the sluices.

Gold Dredging.

Recovery of Fine Gold from Snake River Sands.[22]—Robert Bell states that the fine gold in the Snake River placer beds is recovered on a commercial scale up to 95% of the gross content of the gravel. The fine material after separation from the coarser gravel by passage through a screen-floored sluice box, is concentrated by gravity on burlap tables, the gold in the small quantity of concentrates being collected by mercury in a clean-up barrel. This method is simple, efficient and adapted for operation on a large scale.

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[17] *Mining and Scientific Press*, Vol. LXXXIV., (1902), p. 22.
[18-19] *Engineering and Mining Journal*, Vol. LXXIV., (1902), p. 482.
[20] *Ibid.*, Vol. LXXIII., (1902), p. 182.
[21] *Ibid.*, Vol. LXXIV., (1902), p. 582.
[22] *Ibid.*, Vol. LXXIII., (1902), p. 241.

A Snake River Suction Dredge.[23]—According to Robert Bell, a dredge with a 10-in. nozzle has a daily capacity of 2,500 cu. yd. at a cost of 4·5c. per yd., the motive power is supplied by a 125-H.P. vertical, compound-condensing marine engine. Under less favorable conditions a chain elevator bucket dredge showed a capacity of 2,000 cu. yd. per day, at a cost of 5·5c. per cu. yd.

Advance Stripping in New Zealand.[24]—According to F. W. Payne, the saving of gold in Otago has occasionally been rendered difficult by the presence of a large quantity of clay, which, in rolling inside the screen and over the tables, collected the gold on its surface and carried it overboard. This difficulty has been overcome to a great extent by what is known as "advance stripping," the clay being removed first and the auriferous gravel left for the next cut. The clay containing no gold is not treated on the tables, but is delivered direct to the tailings elevator. A centrifugal tailings elevator wheel has been used in this district with reported satisfactory results.

Dredging in New Zealand.[25]—The latest New Zealand dredge is of the bucket elevator type. The bulkheads of the bucket ladder are set diagonally, the device being designed for paddock dredging, where grass, tussock, flax and small scrub have to be removed. It is claimed that the absence of cross-stays and bracings avoids the accumulations of débris. In the Southland dredging field several machines are fitted with tines to loosen the ground in advance of the buckets.

Dredging in British Columbia.[26]—The development of gold dredging on the Saskatchewan River is progressing favorably. Of the several dredges that have been used, the bucket elevator type gives the best results.

Dredging Practice in General.[27]—David K. Blair describes the construction and manipulation of gold dredges, including accidents to various parts of the machinery—their cause, effect and remedy.

Dredging in California.[28]—At Oroville, a conveyor 75 ft. long, with a 28-in. belt inclined 18° traveling at the rate of 250 ft. per minute can handle 75 cu. yd. per hour.

Dredging in Nevada.[29]—A current motor dredge is being operated in the Colorado River, near El Dorado canyon. One man operates the dredge, which is claimed to have a capacity of 10 cu. yd. per hour in loose, river-bar gravel. The dredge consists of two flat bottom scows connected side by side by a hinged platform, having the current wheel in the intervening space between them. The wheel is connected to the dredging machinery which is set on a second pair of scows having the bucket ladder between them; the two pairs of boats are connected by a hinged frame, forming a catamaran structure.

Dredging in West Siberia.[30]—According to C. W. Purington and J. B. Landfield, Jr., dredging during the past three years has received attention, and the dredge in operation during 1900 is reported to have been a complete success.

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[23] *Engineering and Mining Journal*, Vol. LXXIII., (1902), p. 241.
[24] *Institution of Mining Engineers*, Vol. XXIII., p. 582.
[25] *Engineering and Mining Journal*, Vol. LXXIV., (1902), p. 680.
[26] *Canadian Mining Review*, Vol. XXI., (1902), p. 59.
[27] *Ibid.*, Vol. XXI., (1902). p. 274.
[28] *Engineering and Mining Journal*, Vol. LXXIII., (1902). p. 184.
[29] *Mining and Scientific Press*, Vol. LXXXIV., (1902), p. 48.
[30] *Engineering Magazine*, Vol. XXII., p. 393.

Platinum Washing in the Urals.[81]

According to L. St. Rainer, it is necessary to use a large volume of water in washing the clayey gravels, and mechanical agitation is also required in order to disintegrate the material. In one intsance a trommel 3 m. long, 1 m. diameter at the feed end, and 1·6 m. diameter at the outlet is used. It is made of strong iron plate perforated with 15-mm. holes. A strong stream of water is played into the trommel which revolves slowly, the fines passing through to the washing apparatus below. It is necessary to treat tough gravels in a "boronka" in order to free the rich sands. A boronka consists of a third of a conical trommel made of cast iron plates, having suspended stirrers which are given a slow backward and forward motion, thereby causing the gravel to be gradually passed along to the discharge end. The stirring combined with the strong streams of water thoroughly disintegrates and washes the gravel so that the discharged material is practically free from rich sands. In the Plast district, however, the gravel requires even a more thorough stirring, and for this purpose a "tschascha" is used, which consists of a cast-iron cylindrical tank 2·1 to 3·5 mm. diameter, containing a six-armed stirrer revolved by a central vertical shaft. Attached to the arms are vertical iron bars which disintegrate the clayey pulp. The bottom is made of three cast-iron sectors with conical holes 15 mm. diameter at the top. One of the sectors is fitted with a gate or trap so that from time to time the tailings can be discharged. A machine of this type 4·16 m. in diameter, the arms making 25 revolutions per minute, requires 13 H.P. to operate, and has a capacity of 40 tons of clayey gravel per hour; from five to ten volumes of water per volume of sand is required for successful work. The washed material passes direct to the riffle tables from 8 to 13 m. long having 44-mm. riffles, 265 mm. apart; the grade is from 13 to 16%. The upper portion of the table is covered with linen or felt protected by a wooden grate. When necessary the tailings are elevated by a machine of the Archimedian screw type. Washing is carried on continuously for 11 hours when the feed is stopped, the riffles removed, and the concentrates carefully washed on the table until reduced to one-third the original bulk. The concentrates are then shoveled into buckets and rewashed on a smaller table until there remains only a fine gray slime, which subsequently is worked on a plane surface with a brush, the gold being extracted with mercury. The tailings are washed in sluices, and the resulting concentrates treated as described above. In working a gravel carrying 2·6 g. metal per ton, the loss by washing was 0·27 g. per ton, while that by theft amounted to 0·43 g. per ton, making a total of 27% of the metal content. It would seem that improved methods especially of classification would give more satisfactory results.

[81] *Berg- und Huettenmaennisches Jahrbuch*, Vol. L., p. 855.

A Review of the Cyanide Process during the Year 1902.

By Charles H. Fulton.

The progress in cyaniding during 1902 has consisted mainly in the perfection of detail and a more extended application of the process, especially in South Dakota, where a number of new and important mills have been erected. The wet crushing of ore by stamps in cyanide solution and the treatment of the slimes by decantation have been much improved, and are supplanting fine dry-crushing by rolls in South Dakota. An innovation in American progress has been the adoption of the filter press method for the treatment of slimes at the Sunshine mine, Utah.

Arizona.—In Arizona several new cyanide plants have been erected. The Cyclopic Co. at Gold Roads in Mohave County has added to its plant. The cyanide plant of the Congress Gold mine in Yavapai and the tailings plant of the Mammoth Cyanide Co. in Pinal County have been in operation. The G. & C. Consolidated Mining Co. is erecting a cyanide plant 12 miles southwest of Prescott.

California.—A number of new mills have been erected, all of small capacity, principally in Southern California, where the ores are more amenable to treatment, than are those of Northern California. Practically all of the cyaniding is carried on in San Bernardino, San Diego, Inyo, El Dorado, Placer, Shasta, Kern and Mono counties. According to the report of the State Mineralogist, Mr. Lewis E. Aubury, the following plants are in existence, most of them being in operation:—

	Capacity in Tons per Day.		Capacity in Tons per day.
San Diego County—American Girl	100	*San Bernardino County*—Bagdad Mill	25
Blossom M. & M. Co.	18	Black Hawk Mill	20
California Kings G. M. Co.	750	Fearnot M. Co.	20
Free Gold Mining Co.	420	T. K. Mill	16
Western Extraction Co.	50	Rose Min. Co.	70
El Dorado County—Vandalia Mill	200	Yoder Mill	18
Shasta County—Midas Mill	48		

A number of small cyanide plants are in operation, and some are being erected in Inyo County. The Standard Consolidated is operating in Mono County, and a few scattered ones in other counties.

The tailings plant of the Free Gold Mining Co., formerly the Golden Cross Mining Co., at Hedges, San Diego County, has been operative during the year treating about 420 tons of tailings per day. The process there is described by H. A. Barker in a private communication. There are 5 steel leaching vats 45 ft. in diameter and 7 ft. deep, which are charged from a bridge work constructed over them, by means of 2·5-ton side discharge cars. The mill tailings, which are treated, are in beds from 15 to 30 ft. in depth, the tailings being shoveled into the cars, 6 cars being loaded at a time and run down an incline about 400 yd. long. From the foot of the incline the cars are hoisted to the bridge work over the vats. The actual treatment extends over a period of four days. The strong solution is 0·12% cyanide, and the weak solutions 0·08 and 0·04% cyanide. All solutions whether strong or weak pass through the same zinc box. The precipitation is very good notwithstanding the presence of considerable copper in

the tailings. The strongest solution, which runs lowest in gold, assays 10c. per ton after precipitation. The total quantity of zinc available for precipitation is from 100 to 120 cu. ft. The precipitates obtained vary in value and quantity, the bulk of the values coming generally from the short coppery shavings removed each month. These shavings are treated with sulphuric acid, and the sludge washed, dried and roasted with gentle rabbling. It is then returned to the acid tank and again treated with dilute acid, and in this way the great bulk of the copper removed. The coppery washings after thorough settling are run to waste over scrap iron. The precipitates after this treatment are then clean enough to be cast into a brick of base bullion.

The entire water supply is drawn from the Colorado River, 12 miles distant, at a cost of approximately 2c. per ton of ore treated. The leaching vats are sluiced out, by pressure furnished by a steam pump, in from 3 to 4 hours, through four 16-in. square gates. The average value of the tailings treated approximates $1·40 per ton, the residues assaying 40c. to the ton, making an extraction of 71·4%. Material of $1 per ton in value has been treated with a small profit at the plant.

Successful experiments are being made at some of the Mother Lode mines in the treatment of raw concentrates by the cyanide process. The concentrates are ground to 100-mesh size or finer, and then agitated.

The largest plant in the State is that of the California King Gold Mining Co., at Picacho, in San Diego County, near the Arizona line. It has a capacity of over 750 tons per day, and although constructed in 1901, it has not yet become operative.

Colorado.—A few new mills have been constructed, mainly of small capacity, the principal one being that of the Tobasco Mining Co., near Lake City, Hinsdale County. Some plants have been projected to treat Cripple Creek dumps, and one or two small ones have been built which are said to operate successfully on $4 to $5 material when it is suitable. One of these plants is treating the dump of the Pharmacist mine, and another is soon to be erected in the district by Temple & Crumb, of Colorado Springs, which is to crush coarse, and have a capacity of 50 tons per day. The cyanide plants of the Liberty Bell and Smuggler-Union mines near Telluride, have been in operation during the year, as well as the Gold Run cyanide plant, which treated old accumulated tailings from the Tomboy and Smuggler-Union mines. The cyanide tailings plant of the Camp Bird mine, near Ouray, has also been in operation.

The cyaniding of the Cripple Creek milling ores has received a serious check on account of the preference for chlorination, the Dorcas mill at Florence being the only cyanide mill in continuous operation. This mill has installed the Begeer pneumatic cyanide process, which consists essentially in passing the cyanide solution from the extractor boxes (after standardizing) repeatedly through a centrifugal pump, provided with suitable pipes and cocks to allow the absorption and mixing of air with the solution to the fullest extent, thereby causing the solutions to absorb a maximum quantity of oxygen.

At Colorado Springs the Telluride Reduction Co. has erected a bromination plant, in which it is intended to treat the dust by the Riecken process.

A small plant using the pneumatic process has been erected at the Gold Standard mine at Idaho Springs.

The process at the Smuggler-Union mine is described by Mr. William H. Davis[1] as follows: "The plant was designed and built by F. L. Bosqui in 1901, and began operations early in 1902. There are 16 leaching tanks arranged in 2 rows of 4 double tanks, one above the other for double treatment. The upper tanks are 40×8 ft., and the lower, 40×9 ft. made of California redwood and holding 475 tons of tailings, the daily capacity. Each tank gets a 16-day treatment. The tailings come to the plant by launders, and the tailings are charged into the tanks by Butters & Mein distributors. Overflow gates carry off the slimes. The fineness of the ore is regulated by the height of the column of water over the ore, manipulated by the overflow gates. It has been found, that when from 30 to 35% of the deposited tailings pass a 120-mesh screen, about the limit is reached at which the tailings will leach satisfactorily. However, as much of the slimes as possible, without impairing the leaching, must be settled. The filling is completed in 24 hours, the tank is then allowed to drain as dry as possible, and the material is leveled, lime added, and a waste solution applied. The waste solution having a high protective alkalinity distributes the lime and displaces the water, and is applied for 18 hours, after which it is displaced by weak solution, which is allowed to stand on the ore for 24 hours, and it is then leached with weak solution until the tailings are dried for shoveling into the lower vats. The drying is accomplished by vacuum until 15% moisture remains. In the upper tanks the weak solution coming off after the 24-hour contact is the first to carry values in either cyanide or gold. (The weaker solutions do not attack silver.) Usually the solutions must carry 0·5 lb. cyanide before they have value in them. The solutions from the upper vat treatment are run through the waste solution zinc box, and are re-used as waste solution, which includes also all solutions in the plant containing less than 2 lb. KCN per ton.

The dried ore in the upper vats is shoveled into a 6-lb. solution in the lower vats, and allowed to stand for 36 hours, which equalizes the density in the vat, gives a more uniform leaching, and also equalizes the values in the solution, which carries the highest values and passes to the weak zinc boxes. The strong solution is succeeded by weak solution, then by waste solution, and finally by water. The waste solution is used here in order that the solutions may not be diluted more than is necessary.

Zinc shavings are used to precipitate the values, with good results. The Smuggler-Union ore is a difficult one to treat, the rock being very close-grained and hard. The values are about equally distributed between gold and silver, the latter being present as a double sulphide with arsenic and sometimes with antimony, which is difficult to decompose. The tailings are very low grade, but the plant has been a success, although owing to the recent troubles at Telluride the Smuggler-Union mines have suspended operations.

Gravity filtration was formerly used to settle out solids and precipitates which formed in the weak solution before it entered the extractor boxes, but it was lately displaced by a filter press.

[1] Private communication.

A canvas plant has been installed, in which the overflow slimes from the mill amounting to about 30% of the ore crushed, are handled by contract.

According to Mr. Charles A. Chase,[2] of the Liberty Bell cyanide plant, the cost of cyaniding at that plant on a 4,700-ton per month basis, is as follows:—

Labor.	Cents Per Ton.	Supplies.	Cents Per Ton.
Foreman	1·5	Cyanide	17·2
Solution men	6·7	Zinc	3·0
Laborers	6·8	Lime	5·2
Assays	2·5	Miscellaneous	0·5
Repairs	0·4	Sulphuric acid	0·3
Labor	17·9	Supplies	26·2
		Total labor and supplies	44·1

The Tobasco Mining Co. erected a mill at Lake City, which is described by Smith McKay,[3] of Denver. The rough crushing is done by a 10×15-in. Dodge crusher, the product from which passes to 36×16-in. rolls for the coarse crushing. The ore is fine crushed by two 30×6-in. high-speed rolls. The screening is done by flat impact screens, the final screens having 8-mesh wire cloth. The product from the screens passes to three Bartlett concentrating tables, which separate out concentrates consisting mainly of iron sulphides amounting to from 1 to 2%. The tailings from the tables pass to a tank, and from this to a revolving distributor over the leaching vats. The slimes overflow from the vats and are discarded. There are six 18×5-ft. leaching vats, three 10×12-ft. solution tanks, two 8×10-ft. gold storage solution tanks, all of steel. Precipitation is done in zinc extractor boxes by zinc shavings. Electric power is used at the mill, being transmitted over a distance of 8 miles. A 75-H.P. motor runs the crusher, elevator, screens and rolls, and a 5-H.P. motor the three Bartlett tables. A 20- and a 5-H.P. motor operate three triplex pumps for solutions and water supply.

Idaho.—No new cyanide plants of any size have been erected, although several have been projected, namely, in Shoshone and Lemhi counties. The plant of the De Lamar Co. in Owyhee County, has treated 35,400 tons of ore, valued at $12·24 per ton. The costs amounted to $2·70 per ton, with an extraction of 84·2%. The cost of treating 22,900 tons of old tailings in cents per ton, was labor, 62·42c.; chemicals, 88·53c.; fuel, 15·46c.; supplies, 12·70c.; assaying and express, 5·10c.; total, $1·8421. The average value of the tailings was $3·97 per ton, and the extraction 69·7%.

Montana.—A number of mills have been in steady operation, some new mills have been built and old ones have increased their capacity. The greatest activity is in Fergus County, where, according to Alex. N. Winchell,[4] the following companies are active:—

The Abbey Cyanide Gold Mining & Milling Co., Barnes & King, Kendall Gold Mining Co., McCormack Brothers, Central Montana Mines Co., Great Northern Mining & Development Co., New Year Gold Mining Co.

The Barnes-King and Kendall properties, near Lewiston, are operating on a large scale, the first having a capacity of 240 tons and the latter 350 tons per

[2] Private communication. [3] Private communication. [4] Private communication.

day. The Central Montana Mines Co., near Lewiston, has a dry crushing plant of 250 tons capacity, but is treating at present only 100 tons per day.

The large properties above mentioned treat the ore by direct cyaniding. The ore is quarried and crushed dry to about 0·25-in. size. As a rule, the values are readily extracted, but clayey material is occasionally met with, which is unfavorable to leaching. I am indebted to Mr. W. J. Sharwood, of Marysville, Mont., for much of the information concerning Montana and Nevada.

In Lewis and Clarke County, the plant of the Montana Mining Co., Ltd., at Marysville, has been modified during the year. Six of the seven leaching vats have been fitted with agitators for the treatment of slimes by decantation. Extensions of sheet iron have also been added to the vats, so that these are 38-ft. diameter and 13 ft. deep. Charges of 135 tons of slimes were run through in 48 hours, and while the original plant has treated over 500,000 tons of tailings, it was shut down for the winter.

At the Empire mine, near Marysville, a 500-ton tailings plant has been installed to treat the stored tailings, which are conveyed to and distributed in the 500-ton leaching vats by a system of Robins belt-conveyors. The solutions are precipitated by an electrolytic process on sheet iron plates 3×5 ft. placed 1 in. apart. These plates divide the tank into nearly tight compartments, and the current passes from plate to plate, the side which acts as the anode being protected by a carbonaceous coating, while the other acts as the cathode, and receives the gold, silver and copper as a coherent film which is later removed by stripping.

Nevada.—No new plants of any size have been built in this State, although several have been steadily in operation on the Comstock Lode, treating old tailings from the silver amalgamation mills of early days.

At Tuscarora, in Elko County, the Dexter Gold Mining Co.'s plant treated 22,930 tons of ore in 11 months, at a cost of $1·10 per ton, and an extraction of $1·89 per ton. Near Tuscarora the Montana Mining Co. erected a cyanide plant to treat the tailings from the 20-stamp mill on the Lucky Girl group of mines. The sands are treated by percolation, and the slimes by decantation. The Dexter Gold Mining Co. experimented with the Godbe agitation process on slimes, but with indifferent success. Attempts are now being made with other methods of treatment.

On the Comstock Lode at Virginia City, Charles Butters is treating silver-bearing tailings by the cyanide process, using an electrolytic system of precipitation with aluminum cathodes, from which the deposit of precious metals is said to be readily removed by stripping.

At the new wet-crushing plant of the Chainman Mining & Electric Co. a small tonnage was treated by dry-crushing and direct leaching. The plant has now suspended operations. The Ely Mining & Milling Co.'s plant also has suspended operations. The De La Mar Mining Co.'s plant in this State is expected to resume operations shortly.

The practice in use at the mill of the Horseshoe Gold Mining Co. at Fay, Lincoln County, is described by Ernest Gayford as follows: The ore passes over a grizzly, with 0·5-in. spaces, to a No. 3 Gates breaker crushing to a 2·5-in.

ring. This product passes to another grizzly, again with 0·5-in. spaces, whose oversize passes to a style H Gates crusher, all the ore below 0·5-in. size going to 300-ton bins, which feed into a Gates revolving dryer, whose product is taken by an elevator to a 4×8-ft. revolving 6-mesh screen. The oversize from this goes to a set of 36×16-in. Gates rolls, the product of which is returned to the screen. The undersize from this screen goes by elevator to two 4×8-ft. 12-mesh revolving screens, whose oversize goes to two 26×15-in. rolls. The product from these rolls is returned to the 12-mesh screens whose undersize goes by elevator to three 4×8-ft. 24-mesh revolving screens. The undersize from these screens is finished product, and goes to a 150-ton bin, while the oversize goes to an extra 26×15-in. Gates rolls, whose product is returned to the 24-mesh screens. The cyaniding is done in nine 24×5-ft. steel leaching vats, each holding 90 tons of dry ore. These vats are charged by cars running on suspended tracks above the vats. The leaching tanks are discharged by shoveling into cars beneath the vats through four 16-in. discharge gates. There are also three 15×9-ft. stock solution tanks, which act also as sump tanks, and three 15×9-ft. gold solution storage tanks. The ore is leached with a 0·3% solution, which is first aërated by compressed air in the sump tanks. The solution is put on from the bottom, to the extent of 25 tons, and allowed to have 12 hours' contact, when it is drained off and is followed by 30 tons of weak solution 0·16% KCN, which is drained continuously. This is followed by 8 tons of wash water, and the sands drained by vacuum until they contain 15% moisture. The total time for one tank from filling to filling is 9 days. Four pounds of quicklime per ton of ore are added at the first crusher. Precipitation is carried on in extractor boxes, 7 compartments, each compartment is 15×9·5 in. in cross section and 16 in. deep. The consumption of cyanide is 0·4 lb. per ton of ore, and the consumption of zinc from 0·25 to 0·30 lb. per ton. The precipitates are shipped to smelters for treatment. The cost of cyaniding is $1·35 per ton.

New Mexico.—Cyaniding has not been very active. The new plant, that of the Last Chance Mining Co., at Mogollon, treat 1,200 tons monthly. It is said on good authority that a 3,000-ton per day plant is projected at Nogal, near the Old Abe mine.

Oregon.—The North Pole and Cougar cyanide mills, at Sumpter, have not been in steady operation. About 18 miles west of Sumpter, the Red Boy mine has a cyanide annex for the treatment of raw concentrates from vanners.

South Dakota.—Great activity has been displayed in building new mills, and four large plants have been erected. The 700-ton Gayville plant of the Homestake Co., or "cyanide No. 2," has been in commission for a few months. The recently completed wet-crushing mill of the Penobscot Mining Co. at Garden City, is in operation with a capacity of 125 to 150 tons per day. The Hidden Fortune Co. is erecting a mill below Deadwood with a capacity of 200 to 250 tons per day, with a probability that another section will be added. The Horseshoe Mining Co. is building a large plant at Terry, wet-crushing to be employed. This mill is to be erected in two sections of 250 stamps each, the second section to be commenced immediately after the first begins operations. The capacity

of the plant when finished will be in the neighborhood of 1,000 tons per day. Aside from these three plants, there is under construction, a cyanide annex to the stamp mill of the Jupiter Mining Co. in Blacktail Gulch, with a capacity of 50 or 60 tons per day, and a small 5-stamp 20-ton wet-crushing cyanide mill, at Two Bit, for the Golden Crest Mining Co. The Pluma Mining Co. is adding a cyanide annex to the old Hawkeye mill at Pluma, and Hall & McConnell have built a 60-ton per day tailings plant at Pluma to treat the very low-grade tailings which accumulated before the main cyanide plant of the Homestake Co. began operations. The old Kildonia chlorination mill of the Horseshoe Co. at Pluma has been converted into a dry-crushing cyanide mill, and has been in steady operation during the latter half of the year, with a capacity of about 200 tons per day. These additions to the mills already in operation will give the district the following plants in operation in the near future with a chance for an increase during 1903:—

Name of Mill.	Location.	Ore Treated Per Day.	Name of Mill.	Location.	Ore Treated Per Day.
		Tons.			Tons.
Homestake, tailings plant.....	Lead.....	1,800	Wasp No. 2 Mining Co.....	Flatiron	100
Homestake, tailings plant.....	Gayville.....	700	Dakota Mining & Milling Co...	Deadwood....	100
Imperial Mining Co.....	Deadwood....	125	Deadwood Standard M. Co.....	Cyanide.....	125
Golden Reward Co.....	Deadwood....	125	Portland Mill, Columbus M. Co.	Gayville.....	60
Horseshoe Co. Pluma Plant....	Pluma.....	200	Rossiter or Golden Gate Mill...	Deadwood....	60
Horseshoe Co. Terry Plant....	Terry	500	Alder Creek Mining Co.....	Flatiron.....	60
Spearfish M. & M. Co.....	Cyanide.....	250	Jupiter Mining Co.....	Blacktail.....	50
Hidden Fortune Min. Co.....	Deadwood....	225	Golden Crest M. Co.....	Two Bit.....	20
Penobscot Mining Co.....	Garden City..	125	Highland Chief Plant.....	Spruce Gulch	50

The total tonnage treated, or to be treated shortly, is 125,250 tons per month. The capacity of some of the plants is in excess of their present working.

The most noticeable feature of the mill construction in the Black Hills during 1902 is that all the new mills are wet-crushing mills. The method is to crush the ore with stamps in cyanide solution, the resultant pulp being separated into sands and slimes by hydraulic classifiers and distributors, the sands are leached and the slimes treated by agitation with pumps, and decantation. When this method was first introduced by John Henton in 1899 for those Black Hills siliceous ores which had to be crushed fine, its practical applicability was doubted by many, but the method has certainly demonstrated its usefulness during the last three years, and has practically displaced fine dry-crushing. All new mills are wet-crushing mills. The dry-crushing mills in the district are the Spearfish, the Deadwood Standard, the Wasp No. 2 and the Alder Creek plants, which crush coarse, and the Imperial, the Rossiter, the Golden Reward and the Pluma plant of the Horseshoe Co., which crush fine, the last using dry-crushing mainly for the reason that the plant is the old Kildonia chlorination mill, converted for cyaniding, the rolls and other machinery already being in place. Where coarse dry-crushing is sufficient to liberate the values and make them soluble, that method is preferable to wet-crushing in solution with stamps, because in plants of similar capacities the cost of treatment will be less, but where fine crushing is needed it is the general opinion that wet-crushing in solution is better. The dry-crushing mill, no matter how complete its exhaust facilities to remove dust from its crushing and screening machinery, is always troubled

with dust, especially in the tank rooms of the newer mills where belt-conveyors are used in charging the vats. This last trouble has been overcome in an ingenious manner by J. V. N. Dorr at the Rossiter plant. Here the ore is removed at the finished-product bin into a trough about 6 ft. long, in which is a screw-conveyor. Just above the trough is a perforated pipe, through which a 0·25% cyanide solution is sprinkled into the finely crushed ore (20-mesh size), to the extent of from 5 to 10%. The screw-conveyor serves to mix the ore and solution thoroughly, and to carry it to a 12-in. belt-conveyor, which, with a short auxiliary conveyor serves to charge the leaching tanks.

The advantages of this device are: 1. That the charging operation is practically dustless. 2. The ore is placed in the tank in such a condition that percolation is easier and much more uniform, channeling is avoided, and more dust can be charged with the ore and still have a leachable product. Another feature of fine dry-crushing which must be taken into consideration with many ores of the district, is the quantity of dust produced in the comminution and collected by the exhaust apparatus. This, in many cases, is too large to permit mixing with the ore without seriously affecting the efficiency of the percolation, reducing the extraction by uneven leaching, and thus necessitating its separate treatment by agitation and decantation. This introduces into the dry-crushing mills that adjunct of the wet-crushing plant, the treatment of slimes, to which the advocates of dry-crushing object, as expensive and cumbersome. Generally the dust is of higher value than the crude ore.

In the case of the Golden Reward plant, the dust amounts to about 4% of the ore crushed, and at the Rossiter plant to about 6 or 7%. In both plants it is treated separately by decantation, while at the Imperial plant, it is charged with the sands into the leaching vats, being mixed with the sands automatically by a conveyor. While, however, the fine dry-crushing system is open to objections, it cannot be said that no unsolved problems confront the metallurgist in the wet-crushing with cyanide solution method. The first of these is the larger quantity of dilute solution to be handled in the mill. The ratio of solution to ore crushed varies between 3 and 4 to 1. The quantity of solution to be handled in a wet-crushing mill is about 1·5 to 2 times that in a dry-crushing mill.

The second is the problem of washing the values from the slimes. This would be simple if enough wash water could be applied, but the quantity necessary is prohibitive, since it would enormously increase the mill solution. One wash water, and in most cases two are not sufficient. In dry crushing it is the general practice to use one final wash water amounting to from 10 to 25% of the ore tonnage, and of this from 6 to 15%, and even more, is discharged as moisture in the tailings, depending on the coarseness of the ore and the use of a vacuum. This practice keeps the quantity of mill solution about constant. In washing slimes, the percentage of water must be increased, and in order to remove dissolved values more than one wash should be employed. This, however, would so increase the bulk of solution that at frequent intervals some of the weaker solutions would have to be run to waste. When the precipitation of the values is good, and it may not be very good with a weak solution, the

quantity of precious metals thrown away may be insignificant, but combined with the loss of cyanide this factor will in time become a serious item.

The extraction from slimes is rarely less than 88%, and in some cases more, but in one mill even with two wash waters only from 80 to 82% is recoverable, the balance passing out in the retained moisture with the slimes which are, when discharged, about 50% liquids and 50% solids. Hence, while with fine crushing and the production of slimes, a higher extraction is possible, from the nature of the case, the mills are not able to take advantage of it to the full extent and recover it. In order to keep the bulk of solution within limits, the wash water in most cases is cut down, on the sands as well as on the slimes, from what it should be to wash out most of the values, and the total extraction in a wet mill is but little above that in a dry-crushing mill, working on the same ore. Naturally the final test is the question of the relative cost of treatment by the two methods. In one of the older wet-crushing 60-ton plants the cost amounted to $1·45 per ton of ore treated, exclusive of taxes and insurance. This figure has recently been reduced to about $1·25 per ton, and it is of interest that the estimated cost of treatment by wet-crushing for a 120-stamp unit of the 1,000-ton Horseshoe plant at Terry is 70c. per ton. The cost of fine dry-crushing is not available, but in most instances it is higher than the figures given above. It has been estimated that a new plant treating 4,500 tons per month can do so for $1 to $1·10 per ton. In one of the old small mills the cost has been as high as $3·50 to $4 per ton. The coarse dry-crushing mills, which reduce to from 4- to 10-mesh size, cyanide the ore for from 75 to 95c. per ton, based on capacity of comparatively small plants. According to C. W. Merrill, the cost of cyaniding Homestake tailings is now about 35c. per ton, the mill labor included in this amounting to but 6c. per ton.

The wet-crushing method has the advantage that weaker solution can be used, the usual battery solution being made up with 2 to 2·5 lb. of cyanide per ton, the sands being leached with a somewhat stronger solution, 3 to 3·5 lb. per ton. The usual strong solution for a dry-crushing plant is 5 to 6 lb. per ton. The quantity of lime is greater for wet- than for dry-crushing, for while less is used at the battery, a large quantity is used with the slimes to aid settling.

It has been a problem to find an efficient method of separating the sands from the slimes, for the sands, in order to get a uniform leaching, should be as free as possible from slimes. In the newer mills, the crude and rectangular two-compartment separator box has been discarded, and in general a similar method to that used by C. W. Merrill in the Homestake tailings plants is employed. At the Penobscot mill at Garden City, two cone-shaped hydraulic classifiers in series are employed, in which, if necessary, a rising current of cyanide solution can be used; the overflow from the last classifier passes to the slime vats, and the bottom discharge of the two, passes by launders to a Butters & Mein distributor over the leaching vats. The peripheral overflow from the sand vats again passes to the slime vats. At the new mill of the Horseshoe Co. at Terry, Klein classifiers are to be installed, using an air current introduced at the bottom to aid in the separation. The overflow containing the slimes will pass to the slime vats while the sands pass directly into the leaching vats. At the new Hidden Fortune mill

below Deadwood, the crushed pulp will pass directly to Butters & Mein distributors placed above the leaching vats, this separation being deemed sufficient to eliminate the slimes, as the crushing will be coarse.

At the cyanide plants of the Homestake Co. the separation is made by a triple set of cones placed in series, the first set at the stamp mills and the other two at the cyanide mills. The first two sets are large flat cones, with no current except that induced by charging at the center and the overflow. The last sets are smaller and deeper, and have a rising current introduced at the bottom, as in the case of the regular hydraulic classifier. Aside from these, the leaching vats are charged by Butters distributors, the overflow at the periphery of the vats passes to waste, the Homestake plants treating sands only.

The pneumatic cyanide process has been introduced at the Pluma plant of the Horseshoe Co., where three 35-ft. tanks are fitted with the pneumatic process, as an experiment. An air pressure of 4 or 5 lb. is put on after the vats are charged, and air forced through the ore for 4 hours. Then leaching is commenced, the time on the pneumatic tanks is 72 hours, while on the other tanks the time is 120 hours. It is, however, questionable whether any benefit is derived from the pneumatic process for the Black Hills siliceous ores, for while the time is shortened, the extraction is not much increased, and difficulty is encountered in discharging the tanks, owing to the network of pipes. The Hidden Fortune and the Hall-McConnell tailings plant also will use the pneumatic process. During the year, some of the plants experimented with the Schilz barium dioxide process, but it was found to possess no advantage for their ores. With the exception of the Homestake mills, which use zinc dust, all mills use zinc shavings. The method of precipitating in barrels or precipitation vats, instead of the compartment zinc box, is finding much favor.

The new wet-crushing plant of the Horseshoe Co., in course of erection at Terry, will have its rough crushing department separate from the mill, and above the stamps. The crushed product from four No. 5 Gates crushers will be conveyed to the main storage bins above the stamps by a belt-conveyor 610 ft. long. which extends the length of the bins, and is provided with a movable automatic discharge tripper to distribute the ore uniformly in the bins. The main bins have a capacity of 7,000 tons, while the ore bin ahead of the crusher has a capacity of 1,000 tons. The mill is being built in two sections of 120 stamps (500 tons) each. One section is to be completed before the other will be started. The stamps are of 1,000 lb. weight, with a 6- to 7-in. drop. Double discharge mortars are to be used with a depth of issue of about 1 in., crushing in cyanide solution through a 20-mesh woven wire screen. The pulp from the stamps is raised by two spiral sand pumps, with two extra ones to act as relays to 4 Klein classifiers, the height of lift being 20 ft. For each 500-ton section there will be 8 sand leaching vats 40 ft. diameter and 5 ft. deep; 16 slime vats, 20×10 ft., 8 gold solution storage tanks, 15×10 ft.; 8 sump tanks, 24×10 ft.; and 4 solution storage tanks, 30×16 ft. There will also be two water tanks 35×16 ft. All tanks are of steel. It is the intention to complete the slimes treatment in one vat, sluicing the exhausted material from it after treatment. The slimes will be agitated with air at 30 lb. pressure by a special arrangement of pipes.

The sands, after leaching, will be discharged through four 18-inch bottom discharge gates on to belt-conveyors. The scarcity of water does not permit of sluicing. It is estimated that the total water consumption of the plant will be one ton of water per ton of ore treated. Precipitation will be effected in zinc compartment boxes.

The new Penobscot mill at Garden City, erected during 1902, is well designed, and an improvement on the older wet-crushing mills of the district. The mill is situated a few hundred feet from the mine, with which it is connected by a covered way. A 13×24-in. Blake breaker, on a rock foundation, does the rough crushing. A Jeffrey elevator, capacity 40 tons per hour, takes the crushed product to the stamp supply bins. At the discharge from the elevator an automatic conveyor cuts out 1-60 for the sampling room. The stamp supply bins, of a capacity of 250 tons each, are flat bottomed, the ore sliding on its own cone to the gates. Eight Challenge feeders charge the ore to forty 950-lb. stamps, making a hundred 7-in. drops per minute. The shoes, dies, tappets and cams are of chrome steel. Single discharge mortar-boxes are used, with a low depth of issue. The ore is crushed with cyanide solution. The pulp from the stamps is raised by two Frenier 10×54-in. sand pumps to four cone classifiers, two in a series. The height of lift is 16 ft. The sands pass to Butters & Mein ball-bearing distributors, having twelve 1·5-in. pipe arms. The distributor is on a trolley above the vats and can be shifted to each one in turn. The solution and slimes overflow at the periphery of the vat over a 0·5-in. tongue of wood inserted into the staves. This device was first used by C. W. Merrill at the Homestake plants to secure a uniform overflow. This tongue or feather can be readily planed and the overflow kept perfectly level, which is necessary to prevent an uneven settling of the sands with slimes. The overflow from the sand vats is collected in an annular launder around the tank and can be conveyed to any slime vat in the mill by a 3-in. pipe discharge. There are six sand tanks, 30×6 ft. outside measurements; eight slime vats, 24×12 ft.; two gold solution storage tanks, 20×10 ft.; two sump tanks of the same size, and three stock solution tanks, 16×16 ft. All tanks are of Oregon fir. The siphoned solution from the slime vats is filtered in sand filters, 15 ft. diameter and 2·5 ft. deep, placed above the gold solution storage tanks. The sand leaching vats are discharged by sluicing through three 12-in. bottom discharge gates, by water furnished from a 50,000-gal. tank, with a pressure of 15 lb. per square inch. The slimes are pumped and agitated by two centrifugal pumps, lined with manganese steel. The precipitation is carried on in four 8-compartment steel boxes, 20 ft. long, each compartment being 2×2·5 ft. in cross section and 18 in. deep to the filter. Before entering the compartment boxes the solutions will pass through 25 precipitating barrels. In all 400 cu. ft. of zinc are available for precipitation.

The sand leaching vats are connected beneath the filters with a Rand vacuum pump, and a 3×10 ft. vacuum tank. The precipitates are refined by sulphuric acid in a steel acid tank, 6×3 ft., which discharges in a vacuum steel filter tank, 3 ft. diameter, placed over a wooden waste tank, 10×8 ft. The pumping of solutions and water in the mill is done by three Dean pumps, two of which are 4·75×5·25×5 in., and the other 7·5×6×6 in.

The new cyanide mill of the Hidden Fortune Co. is in course of erection a few miles below Deadwood on Whitewood Creek. As in the Horseshoe mill at Terry, the crushing department is separate from the mill. The crushing will be done by a 15×30-in. Blake, and the crushed product conveyed to the stamp-bins by a 24-in. belt-conveyor discharging by an automatic tripper into 500-ton bins. The railroad bins above the mill have a capacity of 800 tons. Challenge feeders supply the 60 stamps, which are each of 1,000 lb. weight, making 7-in. drops, 90 per minute. The capacity of the mill will be about 250 tons per day. The mortars will be double discharge, with 1-in. depth of issue. Crushing will be done in a cyanide solution. The pulp from the batteries will go to Butters & Mein distributors, placed over the sand leaching vats, in which overflow gates will carry off the slimes, to the slime vats. The pulp is raised to the distributor by three Frenier spiral sand pumps. The leaching vats will be discharged by sluicing through six 15-in. bottom discharge gates. The five leaching vats are 40×6 ft. There are 4 sump tanks, 3 gold solution storage tanks, 2 stock solution tanks, 7 slime vats—21 tanks in all.

The new Gayville mill of the Homestake Co. is similar to the Lead mill.[5]

Utah.—During the year the Golden Gate and Manning mills have been in operation at Mercur, the latter mill treating old Mercur tailings at a cost of 59·4c. per ton. The Annie Laurie mill in Piute County, built in 1901, has been steadily at work and the new mill of the Ophir Mining Co. in Iron County, situated near the Nevada State line, not far from the Horseshoe mill above described, has also been in operation. At the Sunshine mine at Sunshine, the old mill has been remodeled, and a slimes treatment plant installed. The mill has been in operation treating from 100 to 125 tons per day, although it has a nominal capacity of 300 tons per day. Recently the mill was closed for further changes. The process at this mill, which is rather an innovation in slimes treatment in this country, has been described by Mr. M. D. Stackpole.[6] The ore is crushed to 4-mesh size, and the slimes, which are considerable, on account of the talcose and clayey nature of the ore, are separated in a special conically shaped separator, the patent of George Moore. The slimes are agitated in vats by a centrifugal pump, and are separated from the solution by means of four 30-frame filter presses. This is the only plant in this country, as far as I know, that uses the filter press method of treating slimes.

The Midas Mining Co. in the Mercur district, Tooele County, has a cyanide plant in operation treating tailings from amalgamation.

Washington.—Cyaniding has not been active in Washington during the year; the Republic and Mountain Lion mills at Republic have not been in operation.

Cyanide Practice in Foreign Countries during 1902.

Western Australia and New Zealand.—According to Alfred James[7] the Great Boulder Main Reef, the Great Boulder Proprietary, the Hannan's Star, the Brownhill and the Perseverance and others, in the Kalgoorli district in Western

[5] *Engineering and Mining Journal*, Jan. 4, 1902. [6] *Ibid.*, July 12, 1902. [7] *Ibid*, Jan. 3, 1903.

Australia have successfully operated the cyanide process on sulpho-telluride ores during 1902. Of all the modified cyanide processes advocated and tried only the Diehl bromo-cyanogen and the roasting process are still in use. The Diehl process has been successful on the low-grade ores (0·4 oz. gold) of the Hannan's Star mine, but it is the opinion that on the higher grade ores, roasting must be employed, at least for some part of the ore, in order to get sufficient extraction.

The mills using the Diehl process are experimenting with concentration, combined with the use of bromo-cyanogen, *i.e.*, concentrating out the refractory material, which amounts to from 15 to 20% of the ore, roasting and cyaniding these concentrates and treating the tailings by bromo-cyanide. The process to be employed in the future will depend on the result of experiments in concentration now being carried on.

If these are successful, the scheme of treatment will consist of wet crushing by stamps (wet crushing on account of concentration), amalgamation on plates, concentration, roasting the concentrates, regrinding them in tube mills, cyaniding, with filter press treatment of the slimes. The tailings from the concentrators will have similar treatment except that they will not be roasted. The Diehl process as such and with it the use of bromo-cyanide, would then disappear, in favor of the above-described process.

Wilfley tables are used in the district, but suffer a considerable loss in fine sulphides, which are carried away with the coarser tailings. At the Perseverance mill, the canvas strakes which follow the Wilfley tables, yield a concentrate of higher value than that made by the tables.

It is found that to treat the ore raw, without bromo-cyanogen, the sulphides must not exceed 0·5%, so that the concentration must be carried to that extent.

Ball and tube mills have proved themselves efficient crushing machines in the district. The tube mills are very efficient for sliming the sands, one standard mill crushing 70 tons per day from a 12-mesh size feed, through a 60-mesh screen, consuming 27 H.P. The agitator used in the cyanide vats is one with radial arms on a vertical spindle, suspended over the vat, there is no step, but the spindle is guided in a guide of cement or iron. An arrangement for raising the agitator is rarely employed, South African tailings wheels are used to elevate the slimes, which are thickened in multi-bottomed spitzkasten. Dehne filter presses are used, operated by compressed air, but plunger pumps are preferable on account of economy.

The Riecken electrical precipitation process has been tried at the South Kalgurli mine, and at the Great Boulder No. 1, but has been discontinued owing to the defective electrical precipitation, which is the essence of the process.

Mr. S. J. Truscott[8] gives the cost of amalgamation, milling and cyaniding for the year ending December, 1901, as follows:—

Ivanhoe Gold Corporation.—88,084 tons milled (0·58 oz. per ton) (amalgamation) cost $1·66 per ton; 46,459 tons of sands (0·043 oz.), cyanided, cost $1·27 per ton; 60,624 tons of slimes (0·41 oz.), cyanided, cost $1·61 per ton.

Golden Horseshoe.—77,801 tons (0·75 oz.) (milled, including pan amalgama-

[8] *Journal of the Chemical and Metallurgical Society of South Africa*, III., iv., 43, August, 1902.

tion) cost $2·34 per ton; 40,108 tons sands (0·84 oz.), cyanided, cost $1·50 per ton; 51,588 tons slimes (0·44 oz.), cyanided, cost $2·46 per ton.

Lake View Consols.—76,571 tons milled (1·58 oz. amalgamated) cost $1·66 per ton; sands cyanided, cost $1·44 per ton; slimes cyanided, cost $1·70 per ton.

Mr. Alfred James, in the article already mentioned, gives the cost at the Hannan's Star mill, which uses the Diehl process, at $5·33 per ton, on 0·4-oz. ore. The same process on the considerably higher grade ores of the Hannan's Brownhill and Lake View Consuls, cost $8·19 per ton, which includes $2 alone for bromocyanogen. The cost at the Great Boulder Main Reef, which uses the roasting process, is $6·25 per ton with an extraction of 90%. Costs in Kalgoorlie are necessarily high, for power costs about $19 per H.P. per month, and water from 80c. to $1·50 per 1,000 gal.

During 1902 in New Zealand 25 of the 26 cyanide plants were in operation.[9]

Wet Crushing and Direct Cyaniding.—Hamilton Wingate[10] describes the direct cyaniding of wet crushed ores at the Waitekauri Extended mine, Maratoto, N. Z., as follows: Formerly the ore was dry crushed and cyanided, but this method was found to be unsuited to the lower level ores and was high in cost. The choice of a satisfactory process depended on a successful method of slime treatment. In this respect the liberal use of lime was found satisfactory. The ore is a hard, flinty quartz carrying finely divided pyrite. The gold content is uniformly distributed in a fine state of division, while the silver is present as a sulphide. The base sulphides comprise 5% of the ore, and the average value of the ore is from 0·3 to 0·4 oz. gold and 1·75 oz. silver. The mortar boxes, which were double discharge for the old dry crushing method, had one discharge closed for the wet crushing, but were still unsuitable, as a large quantity of slime was produced owing to improper dimensions. A higher extraction by cyanide, however, was obtained on slimes than on sands. The ore was crushed through a 40-mesh screen, the classification of 656 tons of ore giving 54·11% sands, and 45·89% slimes; 70% of the total pulp passed an 80-mesh screen, which was the fineness necessary for a good extraction.

The crushed pulp passed to a 5-ft. square pyramid shaped spitzkasten, 5 ft. deep. At the apex was a 2·5-in. cock to regulate the discharge of the sands. A perforated pipe or rose at the overflow end was necessary to prevent the settling of the slimes with the sands. It was essential to make a clean separation of the sands from the slimes, since those slimes that pass with the sands are lost in the overflow from the sand vats, while any sands in the slimes cause a portion of the slimes pulp to set hard at the bottom of the vat, in a mass too tough to be affected by the agitator.

The discharged sands from the spitzkasten passed to a vat into which they were charged by a Butter's distributor, and the overflow of the spitzkasten containing the slimes passed to an agitator vat. The 30-ton sand vats were 20 ft. in diameter and 4 ft. deep. The sands were treated first with a preliminary alkaline wash, then with a weak sump solution, followed by a 0·5% cyanide solution, and finally by the usual washes of strong and weak sump and wash water. The sands in general presented no difficulty of treatment.

[9] *New Zealand Mines Record*, May, 1902.

[10] A paper read before the American Institute of Mining Engineers, New Haven meeting, 1902.

The slime vats were 22 ft. in diameter and 7 ft. deep, holding on the average 25 tons of slimes. The overflow from the spitzkasten is run in at one end, and the clear liquor allowed to flow off at the other. After charging the vat, the slimes are allowed to settle, and the water is drained off by an inside siphon pipe, leaving a pulp which contained from 42 to 58% of dry slimes. The agitator is then started, being at the same time gradually lowered. The charge was accurately sampled by dip samples. On the average 14 lb. of lime were added, and the charge agitated for an hour to neutralize the acid in the ore. In order to economize cyanide and prevent the quantity of solution from becoming unmanageable, the weight of cyanide required for the slimes was dissolved in 5 tons of strong sump solution, and added to the slimes, the resultant solution containing 0·16% cyanide. The slimes pulp was then agitated for 3 hours at the rate of 40 r. p. m. Then strong sump solution was run on, during agitation until the depth of slimes pulp in the vat was 6·5 ft. The agitator was then raised, and the slimes allowed to settle after which decantation was begun. The decanting pipe consisted of a 2-in. wired, rubber hose fixed inside the vat, and connected at the bottom and side of the vat with the solution pipe to the extractor boxes. The end of the hose is held in an iron collar to which is attached an arm made of 0·5 in. square iron. This arm passes through a guide which can be moved freely along an iron bar 3 ft. long, which is bolted to the inside edge of the top of the vat. A thumb screw through the guide holds the arm in position, and as the hose is lowered the guide can be moved along the fixed iron bar and the arm securely clamped. After the first solution had been drawn off, agitation with sump solution, followed by decantation was continued. From four to eight washes were required, the total weight of which was three or four times that of the dry slimes present in the charge. Each wash was passed through the extractor boxes before being returned to the slimes charge. The rate of flow through the extractors was 2 tons of solution per hour per cubic foot of zinc shavings. The extraction from a test lot of 1,440 tons was 81·4% of the gold and 45% of the silver. Consumption of cyanide was 2·7 lb. per ton, consumption of zinc 0·75 lb. per ton, lime 7 lb. per ton caustic soda 0·75 lb. per ton. The total cost was $2·07 per ton, including all charges. The necessity of strong solutions owing to the nature of the ore and the need of obtaining an adequate extraction of the silver makes the cyanide consumption much higher than the average. Mr. Wingate states that wet crushing has practically superseded dry crushing in New Zealand for the reasons given above.

Several mills in New Zealand crush in the battery with a 0·1% cyanide solution, the process being practically the same as that which is used in some of the South Dakota mills. This method, however, would not be applicable to acid ores owing to the heavy cyanide consumption involved.

The Treatment of Slimes.—A patent has been issued to E. Godbe for a process of treating slimy ores by cyaniding, which consists of stirring the pulp with cyanide solution containing lime, in a circular vat of no greater diameter than depth, and while stirring introducing a stream of cyanide solution from below a false filter bottom. This solution rises up through the agitated and suspended ore, and overflows at the top clear and free from slime. To do this the stirrer is

placed close to the bottom and does not revolve fast enough to throw the slime to the surface, but just sufficient to keep the entire mass in suspension and flowing around the tank, leaving a few inches of perfectly clear solution at the top. Compressed air can be blown into the vat to aid in the solution of the gold. The overflowing solution is ready for precipitation. Weak solution and washes are introduced in a similar manner to the strong cyanide solutions.

J. Yates[11] states that in South Africa the cost of a plant for treating slimes by the decantation method is from $750 to $1,000 per head of stamps. An average of 60% extraction by the decantation method on slimes is the best obtainable in South Africa. Led by these facts John R. Williams is to make a test on a working scale, side by side, of the decantation and filter press methods of slime treatment, which will be of very great interest.

The Bromo-Cyanogen Process.—The Diehl process as practiced at some of the Kalgoorlie mines, Western Australia, and already mentioned, is described by H. Knutzen[12] as follows: The process is used at three mines, the Hannan's Star, the Hannan's Brownhill and the Lake View Consols, at the last named mine both the Diehl process and the roasting process were operated. A number of analyses were made on Kalgoorlie ores, from the different mines, with the following results:—

Insoluble matter (insoluble in dilute hydrochloric acid), 40 to 78%; iron carbonate (spar), 10 to 30%; calcium carbonate, 9 to 38%; gold, 0·8 to 5·5 oz. per ton.

It is thought that this composition accounts for the trouble met with in the roasting process, as the finely ground ore after roasting has cement-like properties, forming an iron cement, which sets in the vats. The Diehl process comprises the following essential stages:—

1. Crushing and sliming the ore.
2. Treating the slimes in agitators with a solution of potassium cyanide in combination with cyanogen bromide.
3. Filter pressing the sludge and precipitating the gold from the solution by means of zinc shavings.

According to the nature of the ore, amalgamation and concentration may be added as part of the process.

It was found that in order to get a good extraction on Kalgoorlie ore it must be slimed. Only part of the gold is present in the metallic state, the greater part being present as a telluride and in sulphides. The slimes from the ore are richer than the sands owing to the brittleness of the telluride minerals. Ore was crushed in a battery through a 40-mesh wire screen with this result:—

On 3·25-oz. ore the sands contained 20·27% of the gold value; the concentrates, 38·49%; the slimes, 29·62%; and amalgamable gold, 11·62%.

On 0·85-oz. ore the sands contained 26·24% of the gold value; the concentrates, 37·51%; the slimes, 35·37%; and amalgamable gold, 0·88%.

The best extraction on sands with a 7-day leaching did not exceed 50% of the gold. The best machine to slime the ore was found to be a Krupp tube mill,

[11] *Journal of the Chemical and Metallurgical Society of South Africa*, III., iv., 41, August, 1902.
[12] A paper read before the Institution of Mining and Metallurgy, June 19, 1902.

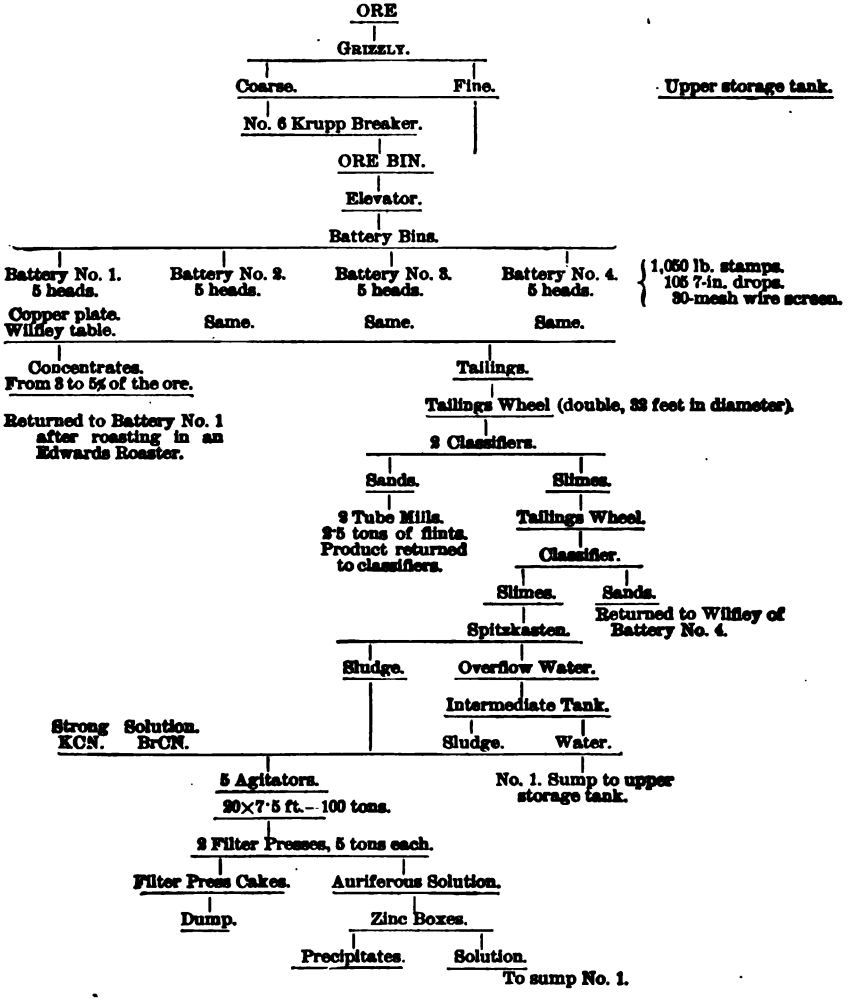
using flint balls. The mill is 18 ft. long, 4 ft. in diameter and charged with 4 tons of flints. The sands are fed by a nozzle at one end, and the slimes discharge at the other. All of the product passes a 200-mesh screen, and less than 3% remains on a 220-mesh screen. One of the advantages of this mill is the small quantity of metallic iron that contaminates the slimes. From the tube mill, the slimes containing from 3 to 5% of solids pass to a system of classifiers to separate out any remaining sands which are sent back for recrushing. The slimes flowing from the classifiers pass to a system of spitzkasten, where they are concentrated to a pulp containing from 40 to 50% dry material. This goes to agitators, which are covered tanks from 20 to 25 ft. in diameter, and 7·5 to 8 ft. deep, provided with stirrers. The capacity of an agitator is from 120 to 125 tons of pulp. When the agitator is filled, a strong solution of potassium cyanide is added (4·4 lb. of cyanide per ton of dry material) and agitated for 1·5 hours, when a solution of bromo-cyanogen is allowed to flow in (1·1 lb. per ton of dry material). Then the pulp is agitated until the total time of agitation is 24 hours. The quantities of chemical vary according to the richness of the ore, the above quantities being for 2 to 3-oz. slimes. Two hours before the agitator is ready to discharge to the filter presses, from 1 to 4 lb. of lime per ton of dry slimes is added, which has the effect of giving a clean precipitate in the zinc boxes. Experiments were made to test the extraction with and without bromo-cyanogen. With plain cyanide solutions ranging in strength from 0·1 to 0·3% an extraction of from 41 to 62% was obtained. With the same cyanide solutions plus bromo-cyanogen added from 0·025 to 0·075% strength the extraction was increased from 77 to 97% on ore carrying approximately 2 oz. gold. Chloro-cyanogen was found to be non-effective in increasing the extraction, rather the contrary.

The filter press is indispensable to the Diehl process owing to the high value of the slimes. The filter presses used have a capacity of from 4·5 to 5 tons. They consist of 50 frames, the cakes from which measure 39·5 in. square and from 2·5 to 3 in. thick. A dry cake weighs from 1·75 to 2 cwt. Each filter press has its own system of receivers, one for slimes, one for weak solution and one for wash water. The presses are operated by compressed air. The cakes are washed once with weak solution and once with wash water. For a charge of 5 tons from 350 to 500 gal. each of weak solution and wash water are used. The cakes are then dry blown 10 or 15 minutes with 80 lb. of air, and then the cakes are discharged into cars below. The time occupied from one charge to the next is 2 hours. The solution goes to the zinc boxes, first, however, being passed through a special filter or another small filter press for clarifying. The plant at the Hannan's Brownhill mine is a new one, built specially for the Diehl process, having a capacity of 75 tons per day. The scheme of working is given on the following page.

At this mill, 2,210 tons of ore were treated during July, 1901, at a cost of $5·84 per ton, which was rather high, the average cost being $5·34.

The Lake View Consols mine had in operation alongside of the Diehl plant a plant using the roasting process, in which the ore was dry crushed by Krupp ball mills. The ore treated by one plant was precisely the same as that treated

by the other, hence a comparison of costs is interesting. In August, 1901, the roasting process treated 3,411 tons of ore producing 5,287 oz. of bullion at a cost of $9·08 per ton. The Diehl process treated 5,888 tons producing 9,020·48 oz.



of bullion at a cost of $8·36 per ton. With the same kind of ore going to the plants, the extraction by the Diehl process was $28·16 per ton, as against $27·27 by the roasting process, the difference between these costs should be added to the cost of the roasting process.

At the Hannan's Star mill the ore is crushed dry in 2 No. 5 Krupp ball mills, through a 30-mesh screen, from which it goes to a mixing machine, where it is mixed with water. From here the pulp follows the same course as at the Hannan's Brownhill.

Refining of Precipitates.—Hamilton Wingate[18] describes the method used at the Waitekauri Extended mine, Maratoto, N. Z. Roasting the vacuum-dried

[18] A paper read before the American Institute of Mining Engineers, New Haven meeting, 1902.

precipitates was adopted in place of treating with sulphuric acid, the facilities for the latter method not being available. It is also a question whether the acid treatment presents any advantages in the treatment of bulky precipitates such as are obtained from ores containing considerable silver. All the precipitate is first washed through a 40-mesh screen. After drying on a filter by the aid of a vacuum pump, the precipitate was weighed and transferred to the oxidizing furnace, consisting of a square cast iron tray 6 in. deep, built over a brick furnace using wood fuel. The tray has a sheet iron hood over it, to collect the fumes, which are conducted through a flue to the dust chamber. The oxidation of the precipitate was conducted at a low heat, which was gradually raised to a dull red, the precipitate being kept broken up by a rake, care being taken to avoid dusting. The oxidized precipitate was fluxed as follows: 50 parts anhydrous borax, 15 parts of anhydrous sodium carbonate, 100 parts of precipitate. This was charged into a No. 50 graphite crucible and melted at a moderate heat, the pot being carefully covered during the fusion and recharged in each case before fusion was quite complete. When the crucible was three-quarters full, the temperature was raised and the slag, now thoroughly liquid, was ladled into molds and the crucible recharged as before until two-thirds full of molten bullion. The bullion was poured into molds, each bar being again melted in a crucible of smaller size and skimmed if necessary before pouring. The bullion averaged 941 fine. This fineness was mainly due to the passage of the precipitate through a 40-mesh screen, which eliminates the coarse zinc. It is impossible to oxidize zinc scattered through a bulky precipitate, and as its presence causes mechanical and volatilization losses, it must be eliminated if subsequent losses in melting are to be avoided. The slags were crushed at the mill and yielded in shot 1·5% of the total value of the bullion. The crushed slag after panning had a value of $121·50 per ton. The sweepings from the dust chamber and flue yielded only $43 after the roasting of about $30,000 worth of precipitates.

P. S. Tavener[14] describes a new method of treating zinc-gold slimes, which consists of smelting them with litharge in a reverberatory furnace, and cupelling the auriferous lead. The process was first introduced at the cyanide plant of the Bonanza Co. at Johannesburg in 1899, and since the resumption of milling 14 months ago, has been in continuous and satisfactory operation. The clean-up of the slimes is conducted in the ordinary way, except that the whole precipitate is pumped at once from the clean-up tub into the filter press, the fine zinc which remains at the bottom of the tub being heaped to one side and allowed to drain before it is transferred to the smelting room. The cakes from the filter press are dried in an oven, 15 minutes per tray being sufficient. The fine zinc is kept separate from the filter press slimes. The dried slimes are passed through a 4-mesh sieve and roughly weighed, for the addition of the mixed fluxes. The charge is made up approximately as follows: Slimes, 100 parts by weight; assay slag, 10 to 15 parts; foul slag, 10 to 15 parts; silica, 5 to 10 parts; litharge, 60 parts; fine zinc, 100 parts; slag, 20 parts; litharge, 150 parts.

The charge is shoveled directly into the furnace, the fine zinc part being

[14] A paper read before the Chemical and Metallurgical Society of South Africa, III., iv., 70-78, October, 1902.

placed on top of the slime charge to prevent loss by dusting and also to have an excess of litharge at the top of the charge. No absolute rule for fluxing can be formulated as that depends upon the nature of the precipitates smelted. In practice it is found that considerably less slag (30% less) is required than

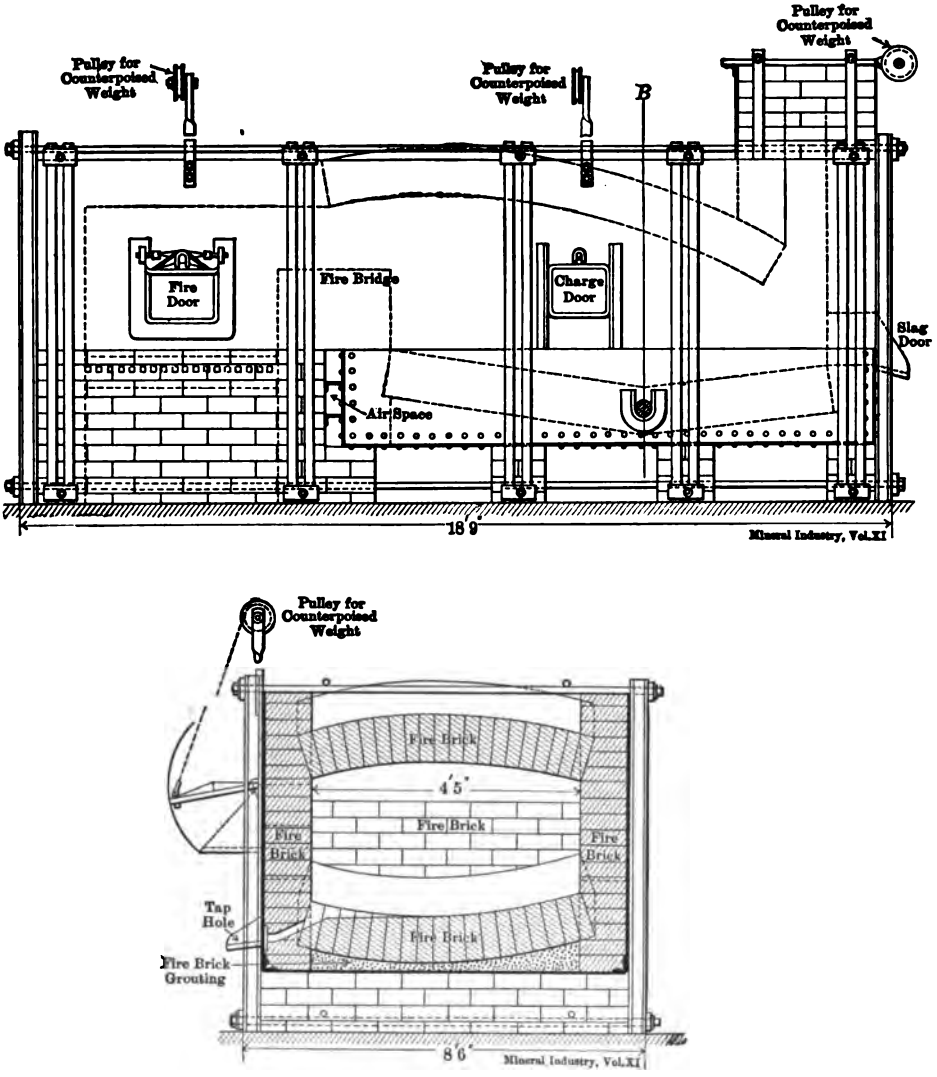
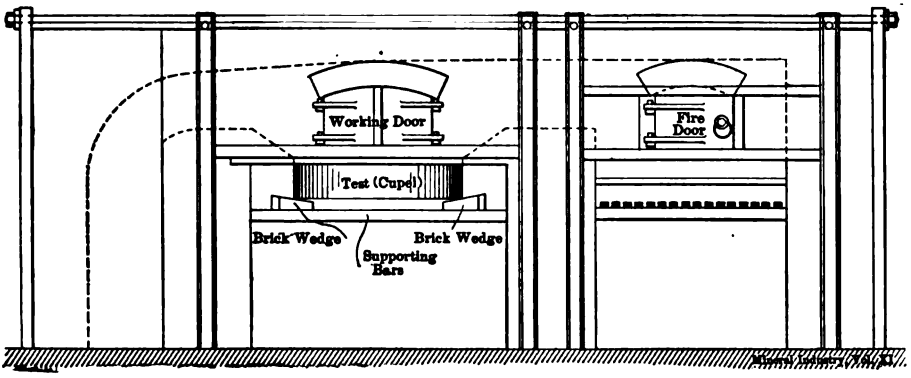


FIG. 1.—TAVENER'S FURNACE FOR SMELTING ZINC-GOLD SLIMES.

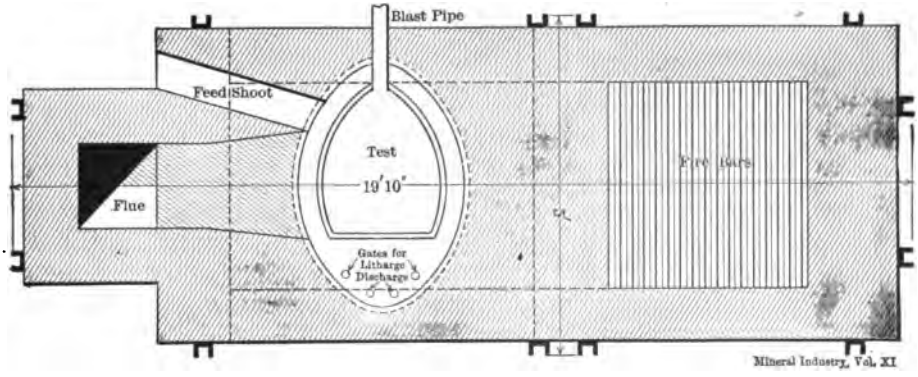
in smelting small quantities of precipitates in crucibles. The lead bullion produced should contain not more than 8% of gold—10% being the limit. As a reducing agent sawdust was employed to the amount of from 1 to 2% of the weight of the litharge present. No sawdust is added with the fine zinc charge, the zinc in the latter acting as the reducing agent. The reverberatory furnace

is shown in Fig. 1, except that the roof should be that of a true reverberatory. The pan should be filled, and the sides lined for 12 in. above the hearth with the best quality of fire brick. The bottom is laid with close joints on a grouting of crushed fire brick mixed with sufficient fire clay to make a binding material, which is tamped into the pan to the required level and faced with cement.

The charge is placed in the furnace, covered first with a thin layer of litharge, followed by a thin layer of easily fusible slag. The furnace is charged on the day previous to the smelting. At 3 A.M. a slow fire is started to dry the charge, at 5 A.M. the fire is urged, the furnace being raised to a smelting heat in 30



Side Elevation.



Horizontal Section.

FIG. 2.—TAVENER'S FURNACE FOR CUPELLING ZINC-GOLD SLIMES.

minutes. By 9 or 10 A.M. the charge is reduced, and any sweeping or foul slag on hand is added. The charge is then well rabbled and sawdust thrown on, repeated to reduced the excess of litharge until the slag shows clean on the rabble. The slag is then drained off into pots. The slag door is 4 in. above the center of the lead charge, when about 12,000 oz. of lead bullion are in the furnace. Before charging the furnace the slag door is built up 12 in. by means of cast iron plates laid in fire clay. In order to draw off the slag these plates are removed one by one. The filled slag pots are allowed to stand a few minutes, and then are tapped 2 in. from the bottom (to recover any lead), the shells and

bottoms being reserved for resmelting. The last of the slag is waved off by rabbling. The last skim of slag on the bath is thickened by cooling and throwing a shovelful of lime over the charge, when it is easily detached, and reserved for the next melt. A clean surface of lead is then exposed, and any zinc present quickly burns off. The lead recovered is clean and soft. The bullion is sampled accurately after stirring by taking a ladleful, and is then poured into bars.

The cupelling test is an oval, cast iron frame filled with bone ash ground to pass a 20-mesh sieve, and moistened with a potash solution of 1 lb. of potash for every 33 lb. of bone ash. The bone ash must be moistened just sufficiently so that if squeezed into a ball in the hand it will break clean. The test requires 500 lb. of bone ash to fill it, 300 lb. remaining after the necessary cutting out. (See Fig. 2.)

The test has a basin cut into it, from 2·5 to 3 in. deep, and is put away to dry at least two weeks before using. A cupel of this size is sufficient for four charges each of 1·5 tons of lead. The last one used at the Bonanza lasted 4 months, and cupelled 7·5 tons of lead bullion, producing 14,978 oz. of bullion.

When the new cupel is placed in the furnace a slow fire is kept burning for 3 or 4 hours before starting to refine. The blast is introduced into the test by a 3-in. pipe flattened at the end, and turned down so that the blast may strike the lead. The temperature is now raised to melt lead, and six bars are put into the furnace by the working door. When these are melted, the temperature is increased, and the remainder of the lead is introduced through the feed chute, the ends of the bars being allowed to melt off gradually. Lead is thus fed in until the bath almost reaches the level of the litharge channel, which has been cut in the meanwhile. The temperature is then increased to the melting point of litharge, and as soon as the bath is covered with litharge the blast is turned on, the litharge formed running into a pot similar to a slag pot, but only 12 in. in diameter and 8 in. deep. The flow of litharge is controlled by the quantity of lead melted from the bars introduced through the feed chute. When the feeding is completed, and there remains only the bath of concentrated bullion, the temperature is raised, and the litharge channel deepened. Nearly all the copper in the bullion enters the litharge just before the completion of the operation, which makes the litharge thick and heavy and requires a high temperature. Just before the cupellation is finished there is danger that the bath will freeze under the cold blast; if that occurs the blast is shut off and the temperature raised until the bath is molten again, after which the blast is turned on and the last impurity driven off. From 6 to 8 lb. of assay slag are then added and melted, and allowed to run off, and by this means the gold is given a clean, bright surface. The fire door is now opened and the gold allowed to cool to a point where it will not crumble when a bar is inserted under the cake. This is lifted, broken in halves, and pulled out into a slag pot. The gold is remelted in crucibles and cast into bars. The advantages of the process can be stated as follows: 1. Saving in cost of treatment. 2. Absence of by-products. 3. Reduced loss in handling. 4. Increased recovery of gold. 5. Facility for treating foul slag.

The results of four months' smelting at the Bonanza are as follows: Weight of moist filter press slimes, 9,058 lb.; of fine zinc, 7,662 lb.; lead bullion cupelled,

15,269 lb.; gold recovered, 12,810 fine oz.; materials used, coal, \$396·74; coke, \$45·24; fire clay, \$14·40; fire brick and slabs, \$83·32; paper bags, \$9; lead foil, \$14·56; bar iron, \$0·76; crucibles and liners, \$8·40; caustic potash, \$2·88; bone ash, \$48; sundries, \$6·04; total, \$631·34; loss of lead, 12% on 15,269 lb.=1 ton at \$96, grand total, \$727·24, or 5·5c. per fine ounce of gold recovered.

Roughly speaking, the cost of acid treatment is about 24c. per ounce of fine gold recovered. A cyanide plant producing 2,500 oz. of fine gold per month would save approximately \$4,800 per year in the cost of refining, besides gaining about \$1,440 from the elimination of by-products, in which gold has to be sold at a discount, and from losses in handling. The lead smelting process has shown an increased recovery from the same slime, of 10% and even more, as compared with the acid process. In one trial for the Village Main Reef Gold Mining Co., the smelting process gave 11% higher recovery than three acid-treated lots; in another trial 10% more; although the reason for this has not yet been carefully investigated, the evidence is too important to be ignored. The large differences have been attributed to the incomplete mixture of the slime and fine zinc in order to insure that in taking equal parts for the comparative tests there will be equal quantities of gold in each, but if that were the case the acid treatment would sometimes give higher recovery than the smelting, a result, however, that has not once been obtained. The use of lead acetate in large quantities which has become necessary in precipitating the very large volume of dilute solution from the slimes plants, has caused trouble in the acid treatment owing to the danger of introducing lead into the bullion. This trouble disappears with the smelting method. It is also true that the very poor and bulky precipitate from the slimes boxes are costly to treat by the acid process, but readily treated cheaply by the smelting process. Recently, Alfred James stated that the loss from the ordinary clean-up as practiced in the Rand amounts to from 1 to 6% of the total output.

E. H. Johnston and W. A. Coldecott[15] used MnO_2 as an oxidizer in refining precipitates, although niter has a higher theoretical power, yet at the temperature of fusion MnO_2 is the most efficient. It also does not corrode the crucibles so readily. The average charge was: 100 parts slimes, 20 to 35 parts borax glass, 20 to 40 parts MnO_2, 15 to 40 parts of sand. Very high-grade bullion was reduced by this method. P. S. Tavener, however, states that the fineness of the bullion is obtained at the expense of the silver, which the manganese dioxide tends to drive into the slag.

Treatment of Concentrates.—C. M. P. Wright[16] describes the treatment of raw concentrates by percolation as practiced at Choukpazat gold mines in Burma. The concentrates contain from 30 to 40% of sulphides, and from 60 to 70% of coarse sands. The sulphides consist mainly of iron pyrite; but 5% consist of franklinite, galena, chalcopyrite, and a little altaite. The franklinite carries 7 oz. gold, the chalcopyrite and iron pyrite from 0·9 to 2 oz. gold, and the galena practically none, the average value of the concentrates is 1·82 oz. gold

[15] *Journal of the Chemical and Metallurgical Society of South Africa*, Vol. III., p. 21, July, 1902.

[16] "Cyaniding Concentrates by Percolation." A paper read before the Institution of Mining and Metallurgy, November, 1902.

per ton. The concentrates are treated first with a plain water or alkaline wash, followed by a weak solution wash 0·10 to 0·12% cyanide, and then nine washes of 0·3% cyanide. The contents of the vat are then turned over, and are treated until for two successive days the effluent solution runs 0·26% cyanide, when the treatment is considered complete. Then follow two washes from the strong sump, 0·25% cyanide, and two weak washes, 0·07%, finally one or two wash waters. From 17 to 20 tons of concentrates are treated per month. The time of treatment is 24 days, and the extraction is 84%. The zinc boxes are made up at the commencement of the treatment and left untouched to the end, all solutions passing through the box as they come from the percolating vat. The precipitates that pass a 30-mesh screen carry nearly as much silver as gold, those that remain on a 30-mesh screen carry practically no silver, but much copper. All the zinc in the box becomes copper coated almost immediately on being put to use. The method of treating the precipitates is as follows: Careful cold acid treatment is followed by a thorough washing and drying in enameled basins, and fluxing the slimes below 30-mesh size with 27% borax, 18% sand, 13% soda, 10% niter. The slimes above 30-mesh size are fluxed with 45% borax, 27% sand, 22·5% soda and 16% niter. The slags run about 8 oz. gold per ton and contain no shot. The bullion from the fine slimes is from 560 to 600 fine, and from the coarse slimes from 500 to 540 fine. The detailed cost of treating 89 tons of concentrates was: Pumping, 13·5c.; supervision, 86c.; labor, 11c.; cyanide (5·12 lb.), $1·345; zinc (0·85 lb.), 7c.; reduction, assaying and sundries, 59c. Total, $3·12 per ton. The tailings assayed 0·25 oz. of gold per ton.

Herbert K. Scott,[17] in his paper on "The Gold Fields of Minas Geraes, Brazil," mentions the success obtained in treating concentrates by the cyanide process at various mines in the State of Minas Geraes, Brazil. At the Moro Velho mine, concentrates from strakes consisting of pyrrhotite, pyrite and mispickel are treated by an "oxygen process," which is a modified cyanide process embracing agitation and aëriation. The Passagem mine of the Ouro Preto Gold Mining Co. in the same district, after experimenting with the same class of material with a modified cyanide process with good results, will replace barrel chlorination of the concentrates by cyaniding. At the Faria mines, near Honoria Bicalho, on the Central Railway of Brazil, the pulp from the batteries passes over amalgamated plates, and into two spitzlütten, which separate out the heavy concentrates. The tailings overflow from the spitzlütten pass to two spitzkasten, which separate the sands from the slimes. The sands and the concentrates are treated separately by percolation, and the slimes by the filter press process. Johnson presses are being used. An extraction of 90% is obtained on the sands, and 55% on the slimes.

At the Sao Bento mines, near Santa Barbara, oxidized siliceous ores are crushed by Blake crushers and Gates rolls to pass a screen of 0·15-cm. opening. An extraction of 86·6% is obtained.

Commercial Potassium Cyanide.—According to A. Whitby[18] the difference in composition of the salt sold as "98% potassium cyanide," is considerable.

[17] A paper read before the American Institute of Mining Engineers, May, 1902.

[18] A paper read before the Chemical and Metallurgical Society of South Africa, Dec. 20, 1902.

Five samples from four distinct sources were analyzed with the following result:—

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Potassium	6·5	30·5	30·8	45·6	.....
Sodium	41·0	23·9	23·1	11·4	47·5
Cyanogen	39·4	38·8	37·7	40·4	51·2
Carbonate (CO_3)	7·5	3·0	4·7	0·3	Trace.
Undetermined	5·6	3·8	4·8	2·3	1·3
KCN and NaCN	78·0	85·6	83·5	94·8	98·7

The object of the analyses was to show how the present system of purchasing cyanide left the manufacturers a wide margin for impurities. For instance, No. 1 contained by calculation 13% of sodium carbonate and 5% of other impurities. No. 5 shows what a commercial sodium cyanide ought to be. It is very easy for the manufacturer to comply with existing conditions, and yet supply the consumer with many things he can do without.

No. 3 is heavily charged with alkaline sulphides, but it was used extensively without complaint about its effectiveness; while laboratory tests may show alkaline sulphide to be injurious, in working solution they are rendered harmless by precipitation as zinc sulphide. Alkaline carbonates are beneficial in increasing the alkalinity of the solution. The cyanates act the same way, in becoming eventually transformed into carbonates. Summarizing, the facts are as follows: The mills use a mixture of sodium and potassium cyanide nicely adjusted to 98% KCN, leaving room for extensive adulteration. The effectiveness of the mixed cyanide being accepted, it would be desirable to adopt the use of a sodium cyanide, demanding an efficiency of at least 50% cyanogen. Or if a potassium cyanide is to be used a limit should be set for the sodium cyanide present in order to control the amount of inactive bodies. For the analyses, 10 g. of cyanide were dissolved in 500 c.c. of water, this solution being used for all tests. For the determination of carbonate and cyanogen freshly prepared solution must be used. For carbonates, from 50 to 100 c.c. of the solution are taken, and a few drops of ammonia and a solution of calcium nitrate in slight excess added. The precipitate is filtered rapidly, and washed with hot water containing a little ammonia. The precipitate is ignited to oxide, weighed and calculated to carbonic acid. The cyanogen is determined in the usual way with silver nitrate. For the determination of the alkalies, 50 c.c. were evaporated with a slight excess of hydrochloric acid, taken up again with a few c.c. of concentrated acid, and again evaporated. For more accurate work it would be necessary to remove heavy bases by dissolving the residue in water made slightly alkaline with ammonia, and passing hydrogen sulphide through to remove traces of lead and iron present. Should calcium be present the treatment must be followed by the addition of a little ammonium oxalate, filtered, and the solution again rendered slightly acid by hydrochloric acid, and evaporated to dryness, gently ignited and weighed. For the purpose of these experiments it was found sufficient merely to evaporate to dryness with acid, as even the most impure samples gave mere traces of insoluble residue. The total chloride was then estimated with decinormal silver nitrate solution, and the ratio of potassium to sodium determined by the indirect method.

According to R. W. Moore,[19] of 80 samples of commercial potassium cyanide imported into the United States, only 24 contained no sodium cyanide, while 50 contained from 10 to 54% of sodium cyanide, averaging 22%, it being evident that much of the cyanide used in the process is a mixture of sodium and potassium cyanide. Under the Dingley tariff, potassium cyanide is admitted under a duty of 12·5%, which is one-half that on chemical salts. The question came up for the Board of General Appraisers as to what duty is to be paid on a mixture of sodium and potassium cyanides, and the decision reached was that the mixture should be admitted as potassium cyanide.

Treatment of Cupriferous Gold Ores.—Louis Janin, Jr.,[20] discusses the treatment of cupriferous gold ores by the cyanide process. Three methods are advocated which have in view the entire or partial elimination of the copper and the consequent protection of the potassium cyanide. They are:—

1. Leaching by sulphuric acid preliminary to cyanide treatment.
2. Scrymgeour's method of dissolving copper minerals in a solution of potassium cuprocyanide, containing no free potassium cyanide.
3. Bertram Hunt's method of leaching with an ammoniacal cyanide solution.

While many copper minerals are soluble in sulphuric acid, this method has serious drawbacks in that it may have a very high consumption of acid if lime and magnesian carbonates are present in the ore. There is also a tendency for the ore to cement and pack in the tanks after the acid treatment. A neutralizing agent such as a caustic soda solution must follow the acid treatment, otherwise the consumption of cyanide will be more even than when treating the original ore before acid treatment. Burnt lime, as ordinarily employed, will not penetrate the ore mass to neutralize the acid. The acid process is then a three-stage process. 1. Leaching the ore with dilute sulphuric acid. 2. Neutralizing the acid remaining with caustic soda. 3. Treatment with cyanide solution.

Scrymgeour's method depends upon the property of potassium cuprocyanide to dissolve copper in certain minerals. The cuprocyanide is obtained by heating the ore with dilute cyanide solution. When the cuprocyanide solution has dissolved the maximum of copper in the form of sub-cyanide the excess of copper is precipitated electrolytically. Then the ore is ready for the ordinary treatment with dilute cyanide solution. The method is a two-stage one employing separate electrolytic precipitation vats, and separate storage tanks.[21]

Bertram Hunt's method is very simple, and essentially a one-stage process. It depends upon the protective influence of ammonia as well as its solvent action for copper, the ammonia and cyanide being employed in the same solution. It is known that the double salt of copper and potassium cyanide has a solvent action on gold. It is not so well known that the cyanides of gold, silver and copper, and other base metals are soluble in ammonia. When a solution of cupric oxide is dissolved in ammonia containing less cyanide than will combine with the copper, then an alkali cupricyanide is formed which exerts a solvent action on the gold equal to the cyanide itself.

[19] *Journal of the Society of Chemical Industry*, Vol. 21, p. 392.
[20] *Engineering and Mining Journal*, p. 816, Dec. 20, 1902.
[21] See also *Engineering and Mining Journal*, Aug. 17, 1901, and THE MINERAL INDUSTRY, Vol. X., pp. 351 and 352.

In treating ores by the Hunt process the strength of solution in ammonia is varied according to the copper content and the condition in which the copper is found. Comstock tailings containing cupric oxide, originally introduced into the ore as copper sulphate in the amalgamation treatment, use as high as 8 lb. of ammonia per ton.

The strength of the solution in cyanide was 1 lb. per ton. The consumption of cyanide was 0·6 lb. per ton. The tailings treated assayed $1·45 in gold and 3·05 oz. in silver, and the residues from the treatment assayed 25c. in gold and 1 oz. in silver. On other material, perfect extraction was attained on the gold and 85·09% on the silver. The high extraction is probably due to the energetic oxidizing power of the cupric oxide dissolved in ammonia. The solution employed on the Comstock tailings is higher than would be used ordinarily, owing to the solubility of the copper in this case, which would rarely occur in an ore where the copper was native.

At the cyanide plant of the Brooklyn Mining Co. at Dale, San Bernardino County, Cal., a complex ore is treated containing lead carbonate, copper bearing pyrite, and copper in various conditions notably as silicate. This last named mineral being soluble in cyanide, caused a loss of from 7 to 8 lb. of cyanide per ton by the ordinary treatment. An addition of 6 lb. of ammonium chloride per ton to a 0·15% cyanide solution brought the consumption down to 1 lb. cyanide per ton. From 7 to 8 lb. of burnt lime are added per ton of ore, and the ammonium chloride is added directly to the cyanide solution in the stock tanks. The solution was allowed to remain in contact with the ore for 12 hours, then draining and washing was continued for about 6 days. Any salt of ammonia may be used instead of aqua ammonia, provided lime or some alkali is added to the ore. If the ore contains ferrous salts these should be removed by adding the ammonia solution and an oxidizing agent previous to adding cyanide.

At Dale, ordinary zinc box precipitation is used, which presents no difficulties, although the product is low grade, $3,500 to $7,000 in value per ton, if acid were used in the clean-up the richness of the product could be doubled. On the whole, however, electrolytic precipitation is preferable. In Hunt's process, the use of peroxidized lead anodes and aluminum cathodes is advisable. The lead anodes are peroxidized in a solution of potassium permanganate before use. A current density of 3 amperes per sq. ft. is employed. Lead anodes alone gradually become peroxidized, and when the current density rises above 1 ampere per sq. ft.—reaction occurs with the formation of basic lead carbonates and lead cyanides. The gold, silver and copper are not precipitated as an adherent coating on the aluminum, but fall as a sludge.

Hunt's ammonia cyanide process has the following advantages:—

1. It makes amenable to the cyanide process ores not before treated.

2. In cases where the consumption of cyanide is high it may be reduced by employing the process.

3. It is a simple process, compared to processes which aim to accomplish the same results, and hence is more economical.

4. The cost of the reagents employed is not high compared to the cost of

cyanide, part of the cost in some cases may be made up by the value of the copper recovered.

5. Unlike the acid treatment, calcareous ores are amenable to the process.

6. There is no limitation to the copper content of the ores which can be treated economically under local conditions, though with high-grade copper ore a plant would have to be installed for ammonia recovery.

It presents a good field for oxidized copper-gold tailings or ores, and possibly may be extended to pyritic ores.

Important Patents Issued during the Year.—Several patents have been granted during the year, of which some may in time have an important bearing on the cyanide process.

A patent has been issued to Ed. D. Kendall, of Brooklyn, N. Y., for the electrolytic recovery of precious metals dissolved in cyanide solutions. The gold-bearing cyanide solution is filtered through a mass of hard fragmental carbon pocketed around the porous cup of an electrolytic cell, and connected as the cathode of a 15-volt current. A carbon plate as anode is placed in the porous cup and immersed in a solution of caustic alkali. The cyanogen set free collects in the caustic alkali solution of the anode, and the precious metals are deposited in a pulverulent form throughout the mass of the cathode. After the deposition of the gold, the two compartments are emptied of their solution, a silvered carbon plate rubbed with graphite replaces the former carbon anode plate, the current is reversed and a strong solution of potassium cyanide is permitted to flow through the cell, successively through the anode and cathode compartments in the order named. The gold is redissolved from the former cathode and deposited in reguline form on the silvered carbon plate now forming the cathode. The idea was first suggested by Dr. Pfleger in 1895, and further developed, and its advantage pointed out by Prof. S. B. Christy.

United States Patent No. 687,258, for the recovery of cyanide from waste and foul solutions, has been issued to William Orr, of Salt Lake City, Utah, and controlled by the Gold & Silver Extraction Co. of America. The quantity of potassium cyanide and potassium-zinc cyanide is determined in the waste solution; the waste solutions are then run into a suitable tank, and the proper quantity of fused zinc chloride added to precipitate all the cyanogen as zinc cyanide. The solution is then separated from the precipitate by decantation or filtering, after which a solution of alkali hydrate is added to dissolve the zinc cyanide. The correct quantity of potassium or sodium sulphide is then added to precipitate the zinc, which is separated, the solution then being again ready for use.

Miscellaneous.—According to Wm. J. Sharwood[22] selenium is found in the precipitates from the cyanide process and may come from the presence of the silver and copper selenides in the ores, both of which are slowly soluble in potassium cyanide, as potassium seleno-cyanide, KCNSe, from which zinc precipitates selenium. If, however, the selenium is found in the precipitate after treatment with sulphuric acid, the selenium probably came from the acid, being precipitated from it by the zinc.

[22] *Engineering and Mining Journal*, p. 668, Nov. 22, 1902.

According to T. L. Carter,[23] cyanide solutions carrying gold which have become useless and foul from long standing, may be treated to recover the gold as follows: Sufficient zinc chloride is added to precipitate the gold as a fine gray powder, and the whole allowed to filter through sand to catch the gold. The sand can then be used in the fluxing of precipitates.

A. F. Crosse[24] describes two methods for the assay of cyanide solution as follows:—

1. Pour 500 c.c. of solution into an evaporated dish, put under a hood with a good draft, add nitric acid until the solution shows an acid reaction, boil for 15 minutes, then add 0·5 g. of silver dissolved in nitric acid, filter and fuse the filter paper with the precipitate, as usual with litharge and flux, and then cupel the lead button.

2. Take 500 or 1,000 c.c. of solution, add an excess of copper sulphate, acidify with sulphuric acid, filter and fuse the precipitate with litharge and flux, and cupel the lead button.

Cyanide Poisoning.—The Victorian Mines Department[25] has issued instructions printed on linen, for posting in cyanide works, which give directions how to proceed in cases of cyanide poisoning in the absence of medical assistance. The credit for the work is due to Dr. Martin, of Melbourne University, and Mr. H. Jenkins, the Government Metallurgist. In a case of poisoning, everything depends on prompt action, for the chances of recovery are very small after the lapse of a very few minutes if a fatal dose has been taken. The first step is to neutralize the rapid poison by the antidote, and then to empty and wash out the stomach as soon and completely as possible. The antidote consists of two solutions, sealed up in bottles, and a sealed powder. One bottle contains 7·5 g. of ferrous sulphate dissolved in 30 c.c. of water; the other 1·5 g. caustic soda dissolved in 300 c.c. of water. The powder consists of 2 g. magnesia put up in a sealed tube. There should also be a gag for the purpose of opening the clenched mouth of the unconscious person, and a stomach tube that can be passed through the gag into the patient's stomach. If the patient is still conscious he must drink the antidote at once; if not a small gag is inserted in the patient's mouth to prevent the stomach tube from being bitten off, and the tube passed down his throat into the stomach. The antidote is then poured down the tube and is followed by some water. If the patient has been able to swallow the antidote the stomach tube is inserted at this time, the patient being placed in a reclining position, and half a pint of water poured down the tube. Before all this descends into the stomach the funnel is lowered to get it to act as a siphon, and to empty the stomach as completely as possible. This is repeated several times in order to wash out the stomach. If the tube is not at hand every endeavor must be made to induce vomiting after the administration of the antidote. When the stomach has been emptied and washed steps must be taken to bring about artificial respiration if the patient is in a state of collapse. This is done as in the cases of partial drowning or suffocation.

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[23] *Engineering and Mining Journal*, p. 211, Feb. 8, 1902.
[24] *Journal of the Chemical and Metallurgical Society of South Africa*, May, 1902.
[25] *Australian Mining Standard*, May 29, 1902.

Cyanide Patent Decisions.—In an action in Queensland, Australia, the chief justice of that State, upheld the validity of the MacArthur-Forrest cyanide patents. The patents have also been successfully maintained in New Zealand and Victoria. In West Australia and New South Wales the courts have held that there was either no novelty or that the specifications were too broad. In the United States, the matter has never been really brought to trial. In the suit against the Mercur Co., of Utah, the latter compromised by agreeing to pay a small royalty. In Mexico and other Spanish-American countries the patents hold good. In South Africa, under the Republic, the patents were declared invalid, but as the Transvaal is now a British colony under the patent laws of the mother country, the patent which is good in England will probably be declared good in the Transvaal, and will raise interesting questions of royalty to be paid. The patents have at most but a few years to live in the different countries, and it is questionable whether in view of the broad lines of the process renewals will be granted.

By a decision of the United States Circuit Court of Appeals, and held as final, zinc dust is admitted free according to paragraph 482, Act of 1897.

Cyaniding Sulpho-Telluride Ores.

By Philip Argall.

The successful use of bromo-cyanide in the treatment of the unroasted sulpho-telluride ores of Western Australia has attracted quite a little attention in the United States, more particularly, perhaps, from those having mining interests in Cripple Creek, Colo. The very fact that sulpho-telluride ores can be treated without roasting, appeals at once to the small producer, who immediately sees a method for reducing his ore to bullion without the use of the usual cumbersome and often expensive roasting plant.

The method of working the Western Australian ores in the raw state, by means of fine grinding and subsequent treatment with bromo-cyanide, is known as the "Diehl" process (see preceding pages of this volume), apparently now established as an economic and commercial success in the treatment of Kalgoorlie ores. I herewith propose to compare this process of cyaniding with the roasting method as heretofore practiced on the ores of Cripple Creek.

The Kalgoorlie ores contain a large quantity of calcium and iron carbonates, together with a small quantity of magnesia. Estimating the latter component as $CaCO_3$, Mr. H. Knutsen gives the following approximate analysis of three samples: Insoluble, 57·98%, 59·61%, and 76·91%; $FeCO_3$, 19·29%, 13·94%, and 12·11%, and $CaCO_3$, 22·55%, 26·73%, and 9·18%.

The sulphur appears to have been neglected in the analysis. Mr. Alfred James, however, gives as a typical analysis of these ores: SiO_2 about 50%, Fe 10%, Al_2O_3 5 to 20% or more, MgO 1 to 5%, S 3 to 7%, Cu 0·1 to 0·3%, Pb trace, Zn 0·02%. As trace, Sb 0·02%, Te 0·03 to 0·1%, and $CaCO_3$ 6 to 17%. Ores of this character after roasting when the solutions reach them form a lime-iron cement which sets hard in the tanks and greatly interferes with, and often prevents, the percolation of the solutions through the charges. For this reason

early attempts at leaching the roasted ores at Kalgoorlie were far from successful; furthermore, these Australian ores, while containing an appreciable quantity of free gold in a comparatively granular condition, still require to be ground very fine in order to obtain a high rate of extraction; the fine grinding produced troubles in the subsequent handling of the slime, and led to the early introduction of filter presses, which soon became standard in the cyanide practice of Western Australia.

One of the most successful combination processes for reducing the sulpho-tellurides ores of Kalgoorlie is briefly outlined as follows: Crushing dry to about 30-mesh size, roasting in mechanical furnaces, fine grinding and pan amalgamation in dilute cyanide solutions, separating the sands from the slimes, treating the latter in the filter presses and the former in tanks, or, as an alternative, reducing the ore under treatment to such a fine state of division that it is all successfully treated in the filter presses, thereby abolishing the leaching in the tanks. According to Mr. Alfred James, the Kalgoorlie sulphide ores yield, without roasting, from 50 to 70% extraction when treated by agitation with ordinary cyanide solutions. My experiments on Cripple Creek telluride ore gave almost identical results; in fact the lowest extraction on 30-mesh size raw ore that I have observed is 54%. It is perhaps permissible to state that fuel is quite expensive in Kalgoorlie, and water may be said to command famine prices, from which it is evident that roasting is at a disadvantage, costing, it is said, on those low tenor sulphur ores, from $1 to $3 per ton, while power costs from 70 to 90c. per horse power per day. Under these conditions, a wet process for working the ore in the raw state has at least a fair show.

The use of the halogen cyanides as accelerators in the cyanide process was discovered and patented by Dr. Gaze in 1892, and in February, 1893, a cyanide mill near Reefton, N. Z., used chloro-cyanide in the solutions; but owing to difficulties in precipitation, the process was soon abandoned. In 1894 Messrs. Sulman & Teed, of London, patented a bromo-cyanide process, and to these gentlemen is due the credit of applying bromo-cyanide to the direct treatment of telluride ore. It is well known that cyanogen in the semi-molecular or nascent state has a powerful action on gold, that bromo-cyanide itself has but little if any solvent power on gold, but when added to a cyanide solution, it not only liberates a molecule of cyanogen from the latter, but also contributes its own cyanogen, thus: $KCN+BrCN=KBr+2CN$.

Bromo-cyanide must be considered as a cyanogen liberator, and it is no doubt through the intense chemical activity of the nascent cyanogen thus liberated that the tellurides are attacked, at least to the extent of setting free part of their contained gold. Briefly, the combination bromo-cyanide process evolved by Dr. Diehl is as follows:—

(1) Stamping the raw ore with or without amalgamation, as may be found expedient.

(2) Separating the heavy minerals from the gangue by concentration.

(3) Roasting the concentrates and returning the roasted tellurides to the batteries for amalgamation, or selling the concentrates to the smelters.

(4) Sliming all the tailings from the concentrators so the material will pass a 200-mesh screen.

(5) Agitating this fine pulp for at least 24 hours in cyanide solutions, to which a solution of bromo-cyanogen is added from time to time.

(6) Filter pressing the agitated slimes.

The Diehl process is fully described by Mr. H. Knutsen[1] in a very able and interesting paper from which the following comparative data of costs are taken. The process is in use at one property alongside a roasting plant, both treating the same class of ores; in the roasting plant two-thirds of the ore is treated in filter presses and one-third in leaching tanks, while in the Diehl all the ore must be filter pressed.

In the roasting process, 3,411 tons were treated, which yielded 5,287 oz. of bullion and no concentrates, while with the Diehl process 5,888 tons were treated, yielding 5,201 oz. of bullion and leaving 3,819·47 oz. in the concentrates. If the concentrates represent but 0·5% of the ore, as reported, then practically 42% of the value of the crude ore is locked up in about 30 tons of concentrates. These latter are treated at the smelting works. A summary of expenditure per ton of ore treated during August, 1901, is given in the subjoined table.

	Roasting Process.	Diehl Process.		Roasting Process.	Diehl Process.
	s. d.	s. d.		s. d.	s. d.
Superintendence	1 5·051	1 0·013	Elevating	... .	0 3·481
General stores and charges	1 4·306	1 7·486	Cyanogen bromide	... .	4 0·046
Electric light	1 4·501	1 2·514	Potassium cyanide	3 0·277	2 9·596
Assay, retorting and smelting	1 9·036	1 6·075	Zinc	3 2·418	2 2·227
Fuel	9 2·548	3 5·746	Filling and emptying presses	1 8·253	2 6·171
Water	3 5·046	3 2·347	Filter cloth	0 4·736	0 3·098
Compressed air	1 4·254	2 0·209	Chemicals	0 1·049	0 1·001
Filling and emptying vats	1 2·564	... .	Firing roaster	1 2·958	... .
Labor, general	1 1·978	1 10·618	Agitation	1 2·723	... .
Engine driving and firing	0 11·479	0 7·662	Royalty	... .	1 9·196
General repairs	3 3·058	2 3·224			
Screens, shoes and dies	... .	0 0·340	Totals	37 4·295	32 9·030

Taking the difference in fuel cost between the two processes, and adding the expense of firing the roaster, the approximate cost of roasting is found to be 6s. 11·7600d. The cost of bromo-cyanide is 4s. per ton of ore treated; to this, the royalty for the use of the process should be added, and a total of 5s. 9·24d. is obtained as an offset to the roasting, which shows 1s. 2·5d. in favor of the Diehl process. It was claimed that the same quality of ore went to both plants, but the Diehl gave a return amounting to 3s. 8d. per ton more than that from the roasting process. This comparison appears to me to be somewhat favorable to the Diehl process, if, indeed, a strict comparison of the costs of the rival processes was intended: for example, the capacity of the roasting plant appears to be about 60% of that of the Diehl, yet the cost for supervision, engine driving, etc., is about 50% greater for the smaller plant. It is in the final products of the plants, however, that the most unfair comparison creeps in; the roasting process produces all its yield in bullion, while the Diehl leaves about 42% of the bullion content of the ore in the form of high-grade concentrates, which can neither be handled nor roasted without loss of metal. There is also an additional smelting

[1] *Proceedings of the Institution of Mining and Metallurgy*, 1902, London; see, also, THE MINERAL INDUSTRY, Vols. IX. and X.

charge for extracting the values from the concentrates that is apparently not included in the foregoing expense table. Furthermore the roasting plant is not credited with flue dust or sweeps, and one cannot believe that the roasting of ores of this character would be attempted without the usual equipment of dust flues and settling chambers.

In a newer Diehl plant the concentrates, amounting to about 5% of the ore treated, are roasted and returned to the batteries for amalgamation, the pulp from the raw as well as from the roasted ores mingling together are treated in agitators for 24 hours with cyanide and bromo-cyanogen solutions. The final tailings are said to "average from 1 to 2 dwt. gold per ton, no matter whether the original ore contained 1 oz. or 4 oz. gold per ton." The consumption of chemicals is given at about 3 lb. KCN and 1·25 lb. BrCN per ton of ore. The working cost is summarized as follows: Milling, 4s. 0·59d.; concentration, 1s. 7·19d.; treatment, concentrates, 1s. 4·08d.; extraction, 17s. 1·02d.; total, 24s. 0·88d.

The bromo salts alone amount to 5s. per ton of ore treated. It will be noticed that bromo-cyanide is not depended on to break up the gold tellurides completely, hence these minerals are first concentrated out as far as is possible, and afterward roasted to set the gold free for amalgamation. In the next place, a tailing approaching $2 in value can scarcely be considered a satisfactory termination of such an elaboration of processes. Yet it is extremely interesting to know that such good work can be accomplished by a wet process, or at least one that eliminates from 80% to 95% of the roasting usually found necessary in treating sulpho-telluride ores. Such a process will have a great future in places where roasting is expensive, either through lack of fuel, or the high sulphur content of the ore; provided that in either case, the bromo-cyanide will extract the values.

The sulpho-telluride ores of Cripple Creek are virtually altered granites, phonolites, and andesites, containing slightly more silica and considerably more iron and sulphur than the original rocks, but on the whole practically of the same chemical composition. Tellurium and fluorite are little more than traces in the ores received at a custom works which contain but little carbonate, and when roasted, exhibit no tendency to harden or set in the tanks unless an excess of lime has been added. Ordinarily a good extraction can be obtained on roasted ores crushed no finer than 30-mesh size (0·017-in. opening). The sulphur content of the ores varies from 1% to 7%, and may be said to average approximately 3%. These ores are quite easily roasted, and the entire process of roasting and cooling would vary in cost from 30c. to 50c. per ton, depending on the sulphur content and on the arrangement of the roasting plant. About four years ago, I made a complete estimate of the cost of cyaniding Cripple Creek ores at a proposed new works to be erected at Cañon City. The works were designed to treat 500 tons of ore per day, to be later enlarged to 750, or even 1,000 tons, provided the ore market justified the increase. I had intended to use the roasting process with some important modifications and improvements which were developed during my experience at the works of the Metallic Extraction Co., and tested to finality on a working scale at that plant. The estimate of the actual

cost of milling the ore, extracting the values, and marketing the bullion on a basis of treating 500 tons per day, worked out to $1·75 per ton of ore. The proposed new method of treatment not only substantially reduced the working cost, but gave also an increased extraction over that attained at the old plant.

On the strength of this discovery and on the improvements that could be made in a new plant, a site for the proposed works was selected near Cañon City, and the Florence & Cripple Creek Railroad extended a branch into that city to accommodate the plant; however, before the new road was completed both the Metallic Extraction Co.'s works and the railroads were under option for sale, and were subsequently sold, which caused the scheme for the cheap milling of Cripple Creek ores to fall through, and with it, for a time at least, the prospect of treating $5 ores at a profit to the miner.

It is true that those results have not been attained in practical working on a commercial scale, but, nevertheless, there is no question as to their accuracy or of the fact that Cripple Creek ores can be roasted and cyanided in a modern up-to-date plant of 500 tons daily capacity at a cost of $1·75 per ton. But one need not enter into the question of the total cost of cyaniding Cripple Creek ores in order to compare the Diehl with the roasting process now in use. I believe the following will suffice:—

Diehl Process.	Cost.	Roasting Process.	Cost.
Bromo-cyanogen and royalty	$1·00	Roasting	$0·50
Fine grinding	·50	Tank work	0·25
Filter press work and agitation	1·25	Total	$0·75
Total	$2·75	Difference in favor of the roasting process	$2·00

Assuming the cyanide consumption to be the same in each case, it is evident that the cost of bromo-cyanide, plus grinding from 30-mesh size to 200-mesh size, plus filter press work, plus concentration, would have to aggregate less than $1 per ton before the Diehl process could compete successfully with the roasting process in the treatment of Cripple Creek sulpho-telluride ores. Therefore, the latter process must prevail at Cripple Creek, as, in my opinion, it will ultimately prevail at Kalgoorlie.

The Treatment of Sulpho-Telluride Ores at Kalgoorlie.[1]

By W. A. Prichard and H. C. Hoover.

Introductory.—The Kalgoorlie field, the mines of which practically are limited to one square mile, has during the eight years since its discovery, to the end of 1902, produced gold to the value of £14,873,982. The feverish requirements of the London stock markets, into whose hands fell the development of these fabulous deposits of refractory ore, coupled with the universal inexperience in dealing with ores of this class, resulted in a number of serious blunders in metallurgical treatment.[2] There has been expended in metallurgical works on this square mile over $8,000,000, much of which has been devoted to the acquirement of experience. Some companies are now operating their second or third plants, and, on the other

[1] *Engineering and Mining Journal*, Aug. 1, 1903.

[2] Admirable detailed discussion of the practice on the Great Boulder Proprietary, by Mr. G. M. Roberts, appeared in the *Monthly Report* of the Kalgoorlie Chamber of Mines for July, and of the Diehl Process by Dr. Knutzen in the *Proceedings of the Institution of Mining and Metallurgy* for 1902.

hand, more conservative companies continue to operate ill-adapted machinery at a high working cost or are only treating selected portions of their ore, with the use, in many cases, of unsuitable machinery such as yields them a low extraction. Some companies continue to hand-pick ores—incidentally to pick the eyes out of the mine—and ship to smelters, while awaiting the final demonstration of the best treatment process. Although obtained at the expense of much costly experimentation and of much high priced advice, both good and bad, the treatment practice in the hands of the progressive companies to-day compares most favorably with that of any other mining center working refractory ores.

The Kalgoorlie field possesses many disadvantages, aside from its refractory ore, in the total absence of natural fresh water, in being limited as to supply of fuel, in being saddled with high freights, high import duties, high cost of living, and consequently high wages, all of which have resulted in a very high state of efficiency and ingenuity in the conservation of water, power, labor and material.

The ores are a siliceous impregnation of the country rock, itself a diabase, and therefore, aside from the state of mineralization, presents a great difficulty in the large percentage of slimes produced—both from oxidized and unoxidized material. In the sulphide ores the gold occurs, in a minor proportion, free, but in richer ores it is intimately associated with tellurides and iron sulphides. The ore also contains considerable amounts (from 4 to 8%) of iron carbonate.

In some mines the tellurides occur in more or less definite shoots, so that the most refractory ores can be separately treated, and in all mines the refractory character increases with the values, *i.e.*, proportion of tellurides. The percentage of free gold varies from 10% in the Oroya Brownhill to 30% in the Ivanhoe, and the average contents of the ores treated varies from 15 dwt. in the Lake View to 2 oz. of gold in the Oroya Brownhill. The percentage of concentrates varies from 4 to 10%. The percentage of slimes in the sulphide ores varies with the mine, and of course with the character of treatment, but the inherent slimes, crushing wet through say 20-mesh screen, would probably average 50% in the eastern mines and somewhat less to the west, the Ivanhoe showing a minimum.

The ores near the surface were oxidized, and in these ores the treatment, except for the heavy proportion of slimes, was a matter of no especial difficulty by ordinary milling, amalgamation and cyanide. Most of the oxidized ores have now been exhausted. The oxidation extended as far down as 200 ft.

The distinctive feature of Kalgoorlie practice is that all ores are now reduced to a slime for final treatment, but this has been developed in two general and distinctly different lines, with excellent results in both cases. First: Wet milling of the ores, concentration and roasting of concentrates and treatment of tailings by grinding to slimes the entire product and treating with cyanide or bromocyanogen, and, second, by dry crushing, roasting the entire product, grinding to slimes and treating roasted residues by cyanide. Other methods have been tried, but not with commercial success. The two successful processes have been applied with wide variations as to detail, owing to the unsettled state of opinion existing at the time of constructing the nuclei of the present plants.

The wet milling process is usually referred to as the "Diehl Process," and it is in use at the Oroya Brownhill, Lake View Consols and Hannan's Star mines.

The other form of treatment, which usually goes by the name of the "Roasting Process," is in use on the Great Boulder Proprietary, Great Boulder Perseverance, Associated Gold mines, Kalgurli, South Kalgurli, and Great Boulder Main Reef. The Ivanhoe mine, whose output ranks fourth on the field, is not yet completely equipped for treating the whole of its ore, nor for securing the most efficient extraction. The working cost is the lowest on the field, but the work is incomplete. The Golden Horseshoe mine, whose output ranks second, is in the same position but with the highest cost. The line of development on both these mines is, however, toward wet crushing by stamps, amalgamation of free gold, concentration and incomplete treatment of tailings being secured by ordinary cyanide and filter press treatment. In both these mines, the richest telluride ores are either mined separately or sorted, and then treated either by smelting or in a small roasting plant. Neither mine has yet solved the problem, *i.e.*, efficient extraction.

Diehl Process.—The essential metallurgical features of this process in its best development are given on pp. 335 and 336 of this volume.

In the Lake View mill, stamps of 1,100 lb. are used, and, as prior to concentration coarse crushing is advantageous, an average duty of 5 tons (of 2,240 lb.) is obtained. Of the product 38% (slimes) will pass 150-mesh screen. If the fineness be increased to 55% slime, the duty is lowered to 3·5 tons, but sliming is secured more economically in the tube mills and, therefore, furnishes a second reason why the high mill duty is desirable. After concentration, the sands are separated in spitzkasten, and run into the tube mills filled with flint cobbles. From these mills, all tailings which will pass the outlet spitzkasten join the slimes from the entrance spitzkasten, and the sands return again to the tube mill. The slimes pass to closed agitators, where bromo-cyanogen is introduced, the period of agitation being about 24 hours. The slimes are then introduced either by pumps or montejus to the filter presses, for recovery of solutions, and the gold precipitated therefrom in the usual way.

The concentrates are amalgamated and then roasted in Edwards or Merton furnaces, the residues being treated by plain cyanide. For roasting concentrates but little fuel is needed, the sulphides furnishing much of the required heat. It has been found in treating concentrates that a much larger tonnage can be roasted when a considerable portion of coarse sand is included with the concentrates. The inclusion of coarse sand with the concentrates has the advantage of throwing more gold, sulphides and tellurides into the concentrates, thereby decreasing the consumption of cyanide and bromo-cyanogen in the slimes treatment. A close concentration, though unnecessary, is very desirable in the bromo-cyanogen process, and it is found, as stated above, that in practice the amount of cyanide and bromo-cyanide required to recover the gold from the tailings increases with the amount of concentrates remaining in them when the slimes are treated. The difficulty is both mechanical and chemical. There is still a further advantage where royalty is paid on gold recovered by bromo-cyanogen, the cost for royalty is reduced by throwing more gold into concentrates. At the Lake View Consols over 50% of gold is obtained from the concentrates.

In the case of the Oroya Brownhill, the concentrates were returned to the battery after roasting, being amalgamated prior to concentration, and consider-

able economy will result in introducing the Lake View method of separate treatment. The average assay of tailings from Oroya North Block and Brownhill ore on the Oroya Brownhill for five months is 3·1 dwt. per ton, the average yield of the ore being 37·1 dwt. per ton fine gold, showing an actual extraction of 92·3% per ton. The average on the Lake View Consols for the same period is 1 dwt. 14 grains, the yield being 14 dwt. 12 grains on an extraction of 90%, and in this case the irreducible minimum in tailings somewhat affects the extraction.

The Hannan's Star is an adapted mill, crushing dry in the first instance is not the best development of the process, yet the extraction averages about 91 to 92%.

Roasting Process.—The essential features of this process are: (1) Breaking in gyratory breakers. (2) Dry crushing in Griffin or Krupp ball mills. (3) Roasting in Edwards' or Merton's, or other furnaces, to oxidize sulphides and tellurides. (4) Amalgamation and sliming in pans. (5) Separation of sands and regrinding in pans. (6) Agitation of slimes with cyanide. (7) Recovery of solution from slimes by filter pressing. (8) Precipitation of gold by zinc shavings.

In dry grindings, with either Krupp ball mills or with Griffin mills, fine rock-breaking is essential, and it is usually conducted in two stages. For rock breaking, gyratory crushers are universally favored in all processes, as the hardness and unfriability of the Kalgoorlie ore makes it unsuitable for ordinary jaw crushers. In the grinding stage Krupp ball mills, Nos. 4, 5, or 8, or Griffin mills, are used. The No. 5 ball mill most commonly used, has a capacity of about 25 tons, when 66% (slimes) will pass a 150 (linear) mesh screen. One Griffin mill has a capacity of about 30 tons per day, of which from 70 to 80% will pass a 150-mesh screen. All dry mills work most successfully on ores containing under 3% of moisture, and should much more exist, drying is necessary.

In roasting, Edwards, Merton or Holthoff-Wethey furnaces are used, with wood fuel, and in one case a combination of wood and coal-generated gas is used, the introduction of gas largely increasing the capacity of the furnace. The hot ore is then introduced into a mixer, where it is puddled with return solutions from the spitzkasten. The pulp then passes to the amalgamating pans or mills.

Of the gold in roasted ores, 50% is recoverable by amalgamation; about the same proportion of gold as is recovered from the concentrates in the Diehl process.

The percentage of slimes is much greater in the product from dry crushers than by wet crushing, hence in the roasting process much of the sliming has been done prior to the second grinding operation, which in the roasting process takes place in the Wheeler type of pans. After grinding and amalgamating, the remaining sands are separated by spitzkasten and clarified by spitzlutten. The sands are returned to the same or other pans for regrinding, and excess water is returned to the mixers. The slimes are led to agitation vats, where the cyanide solutions are introduced and agitation is continued for about 24 hours. The mechanical part of agitation is identical in both processes, as is filter pressing, and is also the subsequent treatment of solutions, but in the roasting process ordinary cyanide is used. The Great Boulder Proprietary shows an extraction of about 90% on ores averaging between 27 and 30 dwt. fine gold. The Great Boulder Perseverance shows an extraction of 88 or 89% on ores of similar grade.

Comparative Results.—The extraction secured by the two processes on ore of

the same grade shows a difference of from 1 to 3%, generally in favor of the Diehl method. However, much depends upon the efficiency of the individual plant. In initial expenditure, the advantage lies on the side of the Diehl process, largely owing to the more limited outlay on roasting and appliances and less cost of erection. In working expenditure the advantages on the side of the Diehl process are: (1) Preliminary breaking in one stage. (2) Cheaper crushing wet. (3) By concentration the product necessary to roast is less than 5% of the total ore against 100% in the roasting process. (4) Less cost of maintenance and wear and tear. The advantages of the roasting process are: (1) Less cost in chemicals. (2) No royalties. The other operations fairly well compensate each other, and it seems that the Diehl process should have, under equally efficient management, about 2s. 6d. or 60c. per ton the advantage in costs.

Working Costs.—Working costs are difficult of comparison even on so limited a field as Kalgoorlie. The factors bearing on comparative costs are not wholly the efficiency of management or the process in use. In the first instance, there is a great difference of volume in ore treated at different plants, and consequently an increased cost per ton in smaller mills from fixed charges, and decreased cost in larger mills by the range of supervision of each employé. Moreover, the hardness of the ore varies greatly, not only in different mines, but in the same mine; in general, it increases toward the southern end of the field. The consumption of chemicals varies with the richness of the ore. Besides these factors, the cost of water varies considerably; some mines obtain a portion from their own property, others are compelled to purchase all that they use.

The Oroya Brownhill and Lake View Consols mines, using the Diehl process, represent two extremes of conditions. Oroya Brownhill treats an average of about 4,000 tons per month of ore averaging over 2 oz. per ton, being one of the smaller mines as regard tonnage, and the richest in character of ore treated. The Lake View treats about 7,500 tons per month of an average value of about 14 dwt., this being the lowest grade sulphide ore treated. The costs include all charges except general management.

	Oroya Brownhill.	Lake View Consols.
	Shillings.	Shillings.
Milling	3·38	3·61
Concentrating	1·81	2·17
Treatment of concentrates	15·81	10·45
Total	21·00	16·23

For the month of May the Oroya Brownhill costs were further reduced by 1s. 6d. or 36c. per ton, to 19s. 6d. or $4·68.

Of mines using the roasting process, the working costs of the Great Boulder Proprietary, treating about 9,400 tons per month, and the Great Boulder Perseverance, treating between 11,000 and 12,000 tons per month, not including general management, but including superintendence of the plant, as given in their annual report for 1902, are 23s., or $5·52, for the former, and 22s., or $5·50, for the latter. Some reductions have been effected since that date, and the costs of the latter mine are given at 19s. 6d. or $4·68 for May.